

**Computational Analysis and Development of
Web based System for Pāṇinian Derivational
Process of Sanskrit Words Ending with
Feminine Suffixes**

*Dissertation submitted to University of Delhi
in partial fulfillment of the requirements
for award of the
degree of*

MASTER OF PHILOSOPHY

by

Bhaskar Upreti

Advisor:
Dr. Satyapal Singh

Advisor:
Dr. Mohini Arya

Supervisor:
Dr. Subhash Chandra
Assistant Professor



**Department of Sanskrit
University of Delhi
Delhi-110007, India
2020**

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Department of Sanskrit

University of Delhi
Delhi-110007, India

Date : 26.02.2020

DECLARATION

The dissertation entitled “**Computational Analysis and Development of Web based System for Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes**” carried out by me is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions. The work was done under the supervision of Dr. Subhash Chandra, Assistant Professor at Department of Sanskrit, University of Delhi, Delhi. This is my original work. The research work is not published completely or partially in the form of books, monographs or articles.

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In our capacity as advisors of the candidate’s dissertation, I certify that the above statements are true to the best of our knowledge.

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Certificate of Originality

The research work embodied in this dissertation entitled “**Computational Analysis and Development of Web based System for Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes**” has been carried out by me at the Department of Sanskrit, University of Delhi, Delhi, India. The Manuscript has been subjected to plagiarism checked by **Turnitin Software**. The work submitted for consideration of award of M.Phil. is original.

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Student Approval Form

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Dissertation Title	Computational Analysis and Development of Web based System for Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes
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Supervisor's Certificate for Exclusion of Self-Published work

Following one (1) Research papers based on this research have been published in the international peer reviewed journals and international conference proceedings:

1. Upreti Bhaskar and Chandra Subhash. (2019). Development of Web based Pāṇinian Derivation System of Sanskrit Words Ending with Feminine Affixes. *International Journal of Research and Analytical Reviews (IJRAR)*, E-ISSN: 2348-1269 and P- ISSN 2349-5138, Volume 06, Issue 4, April 2019, pp.90-94. Impact Factor: 5.75., UGC Listed: UGC Journal No. 43602.

Following one (1) Research papers based on this research have been presented in the conferences:

1. The paper entitled "वेब आधारित संस्कृत स्त्रीप्रत्ययान्त पदों की रूपसिद्धिप्रक्रिया सिस्टम का विकास". Presented in *National Seminar on Multi Dimensional Aspects of Sanskrit & Larger World organized by Department of Sanskrit, Jamia Millia Islamia University, New Delhi on Feb 15-17, 2019.*

This published works have been included in the dissertation and has not been submitted for any degree to any University/institute.

Signature of Student

Signature of Supervisor

*To
My
Parents*

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Bhaskar Upreti

Date : 26.02.2020..

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Certificate of Presentation	118-119
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First Presentation	118-119
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The paper entitled “वेब आधारित संस्कृत स्त्रीप्रत्ययान्त पदों की रूपसिद्धिप्रक्रिया सिस्टम का विकास”. Presented in *National Seminar on Multi Dimensional Aspects of Sanskrit & Larger World* organized by Department of Sanskrit, Jamia Millia Islamia University, New Delhi on Feb 15-17, 2019.

INTERNATIONAL ALPHABET FOR SANSKRIT
TRANSLITERATION (IAST)

संस्कृत लिप्यन्तर के लिये अन्तर्राष्ट्रीय वर्णमाला (आईएसटी)

अ <i>a</i>	आ <i>ā</i>	इ <i>ī</i>	ई <i>ī</i>	उ <i>u</i>
ऊ <i>ū</i>	ऋ <i>r̥</i>	ॠ <i>r̄</i>	ऌ <i>ḷ</i>	ए <i>e</i>
ऐ <i>ai</i>	ओ <i>o</i>	औ <i>Au</i>	ं <i>m̐</i>	ः <i>ḥ</i>
क <i>k</i>	ख <i>kh</i>	ग <i>G</i>	घ <i>gh</i>	ङ <i>ṅ</i>
च <i>c</i>	छ <i>C</i>	ज <i>J</i>	झ <i>jh</i>	ञ <i>ñ</i>
ट <i>ṭ</i>	ठ <i>ṭh</i>	ड <i>ḍ</i>	ढ <i>ḍh</i>	ण <i>ṇ</i>
त <i>t</i>	थ <i>th</i>	द <i>D</i>	ध <i>dh</i>	न <i>n</i>
प <i>p</i>	फ <i>ph</i>	ब <i>B</i>	भ <i>bh</i>	म <i>m</i>
य <i>y</i>	र <i>r</i>	ल <i>L</i>	व <i>v</i>	
स् <i>s</i>	श् <i>ś</i>	ष् <i>ṣ</i>	ह <i>h</i>	
क्ष <i>kṣ</i>	ज्ञ <i>jñ</i>	श्र <i>śr</i>		

**UNICODE DEVANAGARI INPUT MECHANISM THROUGH
BARAHA SOFTWARE**

बराह सॉफ्टवेयर द्वारा देवनागरी के लिये यूनीकोड में संस्कृत टंकण हेतु
सहायक तालिका

Unicode Devanagari Input Mechanism through Baraha software (http://www.baraha.com)				
अ (a)	आ (A/aa)	इ (i)	ई (I/ee)	उ (u)
ऊ (U/oo)	ऋ (Ru)	ॠ (RRu)	ऌ (IRu)	ॡ (IRRu)
ए (e)	ऐ (ai)	ओ (o)	औ (au)	अं (aM)
◌ः (aH)				
क् (k)	ख् (K/kh)	ग् (g)	घ् (G/gh)	ङ् (~G)
च् (c)	छ् (C)	ज् (j)	झ् (J/jh)	ञ् (~j)
ट् (T)	ठ् (Th)	ड् (D)	ढ् (Dh)	ण् (N)
त् (t)	थ् (th)	द् (d)	ध् (dh)	न् (n)
प् (p)	फ् (ph)	ब् (b)	भ् (bh)	म् (m)
य् (y)	र् (r)	ल् (l)		व् (v/w)
स् (s)	श् (S/sh)	ष् (Sh)	ह् (h)	ळ् (Lx)
क्ष् (kSh)	ज्ञ् (j~j)	श्र् (Sr/Shr)		

Acronyms and Abbreviations

AD	<i>Aṣṭādhyāyī</i>
AI	Artificial Intelligence
CSS	Cascading Style Sheets
DeitY	Department of Electronics and Information Technology
DP	<i>Dhātupāṭha</i>
GP	<i>Gaṇapāṭha</i>
HTML	Hypertext Markup Language
JS	Java Scripts
LSK	<i>Laghusiddhāntakaumudī</i>
MT	Machine Translation
NLP	Natural Language Processing
PG	Post Graduate
PP	Prātipadika
PSP	Python Server Page
SaHiT	Sanskrit-Hindi-Machine-Translator
SCL	Sanskrit Computational Linguistics
SK	<i>Siddhānta-Kaumudī</i>
SP	<i>Sūtrapāṭha</i>
SS	<i>Shivasūtra</i>
TDIL	Technology Development for Indian Language
UG	Under Graduate

Introduction and Scope of the Research, Problem Statement and Methodology

Grammatical advancement in India carries a long history of semantic, syntactic and morphological studies. Sanskrit grammar is considered one of the oldest and universal grammar. It was investigated, assembled and automated by Sanskrit grammarians. It was strongly programmed and well structured in the Aṣṭādhyāyī (AD). AD is a grammatical text, written by Pāṇini around 6th century BCE (Mimansak, 2012). AD is considered universal grammar but it was implemented and tested on Sanskrit language. AD contains around four thousand (4000) rules and few major database such as *dhātupāṭha* (DP), *gaṇapāṭha* (GP) and various listings. Sanskrit is an extremely inflected language, there are two types of morphology in Sanskrit language to generate nominal forms and Verbal to generate the verb forms. Nominal morphology derived in three grammatical genders masculine, feminine and neuter and three numbers singular, plural and dual. And also in eight cases nominative, vocative, accusative, instrumental, dative, ablative, genitive, and locative. Nominal forms includes primary and secondary nominal *kr̥danta*, *samāsānta*, *taddhitānta* and *striṭptayayānta*. Sanskrit has approximately 2000 verb roots mentioned in Pāṇinian DP. Verbal morphology derived in 10 *lakāras* to denote the meaning of tenses and two *padas*. Each *lakāra* generates minimum 9 verb forms. Therefore, a single verb root can generate minimum 90 verb forms.

Scope of the Research, Problem Statement and Methodology

1. Importance of the Research

Sanskrit Computational Linguistics (SCL) and their applications to develop the technology for Sanskrit language have received a great attention of researchers since NASA scientist Briggs (1985). Briggs suggested that Sanskrit is very useful for Artificial Intelligence (AI) to knowledge representation. The technique used by Pāṇini can be applied on AI. Due to tremendous demand and advancement of Information technology around the world, everything is getting digital rapidly. Even in the era of

traditional teaching technology, everyone wants instant information through Internet on the smart phones. In the field of SCL many institutes are working to develop such type linguistics tools. In the field of Sanskrit language technology, Jawaharlal Nehru University, University of Hyderabad, Hyderabad, Department of Sanskrit, University of Delhi, Indian Institute of Technology, Mumbai are the main institutes that are engaged and enhancing the technology for Sanskrit.

Due to increasing demand of the information technology the quality in traditional teaching in the field of education is being supported by the E-learning. But there is not much development has been done in the field of web based learning for Sanskrit. Based on survey, it is a first research and effort towards developing web based Pāṇinian derivation system of Sanskrit words ending with feminine affixes teaching in higher education. So, the main advantage of the online system is that user can use the system anytime and anywhere over the internet (Chandra, 2017). Over the last few years this type of system tested and researched on other part of derivational process were successfully working and contributing in teaching (Chandra, 2017).

2. Scope of the Research

Sanskrit grammar is being taught in almost all Indian universities offering Sanskrit courses at under graduate (UG), post graduate (PG) and research level. Feminine suffixes are included in Sanskrit Syllabus at UG and PG level with Sanskrit grammar course.

The major objective of this research is the Development of Web based Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes to identify, analyse and automatic derivation process generation. The system will be developed using Pāṇinian Rules. Finally the system will be available online for public use at no cost on <http://cl.sanskrit.du.ac.in>. This system may play a very important role in teaching learning process of Sanskrit Feminine Suffixes because of lack of existing effective online tools, which cover courses of Sanskrit in higher education. Apart from this objective research has other secondary objectives which will be discussed in the objectives section.

3. Statement of the Research Problem

In this research, the challenges and methodologies for computing Sanskrit feminine words derivational process with automatic identification and analysis have been studied and experimented. Based on the study and experiment a Web based Pāṇinian Derivation System of Sanskrit Words Ending with Feminine Suffixes is developed using combining rule and example based hybrid approach derived from the Pāṇinian methods of representations.

In Sanskrit language gender identification is very challenging task for human and for machine too. The determination of masculine, feminine and neuter are not done similarly in Sanskrit as in other languages. Because by nature the words containing the meaning of feminine can be used as masculine, any word containing the meaning of masculine can be used as feminine. Similarly any word containing the meaning of neuter can also be used as masculine or feminine. Let's demonstrate few examples here to understand the phenomena. The Sanskrit word 'dāra' contains the meaning of feminine but it is derived as masculine while other synonyms word e.g. *vanitā*, *yośita* etc. are feminine words in Sanskrit. The word 'ap' contains the meaning of water is feminine while 'vāri', 'toya' etc. are neuter. Word 'kāya' contains the meaning of body is masculine while word 'tanus' is feminine and 'śarīra' is neuter. Similarly the words 'amara', 'nirjara' containing the meaning god are neuter while 'devatā' is feminine. Containing the meaning of friend, word 'suhṛd' is masculine but 'mitra' is neuter. Containing the meaning of eye, word 'locana', 'akṣi' are neuter but 'dṛśa' is feminine.

Based on above examples illustrated we can say the determination of gender in Sanskrit is not an easy task. It can only be determined by the textual and using knowledge. Sanskrit has three genders Masculine, Feminine and Neuter. Pāṇini has divided feminine words in 4 major categories e.g. 'ābanta', 'nyanta;', 'ūñ' and 'ti'. Sanskrit grammar is being taught in almost all Indian universities offering Sanskrit courses at under graduate (UG), post graduate (PG) and research level. Feminine suffixes are included in Sanskrit Syllabus at UG and PG level. The major objective of this paper is to present ongoing research for the Development of Web based Pāṇinian

Derivational Process of Sanskrit Words Ending with Feminine Suffixes to identify, analysis and automatic derivation process generation. The system will be developed using Pāṇinian Rules. Finally the system will be available online for public use at no cost on <http://cl.sanskrit.du.ac.in>. This system may play a very important role in teaching learning process of Sanskrit Feminine Suffixes because of lack of existing effective online tools, which cover courses of Sanskrit in higher education.

4. Objective of the Research

The major objective of the research is to Develop Web based Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes to identify, analysis and automatic derivation process generation using combining rule and example based hybrid approach. In order to reach the goal following tasks will be looked upon.

- Implementation of Pāṇinian rules of computer.
- Challenges for computing Pāṇinian rules.
- Identifying the computational methods to compute the AD rules.
- Development of computational rules for identification of Sanskrit feminine words.
- Development of computational rules for analysis of Sanskrit feminine words.
- Development of computational rules for automatic siddhi generation of Sanskrit feminine words.
- Development of an online system for derivational process of Sanskrit words ends with feminine suffixes.
- Digitization of Pāṇinian rules with meaning, explanation and work for online search in AD rules.
- Digitization for various gaṇapāṭhas.

5. Methodology

To achieve the objective, the method adopted by Pāṇini in AD has been used for this research. Sanskrit grammar is very systematic and technical. Various researches has shown its relevance to computer. (Kak, 1987 & Bharati et al, 1995; Briggs, 1985 &

Chandra, 2006). Therefore, the implementation methods of Pāṇini has been used in this research to achieve the objectives. Many researchers has also proven that the methods used by Pāṇini can be implemented easily to develop any types of system. In this direction developed system SWAGATAM by Chandra et al (2017 & Kumar, 2018) has inspired the authors to develop such types of system for the other parts of the Sanskrit Grammar. Therefore, combining rule and example based hybrid approach is used to develop the system to achieve the objective. Basic methods of computing language and web technology are also used. Detailed description of methodology can be seen in chapter 4 Methodology section.

6. Structure and brief Introduction of the Dissertation

The dissertation is structured into five compact chapters. It starts with an introduction and ends with conclusion and future direction of research. Brief introduction of each chapter is following:

Introduction outlines the scope of the study with a detailed introduction, research scope of the study, statement of the research problem, objectives and research methodology with brief introduction of each chapter.

Chapter One highlights of the brief history of Sanskrit grammatical tradition and Sanskrit morphology with Concept of Feminine in Pāṇinian Grammar.

Chapter Two provides a detailed review of the SCL literature. This chapter reviews the previous research works with various techniques for SCL and derivational process generator systems. It also provides the details of Introduction of Sanskrit Words Ending with Feminine Suffixes.

Chapter Three discusses a detailed Basic Facts and Derivational Process of Sanskrit Words Ending with Feminine Suffixes of Pāṇini. This chapter is very useful to learn the Pāṇinian technique of derivation. Based on this chapter the computational rules are developed to achieve the goal.

Chapter Four discusses various types of data collection, digitization and development of computational rules of feminine suffixes and research methodology used.

Chapter Five talks about the developed system of web based recognition, analysis and derivational process system of Sanskrit words ending with feminine suffixes with detailed description of tools and technique used to develop the system. It also covers the various components of the system.

Conclusion and Future Direction of Research shows the overall finding, special features of the system and limitations of the system. It also talks about the future direction of the research.

The thesis also includes various types of rules and data in tabular format. A complete listing is given in appendixes at the end of the dissertation. A list of publication with complete paper and certificate of presentation is also attached at the end of the dissertation.

Chapter One

Pāṇinian Grammar and Sanskrit Words Ending with Feminine Suffixes

1. Brief Introduction of Sanskrit Grammar

Sanskrit grammar is the most incredible part of the genesis of the human mind. The land of Bharat is noted as the *tapasthalī* of sages and they developed Sanskrit language in order to write canonical text. To understand and forge ahead the Indian tradition of knowledge and of Vedas our sages developed six subordinating parts of Vedas called *vedāṅga*. The *vedāṅga* is called the limbs of the Vedas (Morgan, 1987). There are six supplementary disciplines of Vedas which were written in earliest times, and have been related with the study of the Vedas called *Vedāṅga* (Lochtefeld, 2001). These are also considered as the last treatises of the Vedic Literature. The six *vedāṅgas* are:

1. *śikṣā* or phonetics/phonology (or pronunciation)
2. *kalpa* or ritual
3. *vyākaraṇa* or grammar
4. *nirukta* or etymology
5. *chanda* or meter
6. *jyotiṣa* or astronomy

Pāṇinīya śikṣā (Mehto, 2005 & Ghosh, 1938) describes two verses on the significance of the *vedāṅga*. It explained Veda as a *puruṣa* which has six major limbs as six *vedāṅga*. *Chanda* is impersonated as the feet, *kalpa* is arms, *jyotiṣa* is eyes, *nirukta* is ears, *śikṣā* is nose and *vyākaraṇa* is mouth of the *puruṣa*¹.

The third *vedāṅga* is *vyākaraṇa* or grammar, which is essential for the understanding of the Vedas. It is called the mouth of the Veda *puruṣa* (Johnson, 2009; Lochtefeld, 2001 & Ghosh, 1938). This supplementary discipline is dedicated for the rules of grammar and linguistic analysis to establish the exact form of words and sentences to suitably express ideas. *Aṣṭādhyāyī* (AD) of Pāṇini is foremost representative of this *vedāṅga*. AD is considered as the most eminent text-book of Sanskrit grammar. Due to its great merits, this may be assumed that Pāṇini superseded all his predecessors, whose works have consequently perished. Formation of the words

¹ छन्दः पादौ तु वेदस्य हस्तौ कल्पोऽथ पठ्यते,
ज्योतिषामयनं चक्षुर्निरुक्तं श्रोत्रमुच्यते।
शिक्षा घ्राणं तु वेदस्य मुखं व्याकरणं स्मृतम्,
तस्मात्सांगमधीत्यैव ब्रह्मलोके महीयते॥ (पाणिनीय शिक्षा, 41-42)

is the main subject of grammar. It discusses root (*prakṛti*) and suffix (*pratyaya*) of a word to study its meaning. AD of Pāṇini is written in the form of *sūtras*. The first fourteen *sūtras* are referred to alphabets and called as *māheśvara sūtras*. It is considered to be the foundation of Sanskrit grammar. Vararuci (Kātyāyana) has written an elaborated commentary or *vārtika*. Sage Patañjali wrote commentary or *bhāṣya* on AD named as *Mahābhāṣya* (Kielhorn, 1992). *Mahābhāṣya* has clearly stated the importance of grammar among the six *vedāṅga* to understand Veda² (Govindacharya, 2010 & Govindacharya and Sharma, 2015). The importance of grammar is also stated by a father who is describing his son:

O son, although you have studied a lot, still you must learn grammar now. Because without the knowledge of grammar you cannot understand the meaning of texts. Without the knowledge of grammar, you cannot not differentiate between 'svajana' as 'shvajana', 'sakalam' as 'shakalam' and 'sakrit' as 'shakrit'.³

In Sanskrit language the word 'svajan' means one's own people, while 'shvajan' means a dog. 'Sakal' means total, while 'shakal' means a piece. 'Sakrit' means once, while 'shakrit' means excrement.”

The statement implies that the study of grammar is very much essential to understand the texts. The *vākyapadīyam* (Varma, 1970) stated that the grammar purifies the voice⁴.

1. 1 Origin and Development of Sanskrit Grammar

Sanskrit language is originated as Vedic Sanskrit and was preserved vocally as a part of the Vedic chanting practice. There are two forms of the Sanskrit, One is Vedic Sanskrit literature and other Classical Sanskrit literature. The earliest phase of Sanskrit language was the medium of oral communication of society of the ancient Indians. After sometime, it became the medium of literary composition but with no restrictions. The resistance of expressions was required to be controlled in order to put a stop to the evolution of variations to control over a larger area of their usage and make standardization of language. The grammarian Pāṇini standardized and defined the Sanskrit language in AD around 500 BCE (Mimamsaka, 2014; Jha, 2004, 1993; Sharma, 2002; Rocher, 1970; Bhate, 2002 & Kadavy, 2016).

Sanskrit grammatical tradition started in later Vedic India and concluded in the AD of Pāṇini, which contains of around 3990 *sūtras* with the objective of standardising

² ब्राह्मणेन निष्कारणो धर्मः षडङ्गो वेदोऽध्येयो ज्ञेश्च इति।

प्रधानं च षट्स्वङ्गेषु व्याकरणम्। प्रधाने च कृतो यत्नः फलवान्भवति ॥ [महाभाष्य, पस्पशाह्निक]

³ यद्यपि बहु नाधीषे तथापि पठ पुत्र व्याकरणम् । स्वजनः श्वजनो मा भूत सकलं शकलं सकृच्छकृत्॥.

⁴ तद्वारमपवर्गस्य वाङ्मूलानां चिकित्सितम् । पवित्रं सर्वविद्यानामधिविद्यं प्रकाशते ॥ [वाक्यपदीयम्, 1.7]

इयं सा मोक्षमाणानामजिह्वा राजपद्धतिः । [वाक्यपदीयम्, 1.8]

the classical Sanskrit language. The AD was sufficient to analyse the Sanskrit language. Being very adaptive and impressive by the society, scholars started following the AD rules to compose the Sanskrit texts. The AD was written in the *sūtra* style. The term AD mean a work of eight chapters. There chapters are further divided into four *padas* (sub-chapters). The AD is a set of rules which expresses the grammatical regularities of the language (Mimansaka, 2014). Pāṇini has given the formal production rules and explanations to define Sanskrit grammar. In AD the rules are divided into 6 major categories based on their functions. The technique used by Pāṇini can be implemented on any programming language today (Jha, 2004, 1993; Sharma, 2002; Rocher, 1970; Bhate, 2002 & Kadvany, 2016). In many ways Pāṇini’s constructions are very similar to the Mathematical and computer programming language function. The rules of AD are written in such a short form that we need to expand in order to understand. Pāṇini has used lots of databases distinctly with the help of *sūtras*, the information retrieved by the *sūtras* (Jha, 2004, 1993; Sharma, 2002; Rocher, 1970; Bhate, 2002 & Kadvany, 2016). The AD of Pāṇini is considered to be the best reference work for Sanskrit (Cardona, 1991; Mishra, 2017; Rocher, 1970; Bhate, 2002).

About a century later around 400 BCE Kātyāyana composed *vārtikas* (explanations) on the Pāṇinian AD for the simplification of the grammar and has also covered the variations which were left a little bit untouched by Pāṇini in AD. *Vārtika* is criticism in regard to that which is said, omitted and imperfectly expressed in the *sūtras* of AD (Mimansaka, 2014). Kātyāyana’s work, the *vārtikas* are meant to correct or modify the rules of Pāṇini wherever they were or had become partially or totally inapplicable. The *vārtika* of Kātyāyana can be categorize into four major categories viz. supplements, emendations, explanations and refutations (Mimansaka, 2014 & Kielhorn, 1976; Mishra, 1992; Sen et al, 1983).

Three centuries later Patañjali, wrote the *Mahābhāṣya*, the “Great Commentary” on the AD and *Vārtikas* (Mimansaka, 2014; Kielhorn, 1906; Witzel, 1986 & Cardona, 1977). *Mahābhāṣya* is an ancient treatise on Sanskrit grammar and linguistics based on the AD of Pāṇini (Ganeri, 2013). This text was titled as *bhāṣya* or “commentary” on Kātyāyana and Pāṇini’s work by Patañjali (Banerji, 1989; Scharf, 1996 & Cardona, 1997). But it is very well appreciated in the Indian traditions that is generally known as *Mahābhāṣya*. The ideas of Patañjali on grammar, philosophy and structure of language have also influenced scholars of other Indian religions such as Buddhism and Jainism (Scharfe, 1977 & Coward, 2015). These three ancient Sanskrit grammarians are called *Trimuni Vyākaraṇa* (Mimansaka, 2014 & Matilal, 1990).

Later to understand and make the Sanskrit grammar easier, Vāmana & Jayāditya wrote a commentary on Pāṇini’s AD called *Kāśikā* in around 600 CE. *Kāśikā* is considered the “fourth great grammar” of Sanskrit (Haag, 2011 & Sharma, 1985). Due to change in teaching methods later Indian grammarians simplified Pāṇinian rules and

clipped compilation of *sūtras* to essential and re-arranged the sequences as per derivation process (Coward, 2015).

Later Indian grammarian simplified Pāṇinian rules, and clipped his compiling of *sūtras* to essential. The scholar felt few rules of AD are too difficult and complicated or narrowly implemented on language they eliminated. Finally rearrangement of Pāṇinian rules was done by Bhaṭṭoji Dīkṣita (17th century). The most influential work of the Early Modern period was *Siddhānta-Kaumudī* (SK) done by Bhaṭṭoji Dīkṣita (17th century) to positioning Pāṇini's *sūtras* with a commentary for training purposes. In SK, the *sūtras* are organized in two major parts. The first portion deals with the rules of interpretation, *sandhi*, declensions, formation of feminine, case endings, compounds, secondary derivations and the second part with conjugation, primary suffixes, Vedic grammatical accents. Various commentaries were also written by the Sanskrit grammarian to understand the SK. One of the most popular commentary on SK called *Bālamānoramā* is written by Vāsudeva Dīkṣita's (Mimansaka, 2014 & Kielhorn, 1976; Mishra, 1992; Sen et al, 1983). It is considered one of the most eminent commentary on SK. It is written in such a way so that anyone can get detailed explanations, derivations and it is most useful for beginners. As the *Bālamānoramā* was written for the beginners and one other commentary written by Bhaṭṭoji Dīkṣita itself of SK for advance level students. Later lots of the commentaries were also written on the SK and *Praudhamānoramā* by many others.

In around 17th-century, Varadarāja was a Sanskrit grammarian who presented a synopsis of the work of his master on SK. The SK of Bhaṭṭoji Dīkṣita was shorten by him in three versions. *Madhya-SiddhāntaKaumudī* (middle), *Laghu-SiddhāntaKaumudī* (short) and *Sāra-SiddhāntaKaumudī* (substance) are the versions of the SK. These are comparatively accessible introductions to the very technical grammar of Pāṇini himself (Mimansaka, 2014 & Kielhorn, 1976; Mishra, 1992; Sen et al, 1983).

Vyākaraṇa emerged as a distinct supplementary field of Vedic education in earliest times. Pāṇini and Yāska were renowned earliest scholars of *vyākaraṇa*. There were several schools of Sanskrit grammar in ancient India, all established before the Pāṇini. The references of the pre Pāṇinian Sanskrit, grammarian eclipsed all other ancient schools of grammar. Only 10 grammarian are mentioned in AD. These are Apīśali, Kāśyapa, Gārgya, Gālava, Cākravarmaṇa, Bhāradvāja, Shākaṭāyana, Shākalya, Senaka and Sphoṭāyana (Cardona, 1997; Mimansaka, 2014 & Kielhorn, 1976; Mishra, 1992 & Sen et al, 1983).

1. 2 Introduction of Pāṇinian AD:

Pāṇinian grammar AD is considered the key text of Sanskrit grammar and very important for linguistic computation for various reasons. One, it provides a complete and rule based explanation of a natural language in around 4000 rules. second, the

model of a 'grammar-in-motion' that it provides seems to closely mimic a completely well-designed Natural Language Processing (NLP) system (Jha, 1993; Jha, 2004 and Chandra, 2007). AD is systematically divided in eight *adhyāyas* (chapters) and then each chapter is arranged into four sub-chapters (*pādas*) then after *sūtras* are arranged in special sequences such as a computer programme (Chandra, 2007; Jha, 1993; Bhate & Kak, 1991 and Kak, 1987). The *sūtras* have been organized in x.x.x format (to be accessed in as *adhyāya. pāda. sūtra* format). AD is written in the form of *sūtras* and is a composite text which includes various modules to represent the rules. The main modules of AD are:

1.2.1 *Shivasūtra* (SS):

Phonetic module and alphabets of the Sanskrit are discussed and represented by 14 *sūtras* called *śivasūtra-māheśvarasūtra* or *māheśvarasūtra*. These 14 *sūtras* are arranged in systematic manner such as high level Database. From these list Pāṇini generated various *pratyāhāras* and then used in various *sūtras* of AD in short form. The major purpose of SS component is to provide a list of all Sanskrit phonemes in systematic manner. But rather than listing just the phonemes, the *sūtras* in SS module are scattered by meta-linguistic markers, called *anubandhas*. It is a well-defined method in AD *sūtra ādirantyaena sahetā* [AD, 1.1.70] to shorten a group of characters and then use in other rules. Pāṇini creates variables or macros to be used in his grammar. It is very similar to any high level computer programming language. For example, the variable *al* refers to the list of all phonemes, *ac* refers to all vowels, *hal* to all consonants and *ṅam* to all nasals characters in Sanskrit languages. All alphabets of Sanskrit have been organized in such a way in these 14 *sūtras* that they can be denoted in any place of AD without declaring them separately. This shorten method is denoted by *pratyāhāras*. The methods of shortening is denoted by the AD *sūtra ādirantyaena sahetā* [AD, 1.1.70]. Pāṇini has used around 43 *pratyāhāras* in his AD to represent the huge numbers of alphabets but using this methods of generation of *pratyāhāras*, more than hundreds can be generated (Chandra, 2007 and Sharma, 2002).

1.2.2 *Sūtrapāṭha* (SP):

The module contains around 3965 and 3983 *sūtras* in *kāśikāvṛtti*. These are arranged in a very organized fashion in chapters (*adhyāyas*) and sub-chapters (*padas*) in AD. The order of any *sūtra* cannot be changed. The arrangement and distribution of SP in AD are shown table 1.1 (Shastri, 1983).

Chapter	Pāda I	Pāda II	Pāda III	Pāda IV	Total Rules
1 st	74	73	93	109	349
2 nd	71	38	73	85	267
3 rd	150	188	176	117	631
4 th	176	144	166	144	630
5 th	135	140	119	160	554
6 th	217	198	138	175	728
7 th	103	118	119	97	437
8 th	74	108	119	68	369
Total Rules in AD					3965

Table 1: Distribution of AD *sūtras*

sūtras in SP of AD are written verb-less sentences like a mathematical principles. It gives an impression of formula or program code. The *sūtras* are mainly 6 types⁵ based on the function in AD. Three types of another division of *sūtras* is also presented and is very helpful to understand the function of *sūtras*. These are general *sūtras* (*utsarga*), exceptions (*apavāda*) and negation (*niṣedha*).

1.2.2.1 *Samjñā* (definition, introduce classes and technical *sūtras*):

Pāṇini's *samjñā sūtras* generally define a term or assign the value of a term or variable to be used in the *sūtras*. The object which is assigned to a *samjñā* is called a *samjñī*. Pāṇini has used three types of technical terms (Chandra, 2007; Chandra, 2011 and Sharma, 2002). First is *śabdasañjñā* which allocates a *samjñā* to a linguistic terminology, meaning or property, for example, *vṛddhi*⁶, *prātipadika*⁷, *dhātu*⁸, *ghī*⁹,

⁵ संज्ञा च परिभाषा च विधिर्नियम एव च । अतिदेशोऽधिकारश्च षड्विधं सूत्रलक्षणम् ॥

⁶ वृद्धिरादैच् [1.1.1]

⁷ अर्थवदधातुरप्रत्ययः प्रातिपदिकम् [1.2.45], कृत्तद्धितसमासाश्च [1.2.46]

⁸ भूवादयो धातवः [1.3.1], सनाद्यन्ता धातवः [3.1.32]

⁹ शेषो घ्यसखि [1.4.7]

*nadī*¹⁰ etc. The second is *arthasañjñā*. It assigns a *samjñā* to the meaning of linguistic concepts, for example, *luk*¹¹, *lopa*¹², *ślu*¹³, *lup*¹⁴ etc. The third is *dharmasañjñā*. It assigns to the quality (*guṇa*) of a sound segment, for example, *adarśana*¹⁵, *udātta*¹⁶, *anudātta*¹⁷ *svarita*¹⁸, *hrasva*¹⁹, *dīrgha*²⁰ etc.

1.2.2.2 *Paribhāṣā* (Interpretive Rules):

The *paribhāṣā sūtra* are used for interpretation and it provides a check on the operational rules so that they do not suffer from faults such as *ativyāpti* (over application), *avyāpti* (under application) and *asambhava* (impossible application). It also helps to understand the rules for implementation. There are around 75 such types rules described by the Pāṇini in different parts of the AD. *ādyantau ṭakitau* [1.1.47], *midaco'ntyātparaḥ* [1.1.47], *ṣaṣṭhī sthāne yogā* [1.1.49], *sthāne 'ntaratamaḥ* [1.1.50], *uraṇa raparaḥ* [1.1.51], *nicca* [1.1.53] etc. are the examples of the *paribhāṣā sūtra*. Without these rules no one can explain and understand the actual meaning and implantation of the particular rules.

1.2.2.3. *Vidhi* (Operational Rules):

vidhi sūtras are used to perform the certain operation and conditional statement. In other sense, the term *vidhi* refers to *kārya* (operation, action) *vidhi* is also used in the sense of the object of an operation. Operational rules are the pillars of the Pāṇinian system. Subject to applicable, definition, metarules and headings they carry out four basic categories of operations on a string: replacement, affixation, augmentation and

¹⁰ यू स्त्र्याख्यौ नदी [1.4.3]

¹¹ प्रत्ययस्य लुक्श्लुलुपः [1.1.61]

¹² तस्य लोपः [1.3.9]

¹³ प्रत्ययस्य लुक्श्लुलुपः [1.1.61]

¹⁴ प्रत्ययस्य लुक्श्लुलुपः [1.1.61]

¹⁵ अदर्शनं लोपः [1.1.60]

¹⁶ उच्चैरुदात्तः [1.2.29]

¹⁷ नीचैरनुदात्तः [1.2.30]

¹⁸ समाहारः स्वरितः [1.2.31]

¹⁹ ऊकालोऽञ्जस्वदीर्घप्लुतः [1.2.27]

²⁰ ऊकालोऽञ्जस्वदीर्घप्लुतः [1.2.27]

compounding (Stall, 1965). Generally, a derivational process in Sanskrit entails with various operations. It includes placements (*pratyaya*) like *pratyayah* [3.1.1], *paraśca* [3.1.2], *dhātoḥ* [3.1.91] etc., addition (*āgama*) like *hrasvanadyāpo nuṭ* [7.1.54], *āmi sarvanāmnah suṭ* [7.1.52] etc., replacement (*ādeśa*) like *akah savarṇe dīrghah* [6.1.101] etc., modification (*vikaraṇa*) like *kartari śap* [3.1.68] etc. and deletion (lop) like *halantyaṃ* [1.3.3], *laśakvataddhite* [1.3.8], *upadeśe'ajanunāsika it* [1.3.2] etc.

1.2.2.4. *Niyama* (Restriction):

Niyama rules restrict the scope of a given rule. It denotes regulation or binding. Restrictive rule decides to discard the superfluous elements that comes in the way of grammatical operation. It is to be noted here that a *niyama sūtra*, in any case, limits the scope of a particular rule. A *niyama sūtra* can again direct the proper distribution of grammatical elements. In the process of grammatical operation, the major task of a *niyama sūtra* is to eliminate random and surplus component related to the derivational analysis with the way of restriction of the unwanted elements (Bhattacharya, 2006 and Sudha, 2005). For examples: the *sūtra - patiḥ samāsa eva* [1.4.8] restricts the area of the *sūtra - śeṣo ghyasakhi* [1.4.7].

1.2.2.5. *Atideśa* (Extensions):

To extend the application and implementation, Pāṇini has used the *atideśa* rules. This type of rule transmits or spreads the operation or qualities of one grammatical element to another. The function of an extension rule is to widen the scope of application of a technical or operation rule. The rule of extension is generally denoted by the term *vat* meaning 'like that' in the AD (Bhattacharya, 2006 and Sudha, 2005). For example, *sūtra - sthānivadādeśo'nalvidhau* [1.1.56]. The four types of *atideśa* are seen in Pāṇinian AD. It includes *kāryātideśa*, *nimittātideśa*, *sañjñātideśa* and *rūpātideśa*.

1.2.2.6. *Adhikāra* (Heading):

The *adhikāra* (Heading) *sūtras* are generally the governing rules. Heading rule and it signifies a domain of rules related to a common matter of discussion is called an *adhikāra sūtra*. Cardona (1997) has stated and suggested the term headings to explain

the *adhikāra* rule. It magically divides the AD into sections. For example, *pratyayah* [3.1.1], *paraśca* [3.1.2], *taddhitāh* [4.1.76], *dhātoh* [3.1.91], *sahasupā* [2.1.4] etc.

1.2.3 Dhātupātha (DP):

The *dhātupātha* is a database of Sanskrit verb roots. There are 1967 verb roots, 2014 including *kandvādi* roots in Pāṇinian DP (Palasule, 1961 & Pandit, 1966). These are classified into ten classes. The detailed distribution of the DP is shown table 1.2.

Gaṇa	Vika raṇa	Parasmai padī	Ātmane padī	Ubhaya padī	Total	Seṭ	Anieṭ
<i>Bhvādi</i>	<i>śap</i>	677	310	60	1107	1006	101
<i>Adādi</i>	<i>śabluk</i>	41	25	5	71	38	33
<i>Juhotyādi</i>	<i>ślu</i>	16	2	6	24	5	19
<i>Divādi</i>	<i>śyan</i>	96	39	5	140	106	34
<i>Svādi</i>	<i>śnu</i>	24	2	9	35	18	17
<i>Tudādi</i>	<i>śa</i>	134	10	12	156	122	34
<i>Rudhādi</i>	<i>śnam</i>	13	3	9	25	12	13
<i>Tanādi</i>	<i>u</i>	0	2	8	10	9	1
<i>Kryādi</i>	<i>śnā</i>	45	0	16	61	48	13
<i>Curādi</i>	<i>śap</i>	361	0	50	411	409	2
<i>Kaṇḍvādi</i>	<i>yak</i>	40	0	5	45	45	0
	Total	1447	393	185	2085	1818	267

Table 2: Distribution of the DP

1.2.4 Gaṇapātha (GP):

The GP is a database for various lexical items which are generally derived and follows same pattern. The primitive nominal bases are mentioned in the GP (Ayachit, 1958; Pandit, 1971). The various classes like *kṛt*, *taddhita*, *strī*, *sup*, *tin* and the 18 *upasargas* work on these bases (including 23 pronouns). The GP is a list of groups of words used by Pāṇini's *Aṣṭādhyāyī*. In AD there are around 261 *gaṇas* are used by Pāṇini (Karte, 1971; Petersen et al, 2014 and Shastri, 1967).

1.3. Brief Summary of AD

As stated above the AD contains eight chapters and each chapter contain 4 subchapters. The following summary of topics and concepts discussed in AD (Sharma, 2003; Chandra, 2007 and Chandra, 2011) is given below:

AD Chapter I

- Major definitional and the interpretational rules
- *Sūtras* dealing with the extension (*atideśa*)
- *Sūtras* dealing with the *ātmanepada-parasmaipada*
- *Sūtras* dealing with the *kāraka*

AD Chapter II

- *Sūtras* dealing with compounds (*samāsa*)
- *Sūtras* dealing with the nominal inflection
- *Sūtras* dealing with number and gender of compounds
- *Sūtras* dealing with replacements related to roots
- *Sūtras* dealing with deletion by *luk*

AD Chapter III

- *Sūtras* dealing with derivational of roots ending in affixes *san* etc.
- *Sūtras* dealing with the derivational of ending in a *kṛta*
- *Sūtras* dealing with the derivational of ending in a *tiñ*

AD Chapter IV

- *Sūtras* dealing with derivation of a *pada* ending in a *sup*
- *Sūtras* dealing with feminine affixes
- *Sūtras* dealing with the derivational of nominal stems ending in an affix termed *taddhita*.

AD Chapter V, VI & VII

- *Sūtras* dealing with doubling
- *Sūtras* dealing with the *samprasāraṇa*
- *Sūtras* dealing with the *samhitā*
- *Sūtras* dealing with the augment (*āgama*) eg. *suṭ*
- *Sūtras* dealing with the accents
- *Sūtras* dealing with phonological operations relatives to a pre-suffix base (*aṅga*)
- *Sūtras* dealing with operations relative to affixes augment etc.

AD Chapter VIII

- *Sūtras* dealing with doubling (*dvitva*) relative to a *pada*
- *Sūtras* dealing with accent relative to a *pada*

- *Sūtras* dealing with other phonological relatives to a *pada*
- *Sūtras* dealing with miscellaneous operations relative to a non-*pada*

2. Brief Introduction of Sanskrit Words Ending with Feminine Suffixes

The identification of gender in many languages is very challenging task. It is a difficult task in Sanskrit too. Sanskrit is one of the languages considering three genders viz. Masculine, Feminine and Neuter. Pāṇini has divided feminine words in 5 major categories.

2.1 Basic Concept of Gender in Sanskrit

There are three genders in Sanskrit viz. masculine, feminine and neuter. Gender identification in Sanskrit language is a highly challenging task. The differentiation of masculine, feminine and neuter is not done similarly in Sanskrit as in other languages. This is because by nature the feminine words can also be used as masculine words and any masculine word can be used as a feminine word. Similarly, any word holding the meaning of neuter can also be used as masculine or feminine. For example, the Sanskrit word ‘*dāra*’ contains the meaning of feminine but it is derived as masculine while other synonyms word e.g. *vanitā*, *yośita*, etc. are feminine. The word ‘*ap*’ contains the meaning of water is feminine while ‘*vāri*’, ‘*toya*’ etc. are neuter. The Sanskrit word ‘*kāya*’ holds the meaning of the body is masculine while the word ‘*tanuś*’ is feminine and the word ‘*śarīra*’ is neuter. Likewise, the words ‘*amara*’, ‘*nirjara*’ containing the meaning of god are neuter while the word ‘*devatā*’ is feminine. Containing the meaning of a friend, word ‘*suhṛd*’ is masculine but ‘*mitra*’ is neuter. Containing the meaning of eye, word ‘*locana*’, ‘*akṣi*’ are neuter but ‘*drśa*’ is feminine.

On the basis of above examples, we can say that the identification of gender in Sanskrit is a challenging task. It can only be determined by textual knowledge and uses by the people. Pāṇini has given few *sūtras* to generate the feminine words in AD. The text by Pāṇini called *Liṅgānuśāsana* (Durgasiṃha, 1952 and Harṣavardhana, 1931) has discussion about the gender and the various ambiguous word were written in the book in the form of *sūtra* to indicate proper gender. In the Pāṇinian system, no suffix is

discussed to generate the words to represent the masculine and neuter genders. Only feminine suffixes are found which formed new feminine words.

In Sanskrit there are eight feminine suffixes *tāp*, *cāp*, *ḍāp*, *ñīp*, *ñīṣ*, *ñīn*, *uñ* and *ti*, etc. described by the Pāṇini are found. With the help of these suffixes the feminine words may generated from the various types words. The words ending with these suffixes are called *striḥpratyayānta* words. For example, *ajā*, *gaurī*, *kumārī*, *varuṇānī*, *bhavānī*, *gopālikā* and *aśvapālikā*, etc.

The main *sūtras* of these eight suffixes are:

- *tāp* - *ajādyataṣṭāp*
- *cāp* - *yañāścāp*, *āvaṭyācca*
- *ḍāp* - *ḍābubhābhyāmanyatarasyām*
- *ñīp* - *ugitāśca*
- *ñīṣ* - *anyato ñīṣ*, *ṣidgaurādibhyaśca*
- *ñīn* - *śārṅgaravādyañō ñīn*
- *uñ* - *ūñutaḥ*
- *ti* - *yūnastiḥ*

All these eight suffixes are added with specific nominal bases (*prātipadikās*) to indicate femininity. The text *Siddhāntkaumudī* (SK) by *Bhaṭṭojī Dīkṣita* (Govindacharya, 2010) and *Laghusiddhāntakaumudī* (LSK) by *Varadarāja* (Shastri, 2005) has separately describe the feminine part.

Pt. Bhimsen Shastri (2005) a great grammarian has written the ultimate commentary on LSK in six different parts. He has categorized the feminine words divided into five major categories (Upreti & Chandra, 2019) viz. *Jātilakṣaṇa* feminine, *Puṃyogalakṣaṇa* feminine, *Swāṅgalakṣaṇa* feminine, general words ending with feminine affix, Feminine affixes to denote diverse of meanings etc.

2.1.1. Jātilakṣaṇa words ending with feminine affixes:

Generally, *jātilakṣaṇa* feminine words are used for particular female from a particular group or category. Mostly feminine suffix *ñīṣ* is used to generate *jātilakṣaṇa* feminine words. But in few cases as an exception *ñīn* feminine suffix may also be used to generate *jātilakṣaṇa* feminine words. *Jāti* includes defined *jāti* only. *Jāti* is defined by Sanskrit grammarian as:

ākṛtigaṇā jāti, liṅgānām ca na sarvabhāk .
qsakṛdākhyātanigrāhyā, gotrañca caraṇaiḥ saha ..

Based on above mentioned reference of *jāti*. The *jāti* is classified into four categories which are defined as *jāti* according to the above definition.

2.1.1.1. Ākṛtigaṇajāti:

The term *jāti* denotes that entity which is known by the shape, pattern, features or form is (*ākṛtigaṇajāti*) called *ākṛtigaṇajāti*. The universal *gotva* (cowness) is known by various features of a cow such as horns, tail, dewlap, shape etc. These features existing in another animal will make us know the universal *gotva* (cowness). In simple words, we can say a person recognized by the same shape, figure, look, pattern and face called *jāti*. To see the shape, figure, look, pattern and face of few person we can acquire the knowledge of whole human being. These are called *jāti* words. For example *kukkuṭī*, *sūkarī*, *taṭī* etc. In these examples to see the shape, figure, look, pattern and face of any *kukkuṭa* (hen) or *sūkar* (pig) we acquire the knowledge of whole *kukkuṭa* (hen) or *sūkar* (pig). Other examples viz. *hayī*, *gavayī*, *mukayī*, *manuṣī*, *mānuṣī*, *kaṭhī*, *taṭī*, *nārī*, *brāhmaṇī*, *matsī*, *śāraṅgaravī* etc. maybe also seen here.

2.1.1.2. Denotes a class (*jāti*)

When we acquire the knowledge of whole of that particular class by a single entity but the word used to denote the single entity cannot be used in three genders. For example the word *vṛṣala* denotes *jāti* in two conditions, first if once told that a particular person is *vṛṣala* then we come to know the state of being *vṛṣala* in his father, mother, sister, brother, son, daughter etc. second the word *vṛṣala* can be used only in masculine and feminine and not in neuter. It doesn't participate of all genders. Consequently, the suffix *ṇīṣ* is added to denote this type of *jāti*. The word *vṛṣalī* can be generated using the suffix *ṇīṣ* from the word *vṛṣala*.

2.1.1.3. Descendant or offspring (*gotra*) *jāti*:

The word denoting a descendant or offspring (*gotra*) in general is called *jāti*. The word *aupagava* derived from *upagu+añ* by the Pāṇini rules *tasyāpatyam* [4.1.92] in

constructed as a word denoting *jāti*. The suffix *ṅīṣ* added to generate feminine words. For example, *aupagavī* (the daughter of *upagu*).

2.1.1.4. *caraṇavācaka* (*vedaśākhādhyeṭṛvācaka*) *jāti*:

Denoting a student of any branch of veda called *jāti*. The nominal stem *kaṭha* denoting a student of the *kaṭha* branch of the veda is also constructed as denoting *jāti* according to the definition. The affix *ṅīṣ* added to denote the femininity. For example, *kaṭhī* (female student of the *kaṭha* branch of Veda).

2.1.2. *Puṃyogalakṣaṇa* words ending with feminine affixes:

Puṃyogalakṣaṇa feminine words derived to denote a female by the virtue of her relationship with the male and represented by that masculine name. Mostly feminine suffix *ṅīṣ* is used to generate *puṃyogalakṣaṇa* feminine words. But sometime as an exception *cāp* feminine suffix may also be used to generate *puṃyogalakṣaṇa* feminine words (Shastri, 2005). The illustration *gopasya strī gopī* makes the meaning of the *puṃyogalakṣaṇa* clear. The nominal stem *gopa* (cowherd) is a masculine word which denotes a person who takes care of cows. Now to have feminine derivate which denotes cowherd's wife in this instance. The feminine affix *ṅīṣ* is added by the *Pāṇinian* rules and generate the feminine word *gopī*. However, it is not limited to the relationship of husband and wife only but also covers the relationship of progenitor and progeny. For example, *kaikeyī* (daughter of *kaikeya*), *jānakī* (daughter of *janaka*) and *yamī* (sister of *yama*). Other example of words ends with feminine suffix *ṅīṣ* are *varuṇānī* and *bhavānī*. As exception sometime the feminine suffix *cāp* can also be added to denote the meaning of *puṃyogalakṣaṇa*. *Gopalaksya strī gopālikā* makes the meaning of the *puṃyogalakṣaṇa* and *aśvapālikā* etc. are the examples of feminine suffix *cāp* to denote the meaning of *puṃyogalakṣaṇa* feminine words.

2.1.3. *swāṅgalakṣaṇa* words ending with feminine affixes:

swāṅgalakṣaṇa feminine words used when a compound word ends with word denoting the meaning of *swāṅga*. Mostly feminine suffix *tāp*, *ṅīṣ*, *ti*, *ṅīp* etc. The

swāṅga word is technical term in Sanskrit grammar (Shastri, 2005). The word is defined by the grammarian as:

adravaṃ mūrtimat svāṅgaṃ prāṅisthamavikārajam .

atatsthaṃ tatra dr̥ṣṭaṃ ca tena cettattathāyutam ..

Denoting a limb of one's body, serving as subordinate members occurring at the end of a compound and not containing a penultimate conjunct consonants called *swāṅga* (Shastri, 2005). The word *atikeśa* is compound word which contains two words *ati* and *keśa*. It denotes the part of one's body and it also ends with the word *keśa*. So, to denote the meaning of feminine affix *ñīṣ* is added and generates feminine word *atikeśī*. Some other examples are *candramukhī* and *candramukhā* etc. But the word denoting the meaning of limb of one's body that word cannot be the form of liquid (*drava*), that must be personified in human being. For example, the sweat and cough are also considering the body parts but it is present in the form of liquid so the feminine affix *ñīṣ* cannot be added here. For example, *susvedā*, *sukaphā* and *sumukhāśālā*, etc.

2.1.4. General words ending with feminine affixes:

The words that are not qualified in above mentioned three categories are called general words ending with feminine affix (Shastri, 2005). The feminine words to be generated from the word's proper nouns, adjectives, pronouns, word denoting the meaning of age and qualitative etc. fall under this category. The feminine affixes *ṭāp* and *ñīṣ* generally added to generate feminine words. For example, *nadī*, *khaṭvā*, *gaurī*, *kumārī*, *taruṇī*, *gaṅgā*, *dhanakrītā* etc.

2.1.5. Feminine affixes to denote diverse of meanings:

Apart from above, the feminine words are also derived to denote the various meaning of a particular word (Shastri, 2005). For example, *yavānī*, *himānī*, *aranyānī* and *yavanānī* etc.

The table 1.3 shows the distribution of *sūtras* and generated the various types of feminine words.

SR.	Feminine Suffix	No of AD sūtras	No of vārtika
1.	<i>tāp</i>	2	4
2.	<i>cāp</i>	2	1
3.	<i>ḍāp</i>	1	-
4.	<i>ñīp</i>	18	6
5.	<i>ñīṣ</i>	19	15
6.	<i>ñīn</i>	1	-
7.	<i>uñ</i>	6	1
8.	<i>Ti</i>	1	-

Table 1.3 Distribution of AD sūtras for feminine suffixes

Chapter Two

Introduction of Sanskrit Words Ending with Feminine Suffixes and Research Survey

1. Introduction of Sanskrit Words Ending with Feminine Suffixes

In Sanskrit, the word *liṅga* is used for gender, which signifies identity. *Liṅga* word is derived from root ‘*ligi citrīkaraṇe*’¹. As we know, in Sanskrit Grammar, gender determination is very difficult task. In Sanskrit, gender is determined by public behaviour² (Shastri, 2017). For the determination of gender in Sanskrit, this Statement is famous in public behaviour- “*stana keśavatī strīsyāllomaśaḥ puruṣaḥ smṛtaḥ*” In Sanskrit Grammar, Pāṇini has formed suffixes to create only feminine words but there are no suffixes for the formation of masculine words. In Sanskrit grammar suffixes are only indicator not producer of words³. Feminine bases are derived from the masculine by the addition of the suffixes *ā* (*ṭāp*, *cāp*, and *dāp*) *ī* (*nīp*, *nīṣ*, and *nīn*), *ū* (*ūn*) and *ti* (Kale, 1972).

1.1 Feminine Suffixes Ending with ‘ā’

Pāṇini used three major suffixes in his grammar to denote *ā* and the generated forms by these suffixes are called ‘*ābanta*’. These are ‘*ṭāp*’, ‘*cāp*’ and ‘*dāp*’. After deletion of *anubandhas* they from the feminine suffixes ‘*ṭāp*’, ‘*cāp*’ and ‘*dāp*’ only *ā*. Therefore, these types of words called *ābanta*. The *p* of the *ṭāp*, *cāp* and *dāp* is contained as an ‘*it*’ for the general low pitch (*anudātta*) accent⁴ (Sharma, 2008 & Kanshiram, 2012). Due to remaining of the character ‘*ā*’. So, the generated from feminine suffixes looks like similar only the difference arises in various accent. The detailed description of the each suffixes is as follows:

¹ लीनमर्थं गमयतीति लिङ्गम्/ लिङ्गयत्यसौ तत् लिङ्गम् ।

² लिङ्गमशिष्यं लोकाश्रयत्वाल्लिङ्गस्य - महाभाष्य

³ लिङ्गमपि नामार्थः। प्रत्ययानां द्योतकत्वात्। अन्यथा वागुपानहादि शब्देभ्यः इयं तव वागिति स्त्रीत्वबोधानापत्तेः इत्यादि- परमलघुमञ्जूषा (नागेश)

⁴ अनुदात्तौ सुप्पितौ (अष्टाध्यायी- 3.1.4)

1.1.1 The Feminine Suffix ‘*tāp*’

There are only two *sūtras* and four *vārtikas* mentioned in LSK of Bhattoji Dikshit for feminine suffix *tāp*. The first *sūtra* is "*ajādyataṣṭāp*"⁵. To indicate the meaning of a feminine the suffix *tāp* is to be added with a nominal base. this nominal base either ends with character ‘*a*’ or words listed in the *ajādigāṇa*. For example- *ajā* ‘a she goat’, *aśvā* ‘a female horse’. Another *sūtra* of the feminine suffix *tāp* is ‘*tābr̥ci*’⁶. The feminine suffix *tāp* is added with nominal bases to denote the meaning of feminine, after a nominal stem ending with the word ‘*pād*’ when the word signifies a verse (*ṛcā*) of Rigveda. For example- *dvipadā ṛk-* ‘a verse with two parts’, *tripadā ṛk-* ‘a verse with three parts’, *catuspadā ṛk-* ‘a verse with four parts’ etc. (Sharma, 2008; Shastri, 2009 & Kanshiram, 2012).

To denote the feminine, suffix *tāp* is added with nominal bases when nominal base *sam*, *bhastra*, *ajina*, *śaṇa* or *piṇḍ* end with word *phala* by the *vārtika* ‘*sambhastrājinaśaṇapiṇḍebhyaḥ phalāt*’. For example, *samphalā*, *bhastraphalā* etc. When the word *sat*, *ac*, *kāṇḍa*, *prānta* or *śata* followed by the word *puṣpa* then to denote the meaning feminine, the suffix *tāp* to be added. For example- *satpuṣpā* and *prākpuṣpā* etc. When the word *śūdra* is not headed by *mahat* and it signifies a caste (*jāti*), then suffix *tāp* is applied to denote the meaning of feminine. For example, *śūdrā*. When the word *mūla* come first by the negation particle *na*, then the suffix *tāp* is applied to denote the meaning of feminine. For example- *amūlā* ‘a creeper without root’ (Shastri, 2009 & Vasu, 2017).

1.1.2 The Feminine Suffix ‘*cāp*’

There are two *sūtras* given by Pāṇini and described in SK to denote the meaning of feminine by the suffix *cāp*. The feminine suffix *cāp* is added to denote the meaning of feminine with a nominal base which ends with *taddhita* suffix ‘*ñyañ*’ and ‘*ṣyañ*’ by the Pāṇinian rule “*yaṇaścāp*”⁷. For example- *āmbaṣṭhyā*, *kārīṣagandhyā* etc. Here the *yañ* element is common in both suffixes.

⁵ अष्टाध्यायी - 4.1.4

⁶ अष्टाध्यायी - 4.1.9

⁷ अष्टाध्यायी 4.1.74

Suffix *cāp* occurs with the nominal base *āvaṭya* to denote the meaning of feminine by the rule ‘*āvaṭyāśca*’⁸. For example *āvaṭyā*. The *āvaṭya* is listed in the *gargādigāṇa*. So, to denote the meaning of feminine the suffix would be added *nīp*. To avoid the wrong formation Pāṇini has introduced the new *sūtra āvaṭyāśca*. This *sūtra* is exception of suffix *nīp*.

The affix *cāp* to be added with a nominal base to denote the meaning of feminine by the *vārtika* when the letter *ṣ* immediately headed by *taddita* suffix *yañ*. For example- *śārkarākṣyā*, *pautimāṣyā* (Shastri, 2009; Vasu, 2017).

1.1.3 The Feminine Suffix ‘*ḍāp*’

There is only one *sūtra* described by Pāṇini for the feminine suffix *ḍāp*. The feminine suffix *ḍāp* optionally added with both types of *prātipadikās* that ends with word *man* and a *bahuvrīhi* compound which ends with *an*. For example, *pāmā*, *bahurājā* etc.

1.2 Feminine Suffixes Ending with ‘*ī*’

Pāṇini used three major suffixes in his grammar to which remain the *ī* after the deletion of *anubandhas*. These are- *nīp*, *nīṣ* and *nīn*. The term *nī* is common in all three suffixes. Therefore the words derived from these suffixes called “*nyanta*”. As the only character ‘*ī*’ remains for final derivational process and generates the same type of words by each suffix. The only difference arises in various accent. The detailed description of each suffix is following.

1.2.1 The Feminine Suffix ‘*nīp*’

To the formation of feminine words ending with the suffix *nīp*, Pāṇini has given 18 *sūtras* and in his AD. Affix *nīp* added with nominal bases to denote feminine in various conditions by the various rules. If a nominal stem which ends in an ‘*it*’ denoted by the abbreviatory (*anubandha*) term *uk*, suffix *nīp* is employed.⁹ In the formation of

⁸ अष्टाध्यायी 4.1.75

⁹ उगितश्च (अष्टाध्यायी 4.1.6)

feminine if a nominal stem ends in ‘van’ suffix *ñīp* is employed¹⁰. Apart from this if a nominal stem ends with ‘a’ (*adanta*) and have, as their last alphabet (*antya*). A non-secondary (*anupasarjana*) form either marked with the suffix ‘t’, ‘dh’, ‘aṅ’, ‘añ’, ‘dvayasac’, ‘daghnac’, ‘mātrac’, ‘tayap’, ‘thak’, ‘thañ’, ‘kañ’, ‘kvarap’. The feminine suffix ‘ñīp’ is applied¹¹. For example- *kurucarī*, *sauparṇeyī* etc. suffix *ñīp* is also applied to denote feminine, after a nominal-stem which ends in *yañ*.¹² For example- *gārgī* (a female offspring of Garga). A nominal stem denotes the early stage of life and ends in ‘a’, suffix ‘ñīp’ is applied¹³. A compound stem (*bahuvrīhi*) which terminates in ‘an’ and anticipates the removal of its penultimate sound (*upadhā*). Suffix *ñīp* is employed¹⁴. E.g. *bahurājñī*. Suffix *ñīp* is applied to denote a feminine, when the nominal stem terminates in *at* (*a*) in *dvigu* compound¹⁵. These are some of the main *sūtras* to the formation process of feminine words ending with suffix *ñīp*, except these rules, suffix *ñīp* is also used in many other places. Other than these AD *sūtras* *Vārtikakāra kātyāyana* has given some more rules to derive feminine words ending with *ñīp*.

1.2.2 The Feminine Suffix ‘ñīṣ’

Pāṇini has given 19 *sūtras* in his AD for the formation of feminine words ending with the suffix *ñīṣ*. Affix *ñīṣ* arises to denote feminine in various conditions. Some of these are described here. Suffix *ñīṣ* is applied to the formation of feminine after non-*upasarjana* nominal stems marked with *ṣit* (*ṣ* as an *it*) or numbered in the list of *gaurādigāṇa*¹⁶. The word list of the *gaurādigāṇa* is shown appendix II. For example- *gaurī* (a female with fair skin or goddess *pārvatī*) *nartakī* (a female dancer). *ñīṣ* arises to denote feminine subsequently a nominal term, which terminates with eleven words *jānapada* etc¹⁷. e.g. *jānapadī*, *kuṇḍī*, *goṇī* etc. In the opinion of eastern grammarians,

¹⁰ वनो र च (अष्टाध्यायी 4.1.7)

¹¹ टिट्टाणञ्द्वयसज्दघ्नञ्मात्रत्तयपठकठञ्कञ्करपः (अष्टाध्यायी 4.1.15)

¹² यञश्च (अष्टाध्यायी 4.1.16)

¹³ वयसि प्रथमे (अष्टाध्यायी 4.1.20)

¹⁴ अन उपधालोपिनोऽन्यतरस्याम् (अष्टाध्यायी 4.1.28)

¹⁵ द्विगोः (अष्टाध्यायी 4.1.21)

¹⁶ षिडूरादिभ्यश्च (अष्टाध्यायी 4.1. 41)

¹⁷ जानपदकुण्डगोणस्थलभाजनागकालनीलकुशकामुककबराद्वृत्यमत्रावपनाकृत्रिमाश्राणास्थौल्य-

Suffix *nīṣ* is applied when a nominal stem is constituted by word *śoṇa*¹⁸. When a nominal stem denotes a relation of a female with a male, suffix *nīṣ* is applied¹⁹. For example- *kaikeyī* (daughter of *kaikeya*), *jānakī* (daughter of *janaka*) and *yamī* (sister of *yama*). To denote feminine *Indra*, *varuṇa*, *bhava*, *śarva* etc. words are also suffixed with *nīṣ* and the augment *ānuk* is also applied²⁰. e.g. *indrāṇī* (wife of *indra*) *varuṇānī* (wife of *varuṇa*) *bhavānī* (wife of *bhava*) etc. suffix *nīṣ* occurs to signify femininity after a nominal stem terminates with *krīta* (bought) and is used in combination subsequently and initial compound constituent with the significance of *karaṇa*²¹. These are the some of the major *sūtras* for the formation process of feminine words ending with suffix the *nīṣ*, except these rules, suffix *nīṣ* is also used in many other places. Other than these AD *sūtras*, *Vārtikakāra kātyāyana* has given more than ten rules to derivates feminine words ending with *nīṣ*.

1.2.3 The Feminine Suffix ‘*nīn*’

"*śārṅgaravādyaṅo nīn*²²" is the only *sūtra* for the suffix *nīn* in AD. Affix *nīn* occurs to represent feminine, When a nominal stem which signifies *jāti* and is either related to *śārṅgaravādigaṇa*, or ends with character ‘*a*’ of suffix *añ*. The word list of the *śārṅgaravādigaṇa* is shown Appendix V. For example- *śārṅgaravī* (a daughter of *śarṅgara*), *baidī* (a female gotra-descendent of Bida). *Kāśikākāra* says that *jāteḥ*²³ is to be applied here so that *nīṣ* of that rule can be blocked in favor of *nīn* of this rule.

1.3 Feminine Suffixes ending with ‘*ūn*’

There are only six rules and a *vārtika* are given by the Pāṇini for feminine suffix *ūn* to denote the meaning of feminine. Suffix *ūn* happens to signify feminine after a nominal term which ends in *u*, not having *y* in its penultimate position and indicates a

वर्णानाच्छादनायोविकारमैथुनेच्छाकेशवेशेषु (अष्टाध्यायी 4.1.42)

¹⁸ शोणात्प्राचाम् (अष्टाध्यायी 4.1.43)

¹⁹ पुंयोगादाख्यायाम् (अष्टाध्यायी 4.1.48)

²⁰ इन्द्रवरुणभवशर्वरुद्रमृडहिमारण्ययवयवनमातुलाचार्याणामानुक् (अष्टाध्यायी 4.1.49)

²¹ क्रीतात्करणपूर्वात् (अष्टाध्यायी 4.1.50)

²² शाङ्गरिवाद्यजो डीन् (अष्टाध्यायी 4.1.73)

²³ जातेरस्त्रीविषयादयोपधात् (अष्टाध्यायी 4.1.63)

class of humans²⁴. For example, *kurūḥ*. The feminine suffix *ūñ* also comes to signifying a term after a nominal stem ending with the word *bāhu* ‘arm’²⁵. For example- *bhadrabāhūḥ* (a feminine of *bhadrabāhū*). Suffix *ūñ* comes after the term *paṅgu* (a male lame) to indicate feminine entity²⁶. For example, *paṅgūḥ* (a female lame). When *ūru* is the final constituent of a nominal stem, provides the derivative that shows comparison (*aupamya*), feminine suffix *ūñ* is applied²⁷. For example, *karabhoruḥ*. When *ūru* is the final constituent of a nominal stem, preceded by words *saṃhita* (joined) *śapha* (a hoof) *lakṣaṇa* (a mark) *vāma* (good-looking), the feminine suffix *ūñ* is applied²⁸. Apart from the above rules suffix *ūñ* is also signified after the word *kadru* and *kamaṇḍalu*.²⁹

1.4 Feminine Suffixes ending with ‘ti’

The Pāṇinian rule “*yūnastiḥ*” is the only *sūtra* for the feminine suffix ‘*ti*’ to denote the meaning of feminine from a nominal base. The only single feminine word *yuvatīḥ* generate with the nominal base *yuvan* (a young male) to denote the meaning of feminine.

2. Survey of Researches Done

Sanskrit Computational Linguistics is an interdisciplinary area of study and research where the computational techniques and principles are applied on the linguistic analysis of Sanskrit languages to develop the various tools and extracting information from the grammatical and literary tradition of Sanskrit to enhance the linguistic and computational studies in general (Gokhale). As stated in the chapter one briefly, the research on Sanskrit grammatical tradition has started in ancient period. After the period of Pāṇini lot of researches were done on Sanskrit grammar to explore the various new theories.

²⁴ ऊङुतः (अष्टाध्यायी 4.1.66)

²⁵ बाह्वन्तात्संज्ञायाम् (अष्टाध्यायी 4.1.67)

²⁶ पङ्गोश्च (अष्टाध्यायी 4.1.68)

²⁷ उरूत्तरपदादौपम्ये (अष्टाध्यायी 4.1.69)

²⁸ संहितशफलक्षणवामादेश्च (अष्टाध्यायी 4.1.70)

²⁹ संज्ञायाम् (अष्टाध्यायी 4.1.72)

The survey can be divided two major categories. It includes a survey on the Related Research in Sanskrit feminine suffixes and a survey on the ongoing research in Sanskrit Computational Linguistics (SCL).

2.1 A Survey on the Related Research in Sanskrit Grammar and Feminine Suffixes

Traditional research works include primary texts, commentaries, edited texts, research theses, dissertations, research papers etc. There ample number of texts are available in the field of Sanskrit grammar. Historical description and development of Sanskrit grammar are broadly available in the various work (Upadhyaya, 2010; Upadhyaya and Pandey, 1997 & Mimansaka, 2014). Further the work is more elaborated with general introduction of Sanskrit grammatology by Rishi (2016). Dr. Kapildev Dwivedi (2010 & 2017) has written the history of Sanskrit literature. The work by Yudhishtir Mimansaka (2014) is excellent contribution for the history of Sanskrit grammar. In the field of Sanskrit grammar, it is widely accepted and authentic book. The book is divided into three major sections. It starts with the origin of grammatical scripture, a detailed description of grammatical development has been presented as well as evidence on the chronology of grammars.

A survey on Pāṇini is done by Cardona (1998) is essential work to study the Pāṇinian tradition of related work done on Pāṇini. The present work is projected as a critical survey of research carried out in the area of Pāṇinian grammar including works by Pāṇinian on semantics and philosophy of grammar. It is illustrative of the research done in India as well elsewhere on the topics of Pāṇini.

There is great contribution by the various scholars from the University of Poona, Poona, India. Researches done on Pāṇini grammar are of great use. (Joshi, 1996; Pandit, 1966, Bhate, 1968; Palsule, 1968) by this institute e.g. Two methods of interpreting Pāṇini (Joshi, 1966), Mathematical Representation of some Pāṇinian *sūtras* (Pandit, 1966), Some primary and secondary suffixes known to Yāska (Bhate, 1968), Some primary nominal formations missing in Pāṇini, The Role of *k-ṛ* in the Sanskrit grammatical terms, Some Views of Pāṇini and His Followers on Object Language and Meta-language (Palsule, 1968, 1969, 1970), Anubandhās of Pāṇini, (Devasthali, 1967),

The Role of the Particle *Ca* in the Interpretation of the Aṣṭādhyāyī. (Joshi & Bhate, 1983), the fundamentals of anuvṛtti (Joshi, 1984), Zero and Pāṇini (Allen, 1955), Two methods of interpreting Pāṇini (Joshi, 1966) etc. are key works.

Department of Sanskrit, University of Delhi has very rich research tradition since 1921 and considered largest Department of Sanskrit. The research work covers almost every branch of Sanskrit studies. The remarkable works in this area is done by Kuntal (2017). The dissertation is divided into 3 chapters. A comparative study of *Pāṇiniya linganushansam* and *Vamaniya linganushansam* is done in this research. The research work "*prakriyāsaṃgraha tathā laghusiddhāntakaumudī ke strīpratyaya prakaraṇa kā tulanātmaka adhyayana*" (Rani, 2013) is also very important contribution in the field of Sanskrit gender. This study focuses on the comparative study of the feminine suffixes of *prakriyāsaṃgraha* and *laghusiddhāntakaumudī*. The dissertation is divided into 4 chapters. The first chapter focuses on the general introduction of Sanskrit grammar. Second chapter deals with non- Pāṇinian grammatical traditions. Final chapter covers the comparative study of the feminine suffixes mentioned in both texts (Rani, 2013). In this series research work done by Bhatt (2017) is also important in the field. The work focuses on comparative study of the feminine suffixes in *siddhahaimaśabdānuśāsana* and Pāṇinian grammar. Further, an admirable work on comparative study of the feminine suffixes in *cāndra* and Pāṇinian grammar (Bala, 2003).

Rastriya Sanskrit Sansthan has huge contribution in the field of Sanskrit grammar. Many works related to feminine suffix have been accomplished. The most important work in the field of feminine suffix is "*Pāṇiniśākaṭāyanasārasvatavyākaraṇeṣu strīpratyayavidhāyakāṇāṃ sūtrāṇāṃ tulanātmakamadhyayanam*" by Pandey (1992). The research is focused on comparative analysis of the feminine suffixes used in Pāṇini, *śākaṭāyana* and *sārasvata* grammar. Other research works on "*prakriyākaumudīsiddhāntakaumudyoh strīpratyayāntabhāgasya tulanātmakamadhyayanam*" by Dwivedi (1992) is worthy to mentioned here. The comparative study of feminine suffixes mentioned in *prakriyākaumudī* and *siddhāntakaumudī* is done in this research. One more work is very important on feminine suffixes by Kavita (1999) is cited here. The linguistics analysis has been done in this research.

Shri Lal Bahadur Shastri Rashtriya Sanskrit Vidyapeetha is engaged in the work related to Sanskrit grammar since last many years. The department of Sanskrit, Banaras Hindu University, Varanasi is also working on the Sanskrit Grammar. In this direction, Gurukul Kangri Vishwavidyalaya, Haridwar, Uttarakhand is also working in Sanskrit grammar. There are various researches have also been conducted.

2.2 A Survey on the ongoing research in Sanskrit Computational Linguistics (SCL)

Computational linguistics is the technical, scientific and engineering discipline concerned with understanding written and vocal language from a computational outlook, and constructing artifacts that helpfully develop and generate language, either in bulk or in a dialogue setting. (Schubert, 2019). Sanskrit Computational Linguistics is an interdisciplinary emerging area of study where the computational model, logic, techniques and principles are applied on Sanskrit language for the linguistic analysis. The works on Machine Translation (MT) started in 1950's and 60's. It brought into picture a more complete term which could include the fundamental research in languages as well along with mechanistic processes (Ruslan, 2005). Specially, the work on MT gave birth to Computational Linguistics in 1960s. The field grew day by day with increasing automation capacity and started focusing on practical applications in the field of Cognitive Science and Artificial Intelligence (Gokhale).

Sanskrit has a very rich knowledge system and linguistic tradition. The AD is the key text of Sanskrit grammar and linguistics and written in such a fashion like any high-level computer programming languages (Saxena and Agrawal, 2013). The AD is structured as a computer programme. Due to these structure and implantation of rules Pāṇini considered first programmer and it attracted to most of the linguist, scientist and engineers to develop the model of the Artificial Intelligence and Natural language processing (NLP) using Pāṇinian framework. The mission to compute both the formal and semi-formal elements of the AD computationally has given rise to computational linguistics in Sanskrit (Kak, 1987 & Bharati et al, 1995). In 1985, NASA Scientist Rick Briggs has published an article claiming that Sanskrit can be very useful language to computer and can be used for knowledge representation (Briggs, 1985). After this

article, researchers had got attracted to work on Sanskrit Computational Linguistics (Gupta et al, 2012; Selot et al, 2013; Panchal et al, 2018 & Bakarola et al, 2019). Today researches are being done by the various prestigious research institutes, universities, government and private industries (Kak, 1987 & Bharati et al, 1995; Reddy, 2010; Bharati, 1996; Ramanujan, 1992; Rao, 1998).

In India, School of Sanskrit and Indic Studies, Jawaharlal Nehru University is known as to be a leading institution for works related to Sanskrit Computational Linguistics (SCL). IIT Mumbai (<http://www.iitb.ac.in/>), IIIT Hyderabad (<http://www.iith.ac.in/>), Sanskrit Studies Centre, University of Hyderabad (<http://sanskrit.uohyd.ac.in/scl>), Department of Sanskrit, University of Delhi, Delhi etc. are the major institute to promote research in the field of SCL. Technology Development for Indian Language (TDIL), Department of Electronics and Information Technology (DeitY), Ministry of Communications and Information, Government of India provides funding for research and development related to Indian language technology. Under this sponsorship many tools have been made for Sanskrit language. (<http://tdil-dc.in/san>) to analyze the data and make simpler to understand.

Major works under this area include Tagging and Indexing of text, Knowledge extraction, Searching for patterns and mining, Generation of lexical resources, Machine translation, Morphological analysis, Text to speech, Digitization of manuscripts etc.

As discussed above, researchers motivated to work on SCL after the article by NASA to knowledge representation in Sanskrit and its suitability for Artificial Intelligence in 1985 (Briggs, 1985). In India, the earliest work in SCL is done for the Machine Translation by Sangal and Chaitanya (1987). They described the possibility of treating Sanskrit as an intermediate language during machine translation will help the MT related problems and reduce the major works (Sahgal et al, 1987). The research done during the early 1990's was enumerated by the Ramanujam (1992). Work was further progressed day by day to extracting the tools, techniques and concepts from Pāṇinian Grammar and tried to implement to build real rule-based Machine translators by the researches of Indian Institute of Technology, Kanpur under the direction of Prof. RMK Sinha (<https://sites.google.com/site/profrmksinha/home/publications>). The work for the earliest rule-based translator Anusaaraka at Indian Institute of Technology, Kanpur started in 1993-94 (Bharati et al, 1997, 1994, 2003; Kulkarni, 2003 &

Chaudhury et al, 2010). Anusaaraka started using Pāṇinian framework to build English to Indian Languages transition system (Bharati, 1996 & Peter, 1996, 1995).

The work started on SCL under the direction of Prof. Girish Nath Jha of the School of Sanskrit and Indic Studies, Jawaharlal Nehru University, New Delhi in 2002. The main focus of this school is to develop language technology for Sanskrit and other Indian languages. School has also digitized the rare Sanskrit text and made available for information extraction and search for instant references online. At present, the main focus of this institute is on Sanskrit-Hindi-Machine-Translator (SaHiT) with the collaboration of Microsoft and will be available on Microsoft website under Bing translator (<https://www.bing.com/translator>). Any machine translation system has two main components. Analysis of a source language and generation of target language. This center focus on the source language analysis. To fulfill this objective of Machine translation, many tools and resources have been developed through M.Phil and Ph.D research to analyze Sanskrit language. School hosts a dedicated a website to demonstrate the developed tools and technology (<http://sanskrit.jnu.ac.in>). The website hosts various types of tools. It mainly includes four types of computational tools:

- Language Processing Tools
- Lexical Resources and Search
- Online Corpora
- Multimedia & E-learning

The tools under the Language Processing (Jha et al, 2007) includes Sandhi Generator (Kumar, 2007) sandhi analyzer (Kumar, 2007), subanta analyzer (Chandra, 2006, 2010, 2011), subanta Generator (Chandra, 2006), tinanta analyzer (Agrawal, 2007), tinanta Generator (Agrawal, 2007), kridanta analyzer (Singh, 2008), Sanskrit POS Tagger (Chandrashekar, 2007) etc. These are the key tools to analyze the Sanskrit texts. Online indexing with instant search for Sanskrit texts includes: Online Multilingual Amarakoṣa (Jha et al, 2010), Mahabharata search (Mani, 2008), R̥gvedic search are the main development.

Subanta analyzer recognize the subanta and tinanta in given Sanskrit texts. In analysis it provides complete information regarding root, suffix, gender, ending, case and numbers (Chandra, 2006; Chandra & Jha, 2011; Chandra, 2010; Chandra, 2012; Jha et al, 2009; Bhadra et al, 2008; Jha et al, 2006). The system is available for use at

<http://sanskrit.jnu.ac.in/subanta/rsubanta.jsp>. Tinanta analyzer also analyze the Sanskrit verb forms (Agrawal, 2007; Jha et al, 2009; Bhadra et al, 2008; Jha et al, 2006). It is available at <http://sanskrit.jnu.ac.in/tinanta/tinanta.jsp>.

The system POS tagger tags the all elements in a sentence and it is very useful for Machine Translation system (Chandrashekar, 2007).

The work done by the Bhadra (2007) on Computational analysis of gender in Sanskrit noun phrases is very essential and notable work in the field of Sanskrit feminine words. This system determine the gender in Sanskrit text. The research is focused Pāṇinian *Liṅānuśāsana*. The dissertation presented by the Bhadra (2007) contains five chapters. History of grammatical tradition discussed in the first chapters. Chapter two elaborates the Pāṇinian *Liṅānuśāsana* and finally rules and further discussion on gender determination in Sanskrit texts are discussed (Bhadra et. al, 2009).

Department of Sanskrit, University of Hyderabad is also the leading institute for research related to SCL. The center has developed various computational tools for analyzing Sanskrit text by following the Indian grammatical tradition under the direction of Prof. Amba Kulkarni and various computational tools has been developed to analyze Sanskrit texts. These include Morphological Analyzer and Morphological Generator for the analysis of Sanskrit texts (Kulkarni & Shukl, 2009), Sandhi (Vempati, Vyas & Nair, 2006) to joint (*sandhi*) between two characters based on Pāṇinian rules etc. A computational tool “Aṣṭādhyāyī Simulator” related to the conversion of Sanskrit terms, the *pada-viśleṣaka* (morphological analyzer) system also been developed. The system only shows the formation process of the masculine terms (Kulkarni, 2008). For derivational process only the ‘*sūtra*’, ‘*sūtra* number’ and ‘it’s work’ are mentioned in Sanskrit. This *Rupasiddhiprakriya* is based on the rules of Pāṇinian Ashtadhyayi. This process can be useful for the students studying Sanskrit through Sanskrit medium.

Noun-Generator is also associated to the derivation process of Nouns. The system displays the form in a table in seven fractions, after selecting a word and typing any word in Devanagari. Each form is hyperlinked with rules. On clicking on the links Pāṇinian rules displays in a pop-up window.

The Verb-forms-Generator system is an example-based system in which the input cannot be typed by the user, but selects the root (Dhatu), speech and prefix from

the dropdown menu to show the appearance of the ten elements of that root (Dhatu). All forms are displayed in the format of a table in a sorted in order of occurrence in root formation system (Bharati et al, 2006). The Concordance of Pāṇinian *Dhātuvṛtti* system (Shailaja, 2014) is also a notable research work on Pāṇinian root formation system. This system is an output of a Ph.D research. which was a result of comparative study of *mādhavīya dhātuvṛtti*, *kṣīratarāṅgiṇī* and *maitreyarakṣita dhātupāṭha* done in this digital dictionary. In the comparative study, a table showing the set of roots, *aniṭ*, *parasmaipada*, *ātmanepada*, *ubhayapada* etc. is displayed.

The system named 'Compound Generator' is interused to create a compound in two terms based on examples and rules (Satuluri, 2015; Satuluri et al, 2016; Satuluri & Kulkarni, 2013; Kumar et al, 2009; 2010; Kulkarni & Kumar, 2011; 2013; Kulkarni et al, 2012). The system generates the compounds form with *alaukika vighraha* of Sanskrit terms. In this system certain predetermined *alaukika vighraha* of *siddhāntakaumudī* have been selected. Important systems have been constructed by the same center 'Gavastika: The First Search Engine for Sanskrit', Anusarak: An Accessor cum Machine Translator (Kulkarni, 2003), Amarkosh-Gyan-Jalam: Knowledge-Net of Amarakosha (Nair, 2011), *taddhitarūpaniṣpādikā*, *kṛdantarūpaniṣpādikā* etc.

Department of Sanskrit, University of Delhi, Delhi has also began a work in the field with focus on E-learning under the direction of Dr. Subhash Chandra. This group of the department has started the work since 2014. The main objective of this department is to create online computational tools for Sanskrit language. In the last six years this department has been presented so many theses, dissertations, research papers, posters and developed many computational tools. All tools are available on the Sanskrit department's website <http://cl.sanskrit.du.ac.in>. Under the research and development department has developed system called SWAGATAM (Chandra et al, 2017) has been developed for teaching and learning process of Sanskrit Grammar in higher studies. It is based on B.A. and M.A. Sanskrit syllabus of University of Delhi. It includes *Taddhita* (Sakshi and Chandra, 2015) and *Sanādyanta* Analyzer (Kumar and Chandra, 2016), Sanskrit Meter Information System (Meena and Chandra, 2016) the *Sāṃkhya-yoga* Technical Terms Information System (Anju and Chandra, 2018), Vedic Literature Search (Kumar and Chandra, 2016), Pauranic Search System (Chandra and Anju, 2017) etc. Subanta derivation process system (Chandra et al, 2017) and *Tiṅanta* derivation

process system (Kumar and Chandra, 2019; Kumar and Chandra; Chandra et al, 2018) are the two system which generates the complete derivational process of Sanskrit nominal and verbal forms with Pāṇinian rules described in SK. These are developed using combining rule and example based hybrid approach. These systems are very fruitful for Sanskrit students and also teachers teaching Sanskrit grammar specially belongs to the University system. The noun (*sañjñā*) and *Sandhi* chapter of the *laghusiddhāntakaumudī* is included in the syllabus of almost all Sanskrit universities in bachelors curriculum. Therefore, the *pratyāhāra* and *Sandhi* teaching system has been developed by this department according to the BA Sanskrit curriculum of University of Delhi. This system teaches as a teacher (Chandra et al, 2017). In this, the process of *sandhi* between two characters is clearly demonstrated.

Web based support system for teaching Sanskrit meter by Meena (2015) is very useful for students. The system is designed to provide the complete information of Sanskrit meter (Meena, 2016; Meena & Chandra, 2017; 2018). The knowledge of technical terms of any subject is required for further studies. To achieve this goal a system has also been developed for the technical terms of *Sankhya-Yoga* philosophy (Anju & Chandra, 2017, 2018, 2019). Through this system user can learn the technical terms of *Sankhya-Yoga* philosophy online.

As mentioned above, the other objective of this department is to make Sanskrit texts available online. Therefore, in this direction, many books have been made online by this department and any conceptual words or terms found in those texts can also be searched immediately. In this sequence, a system called Rigvedic search (Kumar, 2016), *paurāṇika* Search (Chandra & Anju, 2017) are developed.

Based on above mentioned details there are no such system that has been developed on Sanskrit feminine words.

Chapter Three

Basic Facts and Derivational Process of Sanskrit Words

Ending with Feminine Suffixes

1. Basic Facts of Derivational Process of Sanskrit Words Ending with Feminine Suffixes

To generate the derivational process from a nominal base there are few steps that need to follow. It includes, *prātipadika*, addition of suffix and deletion of *anubandhas*, apply *sandhi*, adding sup suffixes and finally process sup rules etc. To follow these step and few AD *sūtras* are applied for performing these actions (Kanshiram, 2012; Vasu, 2012; Govindacharya, 2016 & Shastri, 2012). Detailed description is listed below.

1.1 Feminine Suffixes Ending with ‘ā’

Pāṇini used three major suffixes in his grammar to denote *ā* and the generated forms by these suffixes are called ‘*ābanta*’. These are ‘*ṭāp*’, ‘*cāp*’ and ‘*ḍāp*’. Due to remaining of the character ‘*ā*’. So, the generated from feminine suffixes looks like similar only the difference arises in various accent (Kanshiram, 2012; Vasu, 2012; Govindacharya, 2016 & Shastri, 2012).

1.1.1 The Feminine Suffix ‘*ṭāp*’

There are following steps need to follow to get complete siddhi process of words ending with Feminine Suffix ‘*ṭāp*’ and the Pāṇinian rules to be applied to perform the following actions/steps.

1. Do the *prātipadika* of the nominal base.
2. Adding the feminine suffix with nominal base.
3. Deletion of *anubhandhas*.
4. Sandhi work.
5. Adding the *sup* suffixes to generate various forms.

For example the feminine word ‘*ajā*’ is derived from nominal base ‘*aja*’ according to above mentioned 5 steps.

1. Firstly, the word ‘*aja*’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the nominal base ‘*aja*’ obtains feminine suffix *ṭāp* by the Pāṇinian rule “*ajādyataṣṭāp*”, *aja+ṭāp* in this condition.
3. The deletion of *anubhandhās* of feminine suffix ‘*ṭāp*’ by the Pāṇinian rule “*cuṭū*” and ‘*halantyam*’, *aja+ā* in this condition.
4. After applying *sandhi* by Pāṇinian rule “*akahsavarne dirghah*” the feminine word ‘*ajā*’ is generated.
5. To use in language the *sup* suffixes to be added by the various rules and generates various forms from the feminine word ‘*ajā*’.

1.1.2 The Feminine Suffix ‘*cāp*’

There are following steps need to follow to get complete siddhi process of words ending with Feminine Suffix ‘*cāp*’ and the Pāṇinian rules to be applied to perform the following actions/steps (Kanshiram, 2012; Vasu, 2012; Govindacharya, 2016 & Shastri, 2012).

1. Do the *prātipadika sañjñā* of the nominal base.
2. Adding the feminine suffix ‘*cāp*’ with nominal base.
3. Deletion of *anubhandhas*.
4. Sandhi work.
5. Adding the *sup* suffixes to generate various forms.

For example the feminine word ‘*āmbaṣṭhyā*’ is derived from nominal base ‘*āmbaṣṭhya*’ according to above mentioned 5 steps.

1. Firstly, the word ‘*āmbaṣṭhya*’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the nominal base ‘*āmbaṣṭhya*’ obtains feminine suffix *cāp* by the Pāṇinian rule “*yaṅāścāp*”, *āmbaṣṭhya +cāp* in this condition.
3. The deletion of *anubhandhas* of feminine suffix ‘*cāp*’ by the Pāṇinian rule “*cuṭū*” and ‘*halantyam*’, *āmbaṣṭhya +ā* in this condition.

4. After applying *sandhi* by Pāṇinian rule “*akahsavarne dirghah*” the feminine word ‘*āmbaṣṭhyā*’ is generated.
5. To use in language the *sup* suffixes to be added by the various rules and generates various forms from the feminine word ‘*āmbaṣṭhyā*’.

1.1.3 The Feminine Suffix ‘*dāp*’

There following step need to follow to get complete siddhi process of words ending with Feminine Suffix ‘*dāp*’ and the Pāṇinian rules to be applied to perform the following actions/steps.

1. Do the *prātipadika* of the nominal base.
2. Adding the feminine suffix with nominal base.
3. Deletion of *anubhandhas*.
4. Sandhi work.
5. Adding the *sup* suffixes to generate various forms.

For example the feminine word ‘*dāmā*’ is derivied from nominal base ‘*dāman*’ according to above mentioned 6 steps.

1. Firstly, the word ‘*dāman*’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the deletion of term *an*.
3. Then nominal base ‘*dāma*’ obtains feminine suffix *dāp* by the Pāṇinian rule “*dābubhābhyāmanyatarasyām*”, *dāma* + *dāp* in this condition.
4. The deletion of *anubhandhas* of feminine suffix ‘*dāp*’ by the Pāṇinian rule “*cuṭū*” and ‘*halantyam*’, *dāma*+*ā* in this condition.
5. After applying *sandhi* by Pāṇinian rule “*akahsavarne dirghah*” the feminine word ‘*ajā*’ is generated.
6. To use in language the *sup* suffixes to be added by the various rules and generates various forms from the feminine word ‘*dāmā*’.

Applying the same steps other feminine words can be generated. e.g. *sīmā*, *pāmā*, *bahurājā* etc.

1.2 Feminine Suffixes Ending with ‘ī’

There are three major suffixes are mentioned in AD by Pāṇini. These suffixes are- *nīp*, *nīs* and *nīn*. After deletion of *anubhandhas* only remain ‘ī’. The term *nī* is common in all three suffixes. Therefore the words derived from these suffixes called “*nyanta*”. As the only character ‘ī’ remains for final derivational process and generates the same types of words by each suffixes under this category (Kanshiram, 2012; Vasu, 2012; Govindacharya, 2016 & Shastri, 2012). There are few steps need to follow to generate the feminine word after adding these suffixes.

1.2.1 The Feminine Suffix ‘*nīp*’

To generate the feminine words from the feminine suffix ‘*nīp*’ following steps need to follow and the Pāṇinian rules to be applied to perform the following actions/steps.

1. Do the *prātipadika* of the nominal base.
2. Adding the feminine suffix with nominal base.
3. Deletion of *anubhandhas*.
4. Sandhi work.
5. Adding the *sup* suffixes to generate various forms.

For example the feminine word ‘*kumārī*’ is derived from nominal base ‘*kumāra*’ according to above mentioned 6 steps.

1. Firstly, the word ‘*kumāra*’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the nominal base ‘*kumāra*’ obtains feminine suffix *nīp* by the Pāṇinian rule “*vayasi prathame*”, *kumāra* + *nīp* in this condition.
3. The deletion of *anubhandhās* of feminine suffix ‘*nīp*’ by the Pāṇinian rule “*laśakvataddhite*” and ‘*halantyam*’, *kumāra* + *ī* in this condition.
4. After applying the deletion of *a* by the Pāṇinian rule ‘*yasyeti ca*’ *kumār*+ *ī* is the condition.
5. After the addition of these feminine words ‘*kumārī*’ is generated.

6. To use in language the *subanta* suffixes to be added by the various rules and generates various forms from the feminine word ‘*kumārī*’.

1.2.2 The Feminine Suffix ‘*nīs*’

To generate the feminine words from the feminine suffix ‘*nīs*’ following steps need to follow and the Pāṇinian rules to be applied to perform the following actions/steps.

1. Do the *prātipadika* of the nominal base.
2. Adding the feminine suffix with nominal base.
3. Deletion of *anubhandhas*.
4. Sandhi work.
5. Adding the *sup* suffixes to generate various forms.

For example the feminine word ‘*gaurī*’ is derived from nominal base ‘*gaura*’ according to above mentioned 6 steps.

1. Firstly, the word ‘*gaura*’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the nominal base ‘*gaura*’ obtains feminine suffix *nīs* by the Pāṇinian rule “*ṣidgaurādibhyaśca*”, *gaura* + *nīs* in this condition.
3. The deletion of *anubhandhas* of feminine suffix ‘*nīs*’ by the Pāṇinian rule “*laśakvataddhite*” and ‘*halantyam*’, *gaura* + *ī* in this condition.
4. After applying the deletion of *a* by the Pāṇinian rule ‘*yasyeti ca*’ *gaur+ī* is the condition.
5. After the addition of these feminine words ‘*gaurī*’ is generated.
6. To use in language the *subanta* suffixes to be added by the various rules and generates various forms from the feminine word ‘*gaurī*’.

1.2.3 The Feminine Suffix ‘*nīn*’

To generate the feminine words from the feminine suffix ‘*nīn*’ following steps need to follow and the Pāṇinian rules to be applied to perform the following actions/steps.

1. Do the *prātipadika* of the nominal base.
2. Adding the feminine suffix with nominal base.
3. Deletion of *anubhandhas*.
4. Sandhi work.
5. Adding the sup suffixes to generate various forms.

For example the feminine word ‘*śārṅgaravī*’ is derived from nominal base ‘*śārṅgarava*’ according to above mentioned 6 steps.

1. Firstly, the word ‘*śārṅgarava*’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the nominal base ‘*śārṅgarava*’ obtains feminine suffix *nīn* by the Pāṇinian rule “*śārṅgaravādyaṅo nīn*”, *śārṅgarava* + *nīn* in this condition.
3. The deletion of *anubhandhas* of feminine suffix ‘*nīn*’ by the Pāṇinian rule “*laśakvataddhite*” and ‘*halantyam*’, *śārṅgarava* + *ī* in this condition.
4. After applying the deletion of *a* by the Pāṇinian rule ‘*yasyeti ca*’ *śārṅgarav* + *ī* is the condition.
5. After the addition of these feminine words ‘*śārṅgaravī*’ is generated.
6. To use in language the *subanta* suffixes to be added by the various rules and generates various forms from the feminine word ‘*śārṅgaravī*’.

1.3 Feminine Suffixes Ending with ‘*ū*’

Pāṇini has mentioned six *sūtras* in his AD to the derivation process of feminine words ending with the suffix *ūn*. Suffix *ūn* comes to indicate feminity after a nominal stem which ends in *u*. To generate the feminine words from the feminine suffix ‘*ū*’ following steps need to follow and the Pāṇinian rules to be applied to perform the following actions/steps.

1. Do the *prātipadika* of the nominal base.
2. Adding the feminine suffix with nominal base.
3. Deletion of *anubhandhas*.

4. Sandhi work.
5. Adding the *sup* suffixes to generate various forms.

For example the feminine word ‘*bhadrabāhūḥ*’ is derived from nominal base ‘*bhadrabāhu*’ according to above mentioned 5 steps.

1. Firstly, the word ‘*bhadrabāhu*’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the nominal base ‘*bhadrabāhu*’ obtains feminine suffix *ūñ* by the Pāṇinian rule “*bāhvantātsamjñāyām*”, *bhadrabāhu* + *ūñ* in this condition.
3. The deletion of *anubhandhas* of feminine suffix ‘*ūñ*’ by the Pāṇinian rule ‘*halantyam*’, *bhadrabāhu* + *ū* in this condition.
4. After applying *sandhi* by Pāṇinian rule “*akahsavarne dirghah*” and the process of ‘*svādikārya*’ the feminine word ‘*bhadrabāhūḥ*’ is generated.
5. To use in language the *subanta* suffixes to be added by the various rules and generates various forms from the feminine word ‘*bhadrabāhūḥ*’.

1.4 Feminine Suffixes ending with ‘*ti*’

In the Pāṇinian AD there is only one *sūtra* to the derivational process of feminine word ending with suffix ‘*ti*’. To signify the meaning of feminine from a nominal stem only single feminine word *yuvatīḥ* generated from the *taddhita* term named *yuvan* (a young male). To generate the feminine words with the feminine suffix ‘*ti*’ following steps need to follow and the Pāṇinian rules to be applied to perform the following actions/steps.

1. Do the *prātipadika* of the nominal base.
2. Adding the feminine suffix with nominal base.
3. Deletion of *anubhandhas*.
4. Sandhi work.
5. Adding the *sup* suffixes to generate various forms.

For example the feminine word ‘*yuvatīḥ*’ is derived from nominal base ‘*yuvan*’ according to above mentioned 6 steps.

1. Firstly, the word ‘yuvan’ named *prātipadika* by the Pāṇinian rule “*arthavadadhāturapratyayaḥ prātipadikam*”.
2. Then the nominal stem ‘yuvan’ obtains feminine suffix *ti* by the Pāṇinian rule “*yūnastiḥ*”, *yuvan + ti* in this condition.
3. The *n* of the nominal stem ‘yuvan’ elided by the Pāṇinian rule ‘*na lopah prātipadikāntasya*’, *yuva + ti* in this condition.
4. After the addition of nominal term and suffix, *yuvati* in the situation.
5. After ‘*svādikārya*’ the feminine word ‘*yuvatiḥ*’ is generated.
6. To use in language the *subanta* suffixes to be added by the various rules and generates various forms from the feminine word ‘*yuvatiḥ*’.

2. Derivational Process of Sanskrit Words Ending with Feminine Suffixes

Pāṇini has described the feminine suffixes to create the words to denote the meaning of feminine words in AD. Even there is no special suffix described by Pāṇini or other grammarian to denote the meaning of masculine and neuter. According to the Pāṇinian grammar to denote the meaning of feminine, the feminine suffixes *ā* (*tāp*, *cāp*, and *ḍāp*) *ī* (*nīp*, *nīṣ*, and *nīn*), *ū* (*ūn*) and *ti* are added with the nominal bases (Kale, 1972; Sharma, 2008; Shastri, 2009 & Kanshiram, 2012) to create the feminine words. For example- *ajā*, *bālā*, *gaurī*, *mūṣikā*, *indrānī*, *yuvatī* etc. The words derived from these suffixes called *nyanta* (words ended with ‘*nīp*, *nīṣ*, and *nīn*’) *ābanta* (words ended with ‘*tāp*, *cāp*, and *ḍāp*’) etc. The feminine suffixes cover under the header rule (*adhikāra*) of *striyām*¹. There are total eight suffixes described in AD. The derivational process of Sanskrit words ending with feminine suffixes is described below.

2.1. Derivational Process of Sanskrit Words Ending with Feminine Affix ‘*tāp*’

The feminine suffix *tāp* is the major suffix under *ābanta* category to generate the feminine words. Pāṇini has mentioned two *sūtras* to add the suffix *tāp* from nominal

¹ अष्टाध्यायी- 4.1.3

bases. To denote the meaning of a feminine the suffix *ṭāp* to be added after a nominal term either the nominal ends with character ‘a’ or listed in the *ajādigana*².

In simple words to denote the meaning of feminine the suffix *ṭāp* can be added with nominal base either the nominal base listed in *ajādigana* or words ends with ‘a’. The complete list of *ajādigana* is shown Appendix-I. For example- the word *caṭaka*, *mūṣika*, *bāla* etc. are listed in *ajādigana*. So, to denote the meaning of feminine the suffix *ṭāp* is added and create then feminine word *caṭakā* (a female sparrow), *mūṣikā* (a female rat) and *bālā* (a female child).

The feminine suffix *ṭāp* also comes with nominal term to signify the meaning of feminine, after a nominal term ending with the word ‘pād’ if the word indicates a hymn (*ṛcā*) of Rigveda.³ For example- *dvipadā ṛk-* ‘a hymn with two parts’, *tripadā ṛk-* ‘a hymn with three parts’, *catuspadā ṛk-* ‘a hymn with four parts’ etc. In the feminine suffix *ṭāp* only *ā* remains after deletion of *anubandhas*. The *p* of *ṭāp* is given for the low pitch accent (*anudāṭṭa*).

Most of the *ābanta* words are derived by *ṭāp* feminine suffix only. As the suffix *ṭāp* is added with nominal base ends with ‘a’ and the string ‘ā’ remain in suffix. Then *dīrgha sandhi*⁴ rules is applied to generate the feminine base word. Finally feminine base word derived in 8 cases and 3 numbers with 21 sup suffixes.

2.2 Derivational Process of Sanskrit Words Ending with Feminine Affix *cāp*

The feminine affix *cāp* is the second major affix in *ābanta* category to denote the meaning of feminine and generate feminine words from the nominal bases. The ‘p’ of affix *cāp* is mentioned for the low pitch accent (*anudāṭṭa swara*) and finally will be deleted. The character ‘c’ of the suffix *cāp* is also deleted. Only character ‘ā’ remains to add with nominal bases.

To denote the significance of feminine the affix *cāp* is added with a nominal stem which terminates with *taddhita* suffix ‘*ñyañ*’ and ‘*ṣyañ*’⁵. For example, the word *āmbaṣṭhya* and *kārīṣagandhya* are terminated with *taddhita* suffix ‘*ñyañ*’ and ‘*ṣyañ*’.

² अजाद्यतष्टाप् (अष्टाध्यायी 4.1.4)

³ टावृत्ति (अष्टाध्यायी 4.1.9)

⁴ अकः सवर्णे दीर्घः (6.1.101)

⁵ यङश्चाप् (अष्टाध्यायी 4.1.74)

So the feminine affix *cāp* added with these word by the AD rule and generate feminine word *āmbaṣṭhyā* and *kārīṣagandhyā*. These feminine base word derived in 8 cases and 3 numbers with 21 sup suffixes to use in Sanskrit literature.

The affix *cāp* also adds with the nominal stem *āvaṭya* to signify the meaning of feminine⁶. For example, nominal base *āvaṭya* is derived with affix *cāp* by AD rule and finally created feminine word *āvaṭyā*. It again derived in 8 cases and 3 numbers with 21 sup suffixes.

2.3 Derivational Process of Sanskrit Words Ending with Feminine Affix *dāp*

The feminine affix *dāp* is the third major affix in *ābanta* group to generate the feminine words. The ‘*p*’ of suffix *dāp* is mentioned for the low pitch accent (*anudātta swara*). The ‘*d*’ of suffix *dāp* is added for the difference from suffixes such as *ṭāp* and *cāp*. The feminine suffix *dāp* optionally added with both types of *prātipadikās* that terminates with word ‘*man*’ and a ‘*bahuvrīhi*’ compound which terminates with ‘*an*’⁷.

For example, the word *sīma+dāp* → *sīma+ā* = *sīmā*, *pāma+dāp* → *pāma+ā* = *pāmā* and *bahurāja+dāp* → *bahurāja+ā* = *bahurājā* etc. In AD by Pāṇini there is only one *sūtra* is described feminine suffix *dāp*.

2.4 Derivational Process of Sanskrit Words Ending with Feminine Affix *nīp*

The second major category of feminine suffixes is *nyanta*. In this category *nīp* is the major suffix to generate feminine word from various types of nominal base. The character ‘*n*’ is employed in order to make common term in *nyanta* group and ‘*p*’ is applied in order to distinguish them from the suffix *nīṣ* and *nīn*. Only character remain ‘*i*’ after deletion of *anubandhas* from *nīp* suffix. Both ‘*n*’ and ‘*p*’ are *it* (deleted) by the *sūtra laśakvataddhite* and *halantyaṃ* subsequently omitted by *tasya lopah*. Suffix *nīp* is described in Pāṇinian AD after the description of suffix *ṭāp*⁸.

The affix *nīp* is added with the nominal bases to denote feminine in various conditions. If a nominal stem which terminates with abbreviator (*anubandha*) term ‘*uk*’,

⁶ आवच्छाश्च (अष्टाध्यायी 4.1.75)

⁷ डाबुभाभ्यामन्यतरस्याम् (अष्टाध्यायी 4.1.13)

⁸ From the *sūtra* ऋन्नेभ्यो ङीप् (अष्टाध्यायी 4.1.6)

then the suffix ‘*nīp*’ is applied.⁹ In the formation of feminine if a nominal ends in ‘*van*’¹⁰, suffix *nīp* is employed¹¹. Apart from this if a nominal stem ends with ‘*a*’ (*adanta*) and have, as their last alphabet (*antya*). A non- secondary term (*anupasarjana*) form either marked with the suffix ‘*ṭ*’, ‘*dh*’, ‘*aṅ*’, ‘*añ*’, ‘*dvayasac*’, ‘*daghnac*’, ‘*mātrac*’, ‘*tayap*’, ‘*ṭhak*’, ‘*ṭhañ*’, ‘*kañ*’, ‘*kvarap*’. ‘*Nīp*’ is applied¹² e.g. *kurucarī*, *kumbhakārī*, *autsī*, *ūrudaghnī*, *pañcatayī*, *itvarī* and *śubhagaṅkaraṇī* etc.

Suffix *nīp* is also applied to denote feminine entity, after a nominal-stem which ends in *yañ*¹³. e.g. *gārgī* (a female offspring of sage *garga*), *vātsī* (a female offspring of *vatsa*).

If a nominal stem denotes the initial stage of life and ends in ‘*a*’, suffix ‘*nīp*’ is employed¹⁴. The stage of life (*vaya*) means conditions of the physical structure of a human being at a particular time period. e.g. child, youth, man or oldman etc. When a *bahuvrīhi* compound terminates in ‘*an*’ and anticipates the removal of it’s penultimate sound¹⁵ (*upadhā*).

Suffix *nīp* is optionally employed in various cases¹⁶. For example- *bahurājñī*. When the nominal stem terminates in *at ‘a’* in *dvigu* compound¹⁷. To indicate feminist suffix *nīp* is applied. The term *dvigu* is here the type of *samāhāradvigu*¹⁸. Suffix *nīp*’ is employed to signify feminist after *bahuvrīhi* compound which terminates with the nominal term *ūdhas* and arises either with a numerical term (*saṅkhyā*) or an indeclinable term (*avyaya*)¹⁹. For example- *dvayūdhnī* (a cow with two udders), *niryūdhnī* (a cow without udder).

Suffix ‘*nīp*’ is also applied to denote femininity after *bahuvrīhi* compound which terminates with the nominal stem *dāman* (rope) and *hāyan* (Year) and arises either with

⁹ उगितश्च (अष्टाध्यायी 4.1.6)

¹⁰ Term ‘*van*’ is derived from suffixes *kvanip*, *vanip* and *ṅvanip*

¹¹ वनो र च (अष्टाध्यायी 4.1.7)

¹² टिड्ढाणञ्द्वयसज्दघ्नमात्रत्तयण्ठक्ठक्क्वरपः (अष्टाध्यायी 4.1.15)

¹³ यञश्च (अष्टाध्यायी 4.1.16)

¹⁴ वयसि प्रथमे (अष्टाध्यायी 4.1.20)

¹⁵ तस्मादुपधालोपिन एव णिव्यथास्यादनुपधालोपिनोमाभूदित्येवमर्थमिदमुच्यते- न्यास

¹⁶ अन उपधालोपिनोऽन्यतरस्याम् (अष्टाध्यायी 4.1.28)

¹⁷ द्विगोः (अष्टाध्यायी 4.1.21)

¹⁸ तद्धितार्थोत्तरपदसमाहारे च (अष्टाध्यायी 2.1.51)

¹⁹ संख्याव्ययादेर्दीप् (अष्टाध्यायी 4.1.26)

a numerical term (*saṅkhyā*)²⁰. For example- *dvihāyanī bālā* (two year old girl), *dvidāmnī*, *tridāmnī* etc. suffix *nīp* is applied to denote feminity after a compound stem, provided the derivate denotes a name (*sañjñā*), or else, is restricted to the vedic language. For example- *surājñī*, *atirājñī* etc. suffix *nīp* denotes the feminine after nominals *kevala*, *māmaka*, *bhāgadheya*, *pāpa*, *apara*, *samāna*, *āryakṛta*, *sumaṅgala*, *bheṣaja* or they are prohibited to the Vedic Sanskrit grammar²¹. Except these rule Pāṇini has given some more rule to the formation process of words ending with the feminine suffix *nīp*.

Apart from these rules, Katyayna has also given few vartikas to apply the feminine suffix *nīp*.

2.5 Derivational Process of Sanskrit Words Ending with Feminine Affix *nīṣ*

In *nyanta* category affix *nīṣ* is the second major suffix to the formation of feminine words. After deletion of *anubandhas* only character 'ī' remain in *nīṣ* suffix. Both character 'n' and 'ṣ' are 'it' by the AD sūtra 'laśakvataddhite' and 'halantyam' subsequently omitted by the sūtra 'tasya loṣaḥ'. The affix *nīṣ* denotes feminine after non-*upasarjana* nominal stems marked with *ṣit* (*ṣ* as an *it*) or listed in the *gaurādigāṇa*²². A list of words in *gaurādigāṇa* is shown in Appendix-II. For example, *gaurī* (a female with beauty or goddess *pārvatī*) *nartakī* (a female dancer or actress), *gārgyāyaṇī* (a female offspring of sage garga). In Pāṇinian grammar *gaurādigāṇa* is denoted as *ākṛtigāṇa*.

Suffix *nīṣ* is employed with a nominal stem denotes a relation of a female with the male²³. For example- *jānakī* (daughter of *janaka*), *gaṇakī* (wife of *gaṇaka*) and *yamī* (sister of *yama*). To denote the feminity of words such as *Indra*, *varuṇa*, *bhava*, *śarva* etc. suffix *nīṣ* is applied and the augment *ānuk* is also used²⁴. E.g. *indrāṇī* (wife of *Indra*) *varuṇāṇī* (wife of *varuṇa*) *bhavāṇī* (wife of *bhava*) etc.

²⁰ दामहायनान्ताच्च (अष्टाध्यायी 4.1.27)

²¹ केवलमामकभागधेयपापापरसमानार्यकृतसुमङ्गलभेषजाच्च (अष्टाध्यायी 4.1.30)

²² षिद्वौरादिभ्यश्च (अष्टाध्यायी 4.1.41)

²³ पुंयोगादाख्यायाम् (अष्टाध्यायी 4.1.48)

²⁴ इन्द्रवरुणभवशर्वरुद्रमृडहिमारण्ययवयवनमातुलाचार्याणामानुक् (अष्टाध्यायी 4.1.49)

Suffix *nīṣ* denotes to signify feminity after a nominal term terminates with *krīta* (purchased) and is used in combination subsequently an initial compound constituent with the significance of *karaṇa*²⁵. These are the some of the major *sūtras* to the formation process of feminine words terminating with suffix *nīṣ*, except these rules, Pāṇini has given some more suffixes to the formation process of feminine words ending with suffix *nīṣ*. There are few vartikas also describe to add this suffix with the specific types of nominal bases.

2.6 Derivational Process of Sanskrit Words Ending with Feminine Affix *nīn*

Pāṇini has given the third major suffix *nīn* in *nyanta* group the formation of feminine words. Affix *nīn* comes to signify feminine, when a nominal stem indicates *jāti* and is either related to *śārṅgaravādigāṇa*, or ends with character ‘a’ of suffix *añ*²⁶. A list of words of *śārṅgaravādigāṇa* is shown Appendix-V. For example- *śārṅgaravī* (a daughter of *śārṅgara*), *baidī* (a female gotra-descendent of *bida*). Suffix *nīṣ* and *nīn* are different in accent only. The word ended with *nīn* is marked as *udātta* at the beginning (*ādyudātta*) and the word ended with *nīṣ* is marked as *udātta* at the end (*antodātta*). A *gaṇasūtra* specifies that the feminine word *nārī* (a female human being) must be derived from the nominal stem *nṛ* or *nara* with an additional provision of *vṛddhi*²⁷.

2.6 Derivational Process of Sanskrit Words Ending with Feminine Affix *ūn*

Pāṇini has given six *sūtras* to the formation of feminine words ending with the suffix *ūn*. Suffix *ūn* comes to signify feminine after a nominal stem which ends in *u*, not having ‘y’ in its penultimate position and denotes a class of humans²⁸. For example, *kurūḥ*.

²⁵ क्रीतात्करणपूर्वात् (अष्टाध्यायी 4.1.50)

²⁶ शाङ्गर्वाद्यञो ङीन् (अष्टाध्यायी 4.1.73)

²⁷ नृनरयोर्वृद्धिश्च (गणसूत्रम्)

²⁸ ऊङुतः (अष्टाध्यायी 4.1.66)

The feminine suffix *ūñ* also comes to identify a term after a nominal stem ending with the word *bāhu* ‘arm’²⁹. E.g. *bhadrabāhūḥ* (a feminine of *bhadrabāhū*). Suffix *ūñ* denotes the term *paṅgu* (a male lame) to indicate feminine entity³⁰. For example- *paṅgūḥ* (a female lame). This *sūtra* presents *ūñ* after the term *paṅgu* to indicate the quality (*guṇa*).

When *ūru* is the final element of a nominal stem, provides the derivative which shows comparison (*aupamya*), feminine suffix *ūñ* is used³¹. For example, *karabhoroḥ* (a women who has thighs like elephant), *kadalīstambhoroḥ* (a woman with thighs like banana tree).

When *ūru* is the last constituent of a nominal term, preceded by words *saṃhita* (joined) *śapha* (a hoof) *lakṣaṇa* (a mark) *vāma* (good-looking), the feminine affix *ūñ* is applied³². Apart from the above rules suffix *ūñ* is also signified after the nominal stem *kadru* and *kamaṇḍalu*.³³ e.g. *kadrūḥ*, *kamaṇḍalūḥ*.

2.7 Derivational Process of Sanskrit Words Ending with Feminine Affix ‘*ti*’

In Pāṇinian AD there is only one *sūtra* is mentioned for the formation of feminine word ending with suffix ‘*ti*’. To denote the meaning of feminine from a nominal base only single feminine word *yuvatīḥ* generated from the *taddhita* term named *yuvan* (a young male). This AD rule is the exception of feminine suffix *nīp* and *nīṣ*.

Based on above description of derivational process of feminine words from the nominal bases it is shown that there are few words has very simple derivational process and few has complicated. So, the computing is easy for few *sūtras* and challenging for few *sūtras* especially for those suffixes which adds with *taddhitānta* and *ṭit* bases.

²⁹ बाह्वन्तात्संज्ञायाम् (अष्टाध्यायी 4.1.67)

³⁰ पङ्गोश्च (अष्टाध्यायी 4.1.68)

³¹ उरुत्तरपदादौपम्ये (अष्टाध्यायी 4.1.69)

³² संहितशफलक्षणवामादेश्च (अष्टाध्यायी 4.1.70)

³³ संज्ञायाम् (अष्टाध्यायी 4.1.72)

Chapter Four

Data Collection, Digitization and Development of Computational Rules of Feminine Suffixes and Research Methodology

Web based derivation system of Sanskrit words ending with feminine affixes is developed using Pāṇinian rules explained in SK and LSK. Pāṇinian AD, SK, LSK and Pāṇinian GP are the key texts for Sanskrit grammar and these were used as a primary source for the generation of computational rules for identification, analysis and siddhi generation. The Pāṇinian technique of implementation, ules and examples based hybrid approach is used for computational rules generation and analysis. Generally, information of the feminine affix is not present in the most of the Sanskrit words. Therefore, the identification of proper Prātipadika (PP) and feminine affixes is a very challenging task. There are two layers of identifications are required, first the *subanta* analyzer system, which removes the *sup* suffix and give the PP and second PP generated by the *subanta* analyzer identify by the current system. For example, the feminine word *ajāḥ*. Here the word *ajāḥ* send to the *subanta analyzer* and it produced the secondary PP *ajā+jas_1.3*. Then word *ajā* sends to the current system. The current system returns identified text as *ajā+ṭāp* with the recognition code. Based on identification, derivation process of the input word is generated using respective rules base. If the secondary PP identification is not done by the *subanta analyzer* correctly, then this system may fail to identify the correct feminine suffix and based on the identification the derivation process may be generated. The data structure for computational rules is followed as *subanta analyzer* (Chandra et al, 2018; Chandra et al, 2017) and *tiṅanta analyzer* (Chandra et al, 2017; Kumar and Chandra, 2019). The all data is stored in text files for testing and finally it is exported in database later.

1. Data Collection and Digitization

The rules and other data have been collected from the various sources. The LSK (Shastri, 1972) SK (Naine, 2010; Sharma, 2002; Panashekar, 1915) and AD (Jigyasu, 2010; Vasu, 1962; Dikshit, 2009; Jha 2014) are used for rules and examples

collection. *kāśīkāvṛtti* (Anantashastri, 1937; Vijaypalo, 1997; Shastri, 1965), *mahābhāṣya* (Vedavrata, 1962; Vaidyanath, 1967) and other Sanskrit literatures are also used for example collection to development of rules.

System uses rule base and example base feminine suffix identification, complete *siddhi* rules for *siddhi* generation and AD rules database. So, all data has been collected, compiled and digitize in text file in specific format. All data initially stored in UTF-8 Devanagari Unicode format. As there are not enough data available online in UTF-8 Devanagari Unicode format. So, all data is being digitized manually by the research student.

2. Development of Computational Rules of Feminine Suffixes

The system is developed using rule based and example-based hybrid methods. So, there are two types of rules has been developed first for feminine form recognition and second for *siddhi* generation. The detailed description is listed below:

2.1 Rules for Identification and Analysis of Feminine Suffixes

The Pāṇinian (*utsarga*) and exception (*apavāda*) methods are used to identify the feminine word. So, there are following two types of rules have been developed.

2.1.1 Rule Base

Under this category, Pāṇinian general rules are listed in computational format. The rules are rearranged according to the computational format. Rules are stored in tabular format. These rules are very helpful for the recognition of the feminine suffix. The sample of the rule base is shown Table 4.1.

Suffix Code	End	add	Suffix	Sup Info
1	ा		टाप्	प्रथमा_विभक्ति_एकवचन
1	क्रोडा	क्रोड	टाप्	प्रथमा_विभक्ति_एकवचन
1	खुरा	खुर	टाप्	प्रथमा_विभक्ति_एकवचन
1	बाला	बाल	टाप्	प्रथमा_विभक्ति_एकवचन
1	शफा	शफ	टाप्	प्रथमा_विभक्ति_एकवचन

1	जघना	जघन	टाप्	प्रथमा_विभक्ति_एकवचन
1	गुदा	गुद	टाप्	प्रथमा_विभक्ति_एकवचन
1	घोणा	घोण	टाप्	प्रथमा_विभक्ति_एकवचन
1	नखा	नख	टाप्	प्रथमा_विभक्ति_एकवचन
1	मुखा	मुख	टाप्	प्रथमा_विभक्ति_एकवचन
1	भगा	भग	टाप्	प्रथमा_विभक्ति_एकवचन
1	गला	गल	टाप्	प्रथमा_विभक्ति_एकवचन
1	पत्नी	पति	डीप्	प्रथमा_विभक्ति_एकवचन
2	बाहू	बाहु	ऊङ्	प्रथमा_विभक्ति_एकवचन
3	ोरू	ोरु	ऊङ्	प्रथमा_विभक्ति_एकवचन
3	चरी	चर	डीप्	प्रथमा_विभक्ति_एकवचन
3	करी	कर	डीप्	प्रथमा_विभक्ति_एकवचन
3	द्वयसी	द्वयस	डीप्	प्रथमा_विभक्ति_एकवचन
4	ीकी	ीक	डीप्	प्रथमा_विभक्ति_एकवचन
4	रनी	रनी	डीप्	प्रथमा_विभक्ति_एकवचन
5	रणी	रणी	डीप्	प्रथमा_विभक्ति_एकवचन
6	ूधी	ूध	डीप्	प्रथमा_विभक्ति_एकवचन
7	दाम्नी	दामन्	डीप्	प्रथमा_विभक्ति_एकवचन
7	दाम्णी	दामण्	डीप्	प्रथमा_विभक्ति_एकवचन
7	हायनी	हायन	डीप्	प्रथमा_विभक्ति_एकवचन

Table 4. 1: Sample of Rule based

2.1.2 Example Base

Under this category, Pāṇinian exception (*apavāda*) rules are listed in computational format. The rules are rearranged according to the computational format. In general words it can be called example base. The sample of the rule base is shown Table 4.2.

Suffix Code	Feminine Nominal Base	Nominal Base	Suffix	Sup Info
2.0	मूषिका	मूषक	टाप्	प्रथमा_विभक्ति_एकवचन
2	मूषिका	मूषिक	टाप्	प्रथमा_विभक्ति_एकवचन
1v	सम्फला	सम्फल	टाप्	प्रथमा_विभक्ति_एकवचन
1v	भस्त्रफला	भस्त्रफल	टाप्	प्रथमा_विभक्ति_एकवचन
1v	सत्पुष्पा	सत्पुष्प	टाप्	प्रथमा_विभक्ति_एकवचन
1v	प्राक्पुष्पा	प्राक्पुष्प	टाप्	प्रथमा_विभक्ति_एकवचन
1v	प्रत्यक्पुष्पा	प्रत्यक्पुष्प	टाप्	प्रथमा_विभक्ति_एकवचन
2v	क्रुञ्चा	क्रुञ्च	टाप्	प्रथमा_विभक्ति_एकवचन
2v	उष्णिहा	उष्णिह	टाप्	प्रथमा_विभक्ति_एकवचन
2v	देवविशा	देवविश	टाप्	प्रथमा_विभक्ति_एकवचन
2v	ज्येष्ठा	ज्येष्ठ	टाप्	प्रथमा_विभक्ति_एकवचन
2v	कनिष्ठा	कनिष्ठ	टाप्	प्रथमा_विभक्ति_एकवचन
2v	मध्यमा	मध्यम	टाप्	प्रथमा_विभक्ति_एकवचन
2v	कोकिला	कोकिल	टाप्	प्रथमा_विभक्ति_एकवचन
1	सकेशा	सकेश	टाप्	प्रथमा_विभक्ति_एकवचन
1	अकेशा	अकेश	टाप्	प्रथमा_विभक्ति_एकवचन
1	विद्यमानकेशा	विद्यमान	टाप्	प्रथमा_विभक्ति_एकवचन
1	सनासिका	सनासिक	टाप्	प्रथमा_विभक्ति_एकवचन
1	अनासिका	अनासिक	टाप्	प्रथमा_विभक्ति_एकवचन

Table 4. 2: Sample of Example base

2.2 Rules for Siddhi Generation

The second type of rules are siddhi generation rules. In this category, the rules are stored in the text file in tabular format. There are two columns in the text file, first has recognition code and second has siddhi rules in decoded format for particular that siddhi code. The sample of the siddhi generation rules is shown in table 4.3.

Recognition Code	Siddhi Code
टाप्_1_RB	Rule_01254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_2541#VF+ा Rule_0#
टाप्_1_EB	Rule_1308#VF+टाप् Rule_1254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_2541#VF+ा Rule_0#
टाप्_2.0_EB	Rule_1254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_3441#MF+आ Rule_2541#MF+ा Rule_0#
टाप्_2_EB	Rule_1254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_2541#VF+ा Rule_0#
डीप्_4.0_EB	Rule_1266#VF+डीप् Rule_156#VF+डीप् Rule_151#VF+डीप् Rule_157#VF+ई Rule_3151#YLH+ई Rule_0#
टाप्_1v_EB	Rule_4000#VF+डीप् Rule_156#VF+डीप् Rule_151#VF+डीप् Rule_157#VF+ई Rule_3151#MNT+ई Rule_0#

Table 4. 3: Sample of the Siddhi generation rules

2.3 AD Rules Database

As the system uses rules of AD and also displayed the meaning and explanation automatically so all the rules used in Feminine suffix part are digitized in specific format. The sample of the AD rules is shown in table 4.4.

Rule No.	AD Ref	Rule	Mean	Exp	Type	Work
3542	7.4.25	अकृत्सार्वधातुकयोर्दीर्घः			विधि	
694	3.1.75	अक्षोऽन्यतरस्याम्			विधि	
3340	7.2.61	अचस्तास्वत्थल्यनितो नित्यम्			विधि+निषेध	
2442	6.1.2	अजादेर्द्वितीयस्य			अधिकार	
590	2.4.56	अजेर्व्यञ्जपोः			विधि	
3587	7.4.70	अत आदेः			विधि	
3395	7.2.116	अत उपधायाः			विधि	
3121	6.4.120	अत एकहल्मध्येऽनादेशादेर्लिटि			विधि	
3498	7.3.101	अतो दीर्घो यञि			विधि	
3359	7.2.80	अतो येयः			विधि	
3049	6.4.48	अतो लोपः			विधि	
3281	7.2.2	अतो लान्तस्य			विधि	
3286	7.2.7	अतो ह्लादेर्लघोः			विधि	
3106	6.4.105	अतो हेः			विधि	
880	3.2.111	अनद्यतने लङ्			विधि	
972	3.3.15	अनद्यतने लुट्			विधि	

Table 4. 4 Sample of the AD rule database

Research Methodology

Pāṇinian Grammar is very systematic and technical grammar. It is shown very relevant to computer in various researches (Kak, 1987 & Bharati et al, 1995; Briggs, 1985 & Chandra, 2006). Therefore, the implementation methods of Pāṇini have been used in this research to achieve the goal. Many researchers have proven that the methods used by Pāṇini can be implemented easily to develop any types of system.

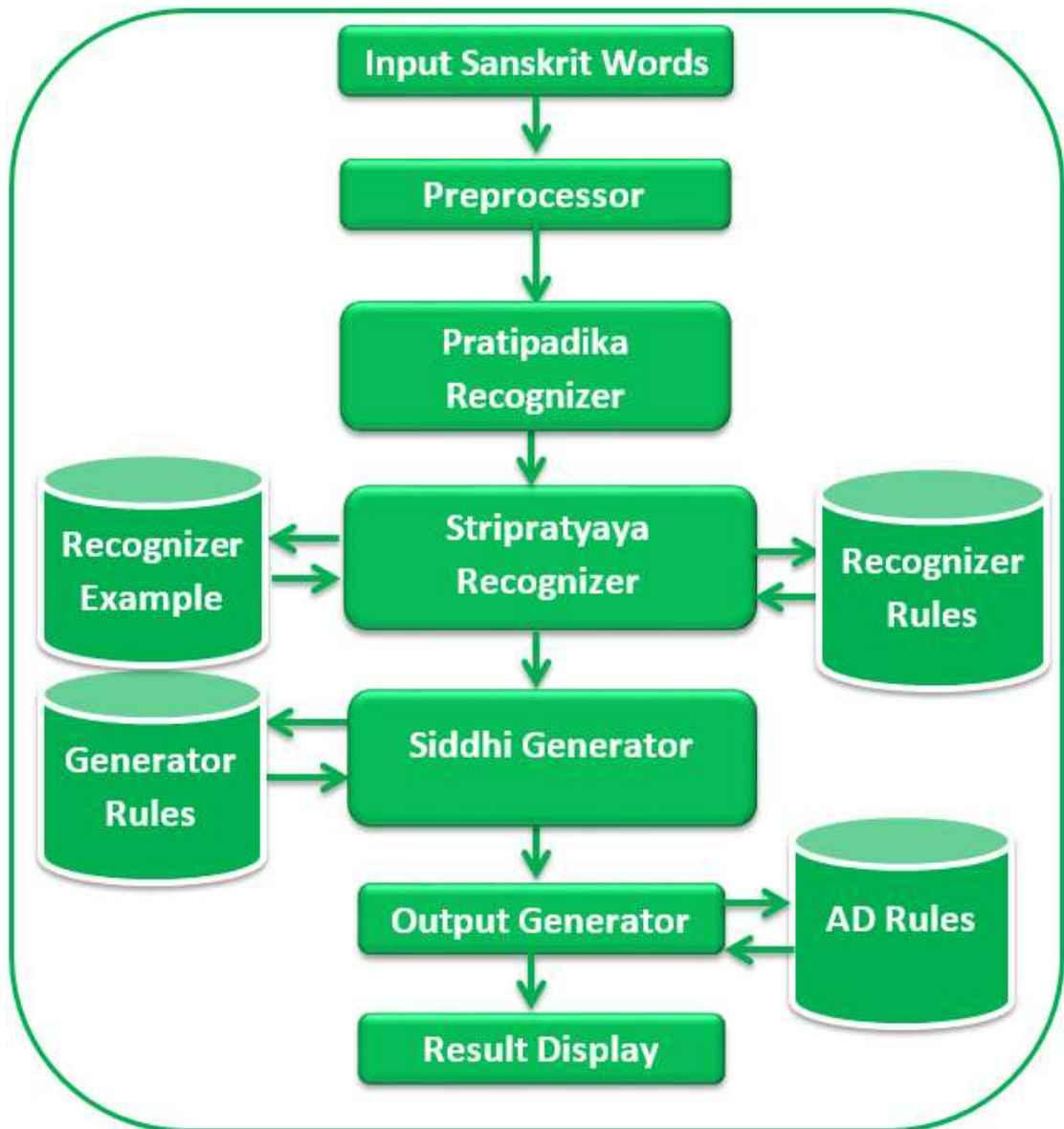


Figure: 4. 1: Architecture and flowchart of the system

In this direction developed system SWAGATAM by Chandra et al (2017 & Kumar, 2018) has inspired the authors to develop such types of system for the other

parts of the Sanskrit Grammar. Therefore, the part of words ending with feminine affixes from the SK and LSK is selected for the research and development. In order to develop the proposed system, the rule and example-based hybrid approach inspired by Pāṇini is used in Pāṇinian system. The methods of computational linguistics and web technology are also used to digitize and compute the rules. As a part of programming, system is developed in Python programming language. Spycy webserver is used for web server because it supports python language. The Cascading Style Sheets (CSS) and JavaScript are used for page decoration and styling.

System can be understood with the help of architecture and flowchart of the system shown in Figure 4.1. Methods are already tested and experimented and seen very useful to develop such type of successful system (Chandra et al, 2017 & Kumar, 2018).

Chapter Five

Introduction of Web based Recognition, Analysis and Derivational Process System of Sanskrit Words Ending with Feminine Suffixes

The result of the research work is an online system for Sanskrit feminine word formation process generator. The name of the system is Web based Recognition, Analysis and Derivational Process System of Sanskrit Words Ending with Feminine Suffixes, through this system user can learn the whole derivational process of Sanskrit Words Ending with Feminine Suffixes online using internet. The input and output can be taken from a user interface. The system will be available at <http://cl.sanskrit.du.ac.in> under e-learning tools tab. The screen shot of the system can be seen in image 5.1.



Figure 5. 1: Text Box

1. Input Mechanism

The system has a user interface where user can give the input and see the output. The input mechanism is also the part of the user interface. The input contains following sub-components.

1.1 Text Box

On the user interface there is a text box where user gives the input to check the derivational process of the words ending with feminine suffixes. As Sanskrit grammar is being taught in most of the universities in Hindi medium Therefore, this system accepts the input in Devanagari Unicode only. The text box can be seen in picture 5.2.

The screenshot shows a web-based application interface. At the top, the title is 'संस्कृत स्त्रीप्रत्ययान्तशब्द रूपसिद्धिप्रक्रिया' (Derivational Process of Words Ending with Feminine Suffixes). Below the title, there is a paragraph of text in Hindi and English describing the research. The text mentions that the research was carried out by Bhaskar Upreti (M.Phil. 2018-2019) under the supervision of Dr. Subhash Chandra, Assistant Professor, Department of Sanskrit, University of Delhi, Delhi, and Advisorship of Dr. Satyapal Singh and Dr. Mohini Arya for the award of M.Phil. degree. The title of the thesis was 'Computational Analysis and Development of Web based System for Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes'. The coding for the application was done by Dr. Subhash Chandra. Data set and rules were prepared by Bhaskar Upreti and Dr. Subhash Chandra.

Below the text, there is a text input box with the following text: 'संस्कृत स्त्रीप्रत्ययान्तशब्द रूपसिद्धि प्रक्रिया के लिए कृपया वृत्तीकोठ में पद लिखें।' (Enter word ends with feminine suffixes in Unicode for Derivational Process). Below the input box, there is a submit button with the text 'संस्कृत स्त्रीप्रत्ययान्तरूपसिद्धि प्रक्रिया के लिए क्लिक करें'.

5. 2: Text Box

1.2 Submit Button

There is a submit button on the user interface as shown in Figure 5.2. After clicking on this button, system verify the input text whether it is Sanskrit text or not. After successful varification system send the given input to backend program to recognize, analyze and finally generate the derivational process. And the result displays the user interface. The submit button is shown a “संस्कृत स्त्रीप्रत्ययान्तशब्दरूपसिद्धि प्रक्रिया के लिये क्लिक करें” on the user interface shown in Figure 5.2.



संस्कृत स्त्रीप्रत्ययान्तशब्द रूपसिद्धिप्रक्रिया Derivational Process of Words Ending with Feminine Suffixes

The "Derivational Process of Sanskrit Words Ending with Feminine Suffixes (संस्कृत स्त्रीप्रत्ययान्तशब्द रूपसिद्धिप्रक्रिया)" is a result of the M.Phil. Research carried out by Bhaskar Upreti (M.Phil. 2018-2019) under the supervision of Dr. Subhash Chandra, Assistant Professor, Department of Sanskrit, University of Delhi, Delhi and Advisorship of Dr. Satyapal Singh and Dr. Mohini Arya for the award of M.Phil. degree. The title of thesis was Computational Analysis and Development of Web based System for Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes. The coding for the application was done by Dr. Subhash Chandra. Data set and rules were prepared by Bhaskar Upreti and Dr. Subhash Chandra.

संस्कृत स्त्रीप्रत्ययान्तशब्द रूपसिद्धि प्रक्रिया के लिए कृपया मूलीकोट में पद लिखें।
(Enter word ends with feminine suffixes in Unicode for Derivational Process)

अजा

संस्कृत स्त्रीप्रत्ययान्तरूपसिद्धि प्रक्रिया के लिए विवरण करें

Result:

Analysis: अजा = अज+टाप्_प्रथमा_विभक्ति_एकवचन

टाप्_1_RB

स्त्रीप्रत्ययान्त शब्द = अजा	
पद पदचान = अज+टाप्	
Recognition Code = टाप्_1_RB	
अजाप्राप्तम् सूत्र से अज शब्द अदन्त होने के कारण स्त्रीत्व की विवक्षा में टाप् प्रत्यय	अजा
आदिर्द्विवचः सूत्र से धानु के आदि में स्थित नि, टु और वु की इत्संज्ञा होकर	अज+टाप्
हन्त्वम् सूत्र से उपदेश में अन्त्य हन् की इत्संज्ञा	अज+टाप्
उत्स शोषः सूत्र से इत्संज्ञक वर्ण का शोष होने पर	अज+आ
अजः सर्वो दीर्घः सूत्र से पूर्व एर्ष पर के स्थान पर सवर्ण दीर्घ होने पर	अजा
वर्ण सम्मेलन करने पर अजा रूप सिद्ध होता है।	अजा

Figure 5. 3: Output of the System

2. Output

The developed system returns the complete information of recognition, analysis and whole derivational process according to Pāṇinian rules of given input. The system has been developed according to Pāṇinian rules described in the SK by Bhattojidikshit. System prints result under the result heading. Sample of the result is shown in Figure 5.3.

3. Result Descriptions

As a result, system generates the complete information of given text. It includes, recognition, analysis and derivational process (*sasūtra siddhi*). The system is developed for teaching and learning but the part of recognition can be used for POS tagger, analysis can be used for Sanskrit parser and machine translation. The detailed description of the system is following.

Result:
Analysis: अजा = अज+टाप्_प्रथमा_विभक्ति_एकवचन
टाप्_1_RB

स्त्रीप्रत्ययान्त शब्द = अजा	
पद पहचान = अज + टाप्	
Recognition Code = टाप्_1_RB	
अजाअजटाप् सूत्र से अज शब्द प्रथम जोड़े के कारण स्त्रीत्व की विशेषता में अज प्रथम	अजा
अदिर्घित्वाः सूत्र	अज+टाप्
ह्रस्वत्वम् सूत्र से	अज+टाप्
उभोः सूत्र से	अज+आ
अः सवर्णे दीर्घः सूत्र से पूर्व एवं पर के स्थान पर सवर्ण दीर्घ होने पर	अजा
वर्ण सम्मेलन करने पर अजा रूप निवृत्त होता है।	अजा

उपदेश में धातु के आदि में स्थित जि, टु और डु की इत्संज्ञा होता है।

Figure 5. 4: Details Result

3.1 Feminine Form Information

The part of the result is the information of feminine forms e.g. स्त्रीप्रत्ययान्त शब्द = अजा.

The sample of result is shown in figure 5.3.

3.2 Feminine Form Recognition Information

After the feminine form information, system gives information of feminine form recognition. For example, पद पहचान = अज + टाप्. The information of the main stem and feminine suffix are provided in this section. The sample of result is shown in figure 5.3.

3.3 Feminine Form Recognition Code

This part of the result is not important for the user but it is very important for developer. It is very useful for the siddhi generation. Actually, all rules for siddhi is stored in dictionary format with text file. The recognition code is the key of the dictionary and value of the rules for each key e.g. Recognition Code = टाप्_1_RB. The sample of the recognition code is shown below:

```
टाप्_1_RB  Rule_01254#VF+टाप् Rule_153#VF+टाप्
          Rule_151#VF+टाप् Rule_157#VF+आ
          Rule_2541#VFा Rule_0#
टाप्_1_EB  Rule_1308#VF+टाप् Rule_1254#VF+टाप्
          Rule_153#VF+टाप् Rule_151#VF+टाप्
          Rule_157#VF+आ Rule_2541#VFा Rule_0#
टाप्_2.0_EB Rule_1254#VF+टाप् Rule_153#VF+टाप्
          Rule_151#VF+टाप् Rule_157#VF+आ
          Rule_3441#MF+आ Rule_2541#MFा Rule_0#
टाप्_2_EB  Rule_1254#VF+टाप् Rule_153#VF+टाप्
          Rule_151#VF+टाप् Rule_157#VF+आ
          Rule_2541#VFा Rule_0#
डीप्_4.0_EB Rule_1266#VF+डीप् Rule_156#VF+डीप्
          Rule_151#VF+डीप् Rule_157#VF+ई
          Rule_3151#YLH+ई Rule_0#
```

टाप्_1v_EB Rule_4000#VF+ङीप् Rule_156#VF+ङीप्
Rule_151#VF+ङीप् Rule_157#VF+ई
Rule_3151#MNT+ई Rule_0#

This recognition code helps the system to extract the exact siddhi process. Without this code the correct siddhi cannot be achieved.

3.4 Derivational Process of Words Ending with Feminine Suffixes

Finally, system prints the complete derivational process (*sasūtra siddhi*) of given word ending with feminine suffix with Pāṇinian rules in tabular format. The derivational process displays in two columns and multiple rows. The first column has the *sūtra* information and the work displays. The second column displays the changes occurred by that particular rules with stem and suffix. All the rules and *vārtikās* are hyper linked. On moving the cursor on the particular rules the meaning of the rules appears and on clicking on the particular *sūtras* the whole explanation of the *sūtra* is displayed in new tab. These features are very helpful for the students as well as teachers. The sample of the *siddhi* process is shown in Figure 5.4.

2. The Development Platform

Python is used as programming language, Python Server Pages (PSP) as Server, HTML for web page development, CSS for controlling the style of the HTML and JavaScript if used for internal web pages checking are used. The detailed description of the development platform is following:

2.1 Python as Programming Language

This system is developed using Python programming language. Python is created by Guido van Rossum in 1991 (Kuhlman, 2009; Esterbrook, 2010). It is an understood, high-level, general-purpose programming language. First time released in 1991. The major design idea of the python is emphasizing code readability with its notable use of significant whitespace. It's language constructs and object-oriented

approach aims to help programmers to write clear, logical code for small and large-scale projects. Python is an easily readable language. It's formatting is visually uncluttered, and it often uses English keywords where other languages use punctuations. Unlike many other languages, it does not use curly brackets to delimit blocks and semicolons after statements are optional (Van, 2007). Python uses whitespace indentation, rather than curly brackets or keywords, to delimit blocks. It is used for web development (server-side), software development, mathematics and system scripting. Python has syntax that allows developers to write programs with fewer lines than some other programming languages (W3schools, 2020).

Due to various features and easy string processing in python the system is developed in python programming language.

2.2 Spyce as Python Server Page (PSP)

Python Server Pages (PSP) is a term used by several diverse implementations of server-side script engines for developing dynamically-generated web pages by embedding Python in HTML. The Spyce is used for the Python Server Pages. It is released in 2002. Spyce technology is similar to PHP that can be used to embed Python code into webpages (Hetland, 2005; Puder, 2003; Mijailovic, 2013 & McDonald, 2006). Spyce is a free software, distributed under a BSD-style license, with some additional restrictions about documentation notices (Spyce - Python Server Pages, 2020). This system is developed using Spyce as Python Server Pages. The python programming language code has been embedded into the HTML code. The sample is shown below.

```
<p align="left">
<font face="Arial Unicode MS" size="6"
color="navy">
[[\
if itext != "":
    a = itext.replace("\r\n", " ").replace("
", "")
    inp = a.strip().replace("\t", " ")
```



```

dd = inp.strip().split(" ")
for word in dd:
    if len(word)>1:
        #print len(word), "<br>"
        Main.main(word.decode("utf-8"))
]]
</font></p>

```

2.3 Hypertext Markup Language (HTML)

Hypertext Markup Language (HTML) is the standard markup language for documents designed to be shown in a web browser. It can be supported by technologies such as Cascading Style Sheets (CSS) and scripting languages such as JavaScript. Generally, web browsers accept HTML documents from a web server or from local storage and extract the documents into multimedia web pages (Raggett, 1995 & HTML5, 2014). HTML describes the structure of a web page semantically and firstly included cues for the appearance of the document on the website. The user interface as shown Figure 5.1 is developed in HTML and the programming language Spycy code embedded with HTML. The system uses HTML5. Sample of the page is shown below:

```

<!DOCTYPE html>
<head>
<!-- Basic Page Needs-->
  <meta charset="utf-8">
  <title>Web based Sanskrit Words Ending with Feminine
  Suffixes</title>
  <meta name="description" content="Department of Sanskrit, Delhi
  University">
  <meta name="keywords" content="Sanskrit, MA, Ph.D, Dr. Subhash
  Chandra, Delhi University" />
  <meta name="author" content="du.ac.in">

  <!-- For Mobile Specific Metas-->
  <meta name="viewport" content="width=device-width, initial-
  scale=1, maximum-scale=1">

  <!-- CSS-->

  <link href="../file/css/bootstrap.css" rel="stylesheet"
  media="screen" />
  <link rel="stylesheet" href="../file/css/zerogrid.css">
  <link rel="stylesheet" href="../file/css/style.css">
  <link rel="stylesheet" href="../file/css/responsive.css">
  <link rel="stylesheet" href="../file/css/responsiveslides.css"
  />

```

```

    <link rel="stylesheet" type="text/css"
href="../file/Menu/css/font-awesome.css">
    <link rel="stylesheet" type="text/css"
href="../file/Menu/css/menu.css">

    <script type="text/javascript"
src="../file/Menu/js/jquery.js"></script>
    <script type="text/javascript"
src="../file/Menu/js/function.js"></script>

<link rel="stylesheet"
href="http://www.jacklmoore.com/colorbox/example1/colorbox.css" />
    <link href='/favicon.ico' rel='icon' type='image/x-icon' />

    <script src="../file/js/responsiveslides.js"></script>
<script src="../file/js/bootstrap.min.js"></script>
<script>
$(function () {
    $("#slider").responsiveSlides({
        auto: true,
        pager: true,
        nav: true,
        speed: 500,
        maxwidth: 800,
        namespace: "centered-btns"
    });
});
</script>

<link href="themes/1/tooltip.css" rel="stylesheet" type="text/css"
/>
    <script src="themes/1/tooltip.js"
type="text/javascript"></script>
    <style type="text/css">
        h4 { font-size: 16px; font-family: "Trebuchet MS",
Verdana; line-height:18px;}
        table {
            border-collapse: collapse;
        }
    </style>

</head>
<body>
<!--Header Start Edit ../file/js/header.js -->

<script language="JavaScript" type="text/javascript"
src="../file/js/header.js"></script>

<!--Header Close-->

<!--Navigation Menu Start-->

<div class="zerogrid">
    <div class="row">
        <div id="headermenu">

```

```

        <a id="menu-toggle" class="button dark" href="#"><i
class="icon-reorder"></i></a>
        <!--Menu Script Start Edit "../file/js/menu.js"-->
                <script language="JavaScript"
type="text/javascript" src="../file/js/menu.js"></script>
        <!--Menu Script Close Edit "../file/js/menu.js"-->
                <div class="clear"></div>
        </div>
</div>
<!--Navigation Menu End-->

```

2.4 Cascading Style Sheets (CSS)

Cascading Style Sheets (CSS) is a style sheet language used for describing the presentation of a document written in a markup language like HTML. CSS is designed to enable the separation of presentation and content, including layout, colors and fonts. CSS uses a simple syntax and uses a number of English keywords to specify the names of various style properties. CSS controls to the web layout. It is very simple for Pāṇinian Rules. The developed system uses many types of CSS files for styling. A sample is shown below:

```

table.rstudent{
    border-collapse: collapse;
    border:2px solid navy;
    border-bottom-left-radius: 25px;
    border-bottom-right-radius: 25px;
}
th.rstudent {
    border:1px solid navy;
    font-size: 15px;
    font-weight: bold;
    padding-left: 5px;
    padding-top: 5px;
    padding-right: 5px;
    text-align: left;
}

```

```

        vertical-align: middle;
    }
td.rstudent {
    font-size: 13px;
    border:1px solid navy;
    padding-left: 5px;
    padding-top: 5px;
    font-weight: bold;
    padding-right: 5px;
    text-align: left;
    vertical-align: middle;
}
table.samkhya2{
    border-collapse: collapse;
    border:none;

```

2.5 Java Script

Java Scripts (JS) are used for scripting in HTML page. Java Script is the programming language of HTML and the Web. JavaScript is high-level, just-in-time compiled, and multi-paradigm language. It has curly-bracket {} syntax, dynamic typing, prototype-based object-orientation and first-class functions. JS is generally used to make the web pages dynamic. The system displays the meaning of each rules through over mouse function using JS. Sample is shown below:

```

<script src="../../file/js/bootstrap.min.js"></script>
<script>
$(function () {
    $("#slider").responsiveSlides({
        auto: true,
        pager: true,
        nav: true,
        speed: 500,
        maxwidth: 800,
        namespace: "centered-btns"
    });
});
</script>

```

```
var tooltipOptions=  
{  
    showDelay: 100,  
    hideDelay: 300,  
    effect: "fade",  
    duration: 200,  
    relativeTo: "element",  
    position: 1,  
    smartPosition: true,  
    offsetX: 0,  
    offsetY: 0,  
    maxWidth: 400,  
    calloutSize: 9,  
    calloutPosition: 0.3,  
    cssClass: "",  
    sticky: false,  
    overlay: false,  
    license: "64628"  
};
```

3. Components of the Web based Recognition, Analysis and Derivational Process System of Sanskrit Verb forms

Web based Recognition, Analysis and Derivational Process System of Sanskrit Words Ending with Feminine Suffixes has mainly five components. The system has following components:

3.1 User Interface

To accept the input there is a user interface which accepts the Unicode Devanagari words in text box. After submission of the button given below. Input sends to the further process to main function. Then the recognition, analysis and complete derivational process displays on the user interface as shown in Figure 5.3.

3.2 Pre-processor

The pre-processor module processes the given input Sanskrit words ends with feminine suffixes. Specially remove the extra white spaces, new lines, comma, etc. After pre-processing the input sends to next process.

3.3 Feminine Word Recognizer

This component recognizes the input words with the help of rules and example database. After recognition the component returns the complete recognition and a recognition code to the main function. The recognition includes nominal base and feminine suffix. For example,

Recognition: अज + टाप्

Recognition Code: टाप्_1_RB

After pre-processing the input sends to next process. As this component do the recognition with the help of recognition rule, so the sample of recognition rule shown in Table 5.3.

7	ायी	ाय	डीप्	प्रथमा_विभक्ति_एकवचन
8	पत्नी	पति	डीप्	प्रथमा_विभक्ति_एकवचन
2	ोष्ठी	ोष्त्र	डीष्	प्रथमा_विभक्ति_एकवचन
10	्री	ृ	डीप्	प्रथमा_विभक्ति_एकवचन
3	ग्राही	ग्राह	डीप्	प्रथमा_विभक्ति_एकवचन
3	शंसी	शंस	डीप्	प्रथमा_विभक्ति_एकवचन
3	वाही	वाह	डीप्	प्रथमा_विभक्ति_एकवचन
3	द्वयसी	द्वयस	डीप्	प्रथमा_विभक्ति_एकवचन
3	दृशी	दृश	डीप्	प्रथमा_विभक्ति_एकवचन
1	क्रोडा	क्रोड	टाप्	प्रथमा_विभक्ति_एकवचन
1	खुरा	खुर	टाप्	प्रथमा_विभक्ति_एकवचन
1	बाला	बाल	टाप्	प्रथमा_विभक्ति_एकवचन
1	शफा	शफ	टाप्	प्रथमा_विभक्ति_एकवचन

3.4 Feminine Word Analyser

This component does the analysis of the recognized input words with the help of rules and example database. The case information is collected from the SupAnalyzer (Chandra, 2016; Chandra, 2019) developed by this group for the analysis of Sanskrit nominal base. Finally it returns to the main function with analysis. Analysis includes the nominal base+feminine suffix+case+number. For example,

Analysis: अजा = अज+टाप्_प्रथमा_विभक्ति_एकवचन टाप्_1_RB,

A sample of analysis rule is shown below.

1	ा		टाप्	प्रथमा_विभक्ति_एकवचन
1	गला	गल	टाप्	प्रथमा_विभक्ति_एकवचन
1	पत्नी	पति	ङीप्	प्रथमा_विभक्ति_एकवचन
2	बाहू	बाहु	ऊङ्	प्रथमा_विभक्ति_एकवचन
3	ोरू	ोरु	ऊङ्	प्रथमा_विभक्ति_एकवचन
3	चरी	चर	ङीप्	प्रथमा_विभक्ति_एकवचन
3	करी	कर	ङीप्	प्रथमा_विभक्ति_एकवचन
3	द्वयसी	द्वयस	ङीप्	प्रथमा_विभक्ति_एकवचन

3.5 Feminine Word Siddhi Generator

The recognition code of the processed input by the Feminine Word Recognizer and Analyzer is send for *siddhi* generation. Based on the recognition code generated by the Recognizer module the *siddhi* code is generated by the Feminine word *Siddhi* Generator module with help of *siddhi* generation database. After process of the recognition code this component returns to the *siddhi* code to main function in following format:

टाप्_1_RB Rule_01254#VF+टाप् Rule_153#VF+टाप्
 Rule_151#VF+टाप् Rule_157#VF+आ
 Rule_2541#VFा Rule_0#

टाप्_1_EB Rule_1308#VF+टाप् Rule_1254#VF+टाप्
 Rule_153#VF+टाप् Rule_151#VF+टाप्
 Rule_157#VF+आ Rule_2541#VFा
 Rule_0#

टाप्_2.0_EB Rule_1254#VF+टाप् Rule_153#VF+टाप्
 Rule_151#VF+टाप् Rule_157#VF+आ
 Rule_3441#MF+आ Rule_2541#MFा
 Rule_0#

टाप्_2_EB Rule_1254#VF+टाप् Rule_153#VF+टाप्
 Rule_151#VF+टाप् Rule_157#VF+आ
 Rule_2541#VFा Rule_0#

डीप्_4.0_EB Rule_1266#VF+डीप् Rule_156#VF+डीप्
 Rule_151#VF+डीप् Rule_157#VF+ई
 Rule_3151#YLH+ई Rule_0#

टाप्_1v_EB Rule_4000#VF+डीप् Rule_156#VF+डीप्
 Rule_151#VF+डीप् Rule_157#VF+ई
 Rule_3151#MNT+ई Rule_0#

A sample of the siddhi generation database is shown table 5.2.

Recognition Code	Siddhi Code
टाप्_1_RB	Rule_01254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_2541#VFा Rule_0#
टाप्_1_EB	Rule_1308#VF+टाप् Rule_1254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_2541#VFा Rule_0#
टाप्_2.0_EB	Rule_1254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_3441#MF+आ Rule_2541#MFा Rule_0#
टाप्_2_EB	Rule_1254#VF+टाप् Rule_153#VF+टाप् Rule_151#VF+टाप् Rule_157#VF+आ Rule_2541#VFा Rule_0#
डीप्_4.0_EB	Rule_1266#VF+डीप् Rule_156#VF+डीप् Rule_151#VF+डीप् Rule_157#VF+ई Rule_3151#YLH+ई Rule_0#
टाप्_1v_EB	Rule_4000#VF+डीप् Rule_156#VF+डीप् Rule_151#VF+डीप् Rule_157#VF+ई Rule_3151#MNT+ई Rule_0#

Table 1: 5.2 Sample of Siddhi Recognition Database

Sample of the python code is listed below:

```
def FemSidhiGenerator(RecCode):
    R = codecs.open(r"siddhiProcRB.txt", "r", "UTF-8")
```

```

SiddhiRB = R.readlines()

R.close()

CompleteSiddhi = {}

for rl in SiddhiRB[1:]:
    rule = rl.split("\t")

    if RecCode.strip().replace("\r\n", "") ==
        \rule[0].strip().encode("utf-8"):
        CompleteSiddhi[rule[0].strip()]=rule[-1].strip()

return CompleteSiddhi

```

3.6 Output Generator

Output Generator module generates the output from the *siddhi* code received from the *siddhi* generator module. Output generator module send the *siddhi* code to table generator to generate the table to display result. A sample of the table generator is shown below:

```

def FemTableGenrator(suffix,pradipadik,inp,
word,info):#,inp,word,info,RecCodeSplit):
    sambodhan = ""
    meanStrt = ""<b><i><a class='tooltip'
href='RulesData/RuleExplanationAutoGeneratedFiles/""
    #print inp[0].split("\t")[0].encode("utf-8"),"<br>"
    link = "" target='_blank'"
onmouseover="tooltip.pop(this, """"
    meanMdl = ""'')">""
    meanCls = ""</a></i></b> &nbsp;&nbsp; ""
    fnlst,exp = [],[]
    #print len(info)
    RecCodeSplit = info
    sff = info.split("_")
    tr = len(inp)
    #print RecCodeSplit[3].encode("utf-8"),"ss<hr>"
    #print info,"<hr>"
    fnlst.append("""<center><table border-collapse:
collapse border="2" width="98%">""")

```

```

fnlst.append("""<tr><td class='main3'
bgcolor='#FFF8DC' colspan='2'>""")

fnlst.append("<b><i><font
color=green>"+word+"</font></i></b><br>")

fnlst.append("<b><i><font
color=green>"+pradipadik+" + "+sff[0]+"
"+</font></i></b><br>")

fnlst.append("Recognition Code = "+RecCodeSplit)
fnlst.append("</td></tr>")

for i in range(0,tr+1):
    for j in inp:
        #print j.split("\t")[0].encode("utf-
8"), "<br>" 3,2,6
        sūtraSplit = j.split("\t")
        sūtraNm = sūtraSplit[0].encode("utf-8")
        sūtraADNm = sūtraSplit[1].encode("utf-8")
        sūtra = sūtraSplit[2].encode("utf-8")
        sūtrartha =
sūtraSplit[3].replace("'", "\'").encode("utf-8")
        sūtraVyakhya =
sūtraSplit[4].replace("'", "\'").encode("utf-8")
        sūtraType =
sūtraSplit[5].replace("'", "\'").encode("utf-8")

```

To generate the table of this module, use AD Database to replace the all rule number with *sūtras*. This module is also hyperlinked to the each *sūtra* with the explanation of that *sūtra* and create an over mouse function with meaning of the *sūtra* as shown in Figure 5.1. The sample of the AD database is shown Table 5.4.

Rule No.	AD Ref	Rule	Mean	Exp	Type	Work
3542	7.4.25	अकृत्सार्वधातुकयोर्दीर्घः			विधि	
694	3.1.75	अक्षोऽन्यतरस्याम्			विधि	
3340	7.2.61	अचस्तास्वत्थल्यनिटो नित्यम्			विधि+निषेध	
2442	6.1.2	अजादेर्द्वितीयस्य			अधिकार	

590	2.4.56	अजेर्व्यघञपोः			विधि	
3587	7.4.70	अत आदेः			विधि	
3395	7.2.116	अत उपधायाः			विधि	
3121	6.4.120	अत एकहल्मध्येऽनादेशादेर्लिटि			विधि	
3498	7.3.101	अतो दीर्घो यञि			विधि	
3359	7.2.80	अतो येयः			विधि	
3049	6.4.48	अतो लोपः			विधि	
3281	7.2.2	अतो लान्तस्य			विधि	
3286	7.2.7	अतो ह्लादेर्लघोः			विधि	
3106	6.4.105	अतो हेः			विधि	
880	3.2.111	अनद्यतने लङ्			विधि	
972	3.3.15	अनद्यतने लुट्			विधि	

Table 5. 1: Sample of AD Rule Database

Finally, table generator module returns to the input with detailed HTML codes of table and required information to output generator to display the result of user interface. And the user interface displays the result on the interface in specific format as shown in Figure 5. 5.

3.7 Computational Platform and Techniques

The front end of the system is using Python Server Page's: Spycy and Spycy codes are embedded with HTML. To make it reusable and comfortable CSS styling is used. To create dynamics and effects Java Scripts are used. The Back end is developed in Python programming language. The system uses various rules and data set to recognize and analyse the feminine words in Unicode Devanagari format. So, all the data is stored primarily in text files and finally will be exported in database.

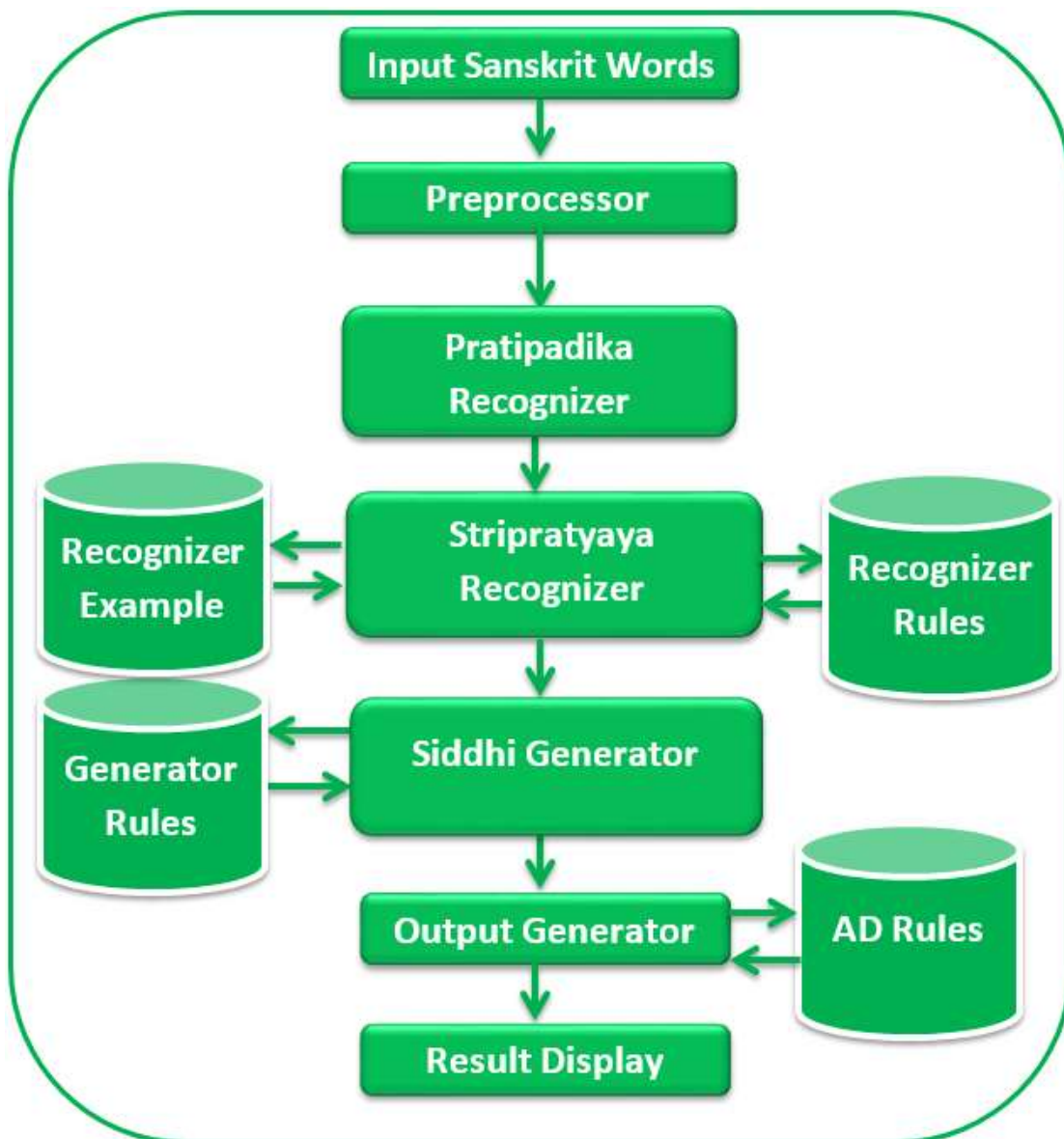


Figure: 5.4: Architecture and flowchart of the system

3.8 How System Work?

The workflow can be understood with help of Figure 5.4. As discussed earlier in this chapter the system has few modules to work. The main module is Main. Main is the controller for all module and send input to each module and receive the output from that particular module. Then as per requirement it send the input to the other module. In initial stage after getting the input from the user interface main function send the input to Feminine word recognizer and Analyzer to get the recognition, analysis and recognition code. After recognition of the input word the main function sends the

recognition code with input text to *siddhi* generator function and then *siddhi* generator function returns the *siddhi* code to the main function. Again, the main function sends the *siddhi* code to table generator and table generator returns the html codes with rules and meaning and other information according to the result format. Finally, the main function sends the input to user interface to display the result. The sample of the python code is shown below:

```
# coding: utf-8
import FemRecongnizer, FemSidhiGenerator,
FemTableGenrator
def main(inp):
    siddhiInfo = []
    FemRecongnition = FemRecongnizer.Main(inp)
    if FemRecongnition:
        for RecCode in FemRecongnition:
            RecSplit = RecCode.split("##")
            RecCodeSplit = RecSplit
            suffix = RecSplit[0].split("_")[0]
            pradipadik = RecSplit[-
1].split("+")[0].split("=")[-1]
            Maindhatu = pradipadik
            word = inp
            info = RecSplit[0]
            print "Analysis: "+RecSplit[-1], "<hr>"
            RecCodeFn = RecSplit[0]
            print RecCodeFn, "<hr>"
            # Send to
            TinSiddhiGenerator.TinSiddhiGenerator to Generate
            Siddhi
            SiddhiCode =
            FemSidhiGenerator.FemSidhiGenerator(RecCodeFn)
            if SiddhiCode:
                for SiddhiCodeLn, fnCode in
                SiddhiCode.iteritems():
                    code =
                    FemSidhiGenerator.SiddhiFnCodeGenerator(fnCode)
                    if code:
                        table =
                        FemTableGenrator.FemTableGenrator(suffix, Maindhatu, co
                        de, word.encode("utf-
                        8"), RecCodeFn) #, info, RecCodeSplit)
```

```
print " ".join(table[0])
else: print inp.encode("utf-8"), " ", "Not Match
with any rules<hr>"
```

Conclusions and Future Directions of the Research

1. Conclusions

Through the research presented, an online system has been developed and presented for the recognition, analysis and derivational process generation for Sanskrit word end with feminine suffixes. Gender recognition in many languages is very complicated task and is also a difficult task in Sanskrit as well. Sanskrit has three genders Masculine, Feminine and Neuter. To generate the feminine words from the nominal bases and to denote the meaning of feminine, Pāṇini has mentioned eight feminine suffixes in AD. These suffixes are described by the Bhattoji Dikhsita in SK and shorten by Varadaraja in LSK. These eight suffixes are distributed in 4 various classes. It includes 'nyanta', 'ābanta', 'ūñ' and 'ti'. Sanskrit grammar is being taught in almost all Indian universities offering Sanskrit courses at under graduate (UG), post graduate (PG) and research level. Feminine suffixes are included in Sanskrit syllabus at UG and PG level.

The major objective of the research was to develop a web based system for Pāṇinian Derivational Process of Sanskrit Words Ending with Feminine Suffixes to identify, analysis and automatic derivation process generation. Therefore, the system has been developed and demonstrated in this research. The system will be available online at <http://cl.sanskrit.du.ac.in> under e-learning tools. This system might play a very important role in teaching and learning process of Sanskrit Feminine Suffixes because of lack of existing effective online tools, which cover courses of Sanskrit in higher education.

In order to develop the proposed system, the rule and example based hybrid approach is used according to the traditional system. Web tools and techniques are used in addition to the methods of computational linguistics. As a part of programming, system is developed in Python programming language. Spycy webserver is used for web server. The Cascading Style Sheets (CSS) and JavaScript are used for page decoration and styling. The system accepts the input in Devanagari Unicode text and generate the result in same format. The system automatically recognize, analyze and

generate the word formation process of Sanskrit words ends with feminine affixes according to Pāṇinian formulation. System prints the complete derivational process of input text in form in tabular format on the user interface as result. The result table is divided into two columns and various rows as per requirements. Pāṇinian rules with the function of the rules are written in first column. Changes in stem/root and suffix due to particular rules are written in second column. All rules of the *siddhi* has over mouse function. On the movement of the mouse on any rule the meaning of the AD rules display in pop-window automatically and after clicking on the rule the explanation of the rules appeared in new window.

With the objective to innovate classroom teaching and learning and e-learning and self-learning there is no such system is developed till date which can generate the whole derivational process of Sanskrit words ends with feminine suffixes based on Pāṇinian rules where students and teachers can be directly benefitted and able to learn the process online using internet. Therefore, this system is playing an important role to learn the feminine suffixes. Based on the survey of research works, it is clear that there is no such type of research has been done yet related to web based system for recognition, analysis and formation process of Sanskrit feminine words. The current system will be the part of developed system SWAGATAM (Chandra et al, 2017) by the department of Sanskrit, University of Delhi.

The major finding of the research is:

- Implementation Pāṇinian rules of computer.
- Challenges of computing Pāṇinian rules.
- Computational methods to compute the Ad rules.
- Computational rules for identification of Sanskrit feminine words.
- Computational rules for analysis of Sanskrit feminine words.
- Computational rules for automatic *siddhi* generation of Sanskrit feminine words.
- Development of an online system for derivational process of Sanskrit words ends with feminine suffixes.
- Digitization of Pāṇinian rules with meaning, explanation and work for online search in AD rules.
- Digitization for various *gaṇapāṭha*.

System has few limitations such as system is dependent on the supRecognizer system. If the supRecognizer return wrong *Prātipadika* then this system may fail to identify correct *Prātipadika*, as well correct suffix. In few cases the identification of *Prātipadika* is also challenging. The *siddhi* generation depends on the feminine suffix recognition and recognition of feminine word is challenging task in Sanskrit.

Various works have been done in the field of e-learning for other languages but there is no such efforts for Sanskrit. Therefore, it was a successful effort to promote Sanskrit and learn the Sanskrit online.

2. Features of Web based Recognition, Analysis and Derivation Process Generator System for Feminine Words

Web based Recognition, Analysis and Derivation Process Generator System for Feminine Words is an intelligent system. In this system user has to write only input text. Remaining work system does automatically. System is developed using rule and example based approach, so the accuracy is around 100%. There are following special features of the system.

2.1 User Friendly

As stated earlier, to use this system, user needs to enter only feminine word in input text box, remain work system does automatically. Due to intelligence of the system is very much user friendly.

2.2 Automatic Recognition

Gender recognition in Sanskrit is very challenging task due to variations in nature and structure. But this system does the identification automatically with the help of recognition rules.

2.3 Full Analysis with Complete Description

This system provides the complete information of the analyzed words. It includes nominal base, feminine suffix, feminine base and sup suffix, case and number etc. This system can be used for parser and machine translation.

2.4 Derivation Process with Complete Rules

The system also provides the *siddhi* with all essential rules, the rules described in other *prakaraṇās* of the Sanskrit grammar such as *sandhi*, *subanta*, *tiṅnta*, *kṛdanta* etc. So the system is very useful for teachers and students.

2.5 Assistance for Self Learning and Teaching

System is very useful for self learning and teaching. User can learn whole *siddhi* process from anywhere anytime through internet. The *siddhi* provided by the system is very useful and each *sūtra* is hyperlinked with meaning and explanation of that particular *sūtra*. The meaning can be seen instant just keeping the cursor on the *sutra*. Whereas, while reading by book user has to go to the particular page to see the details of the *sūtras*.

3. Future Directions of Research

This research provide a broad vision and direction for future researchers. In future ample work can be done. Out of them few are following:

3.1 Development of Multilingual System

As stated, the system accept only Devanagari Unicode input and provide the result in same format. So, the current system is available only for Hindi medium students. In future the rules and methodology may be easily converted in any language medium e.g. Sanskrit, English, Bangla, Punjabi etc.

3.2 Development of the System for other parts of the *Siddhāntakaumudī*

The methodology used in this system can be used to develop the system for other part of LSK and SK with few efforts.

3.3 Voice Input and Output

The input of this system is written or text format only but in future due to huge uses of speech technology and development the system can be developed to accept the input as voice and out may also be voice. This types of system will be very useful for blind students.

References

1. Agrawal, Muktanand. *Computational identification and analysis of Sanskrit verb-forms of bhvaadigana*. M.Phil. dissertation. Jawaharlal Nehru University, New Delhi, 2008.
2. Allen, W. Sidney. *Zero and Pāṇini*. *Indian Linguistics* 16.106.13, 1955.
3. Ayachit, S. M. *Gaṇapāṭha-A Critical Study*. Ph. D dissertation. University of Poona, 1958.
4. Bharati, Akshar. Medhavi Bhatia, Vineet Chaitanya, and Rajeev Sangal. *Pāṇinian grammar framework applied to English*. Department of Computer Science and Engineering, Indian Institute of Technology, Kanpur, 1996.
5. Bharati, Akshar, Vineet Chaitanya, and Rajeev Sangal. *Pāṇinian framework and its application to anusaraka*. *Sadhana*, 19(1):113–127, 1994.
6. Bakarola, Vishvajit, and Jitendra Nasriwala. *Computational Representation of Pāṇinian Rules of Sanskrit Grammar for Dictionary-Independent Machine Translation*. International Conference on Advances in Computing and Data Sciences. Springer, Singapore, 2019.
7. Bala, Shashi. *Cāndra evaṃ pāṇinīya vyākaraṇa meṃ strīpratyayoṃ kā tulanātmaka adhyayana*. M.Phil. Dissertation, Department of Sanskrit, University of Delhi, Delhi, 2003.
8. Banerji, Sures Chandra. *A Companion to Sanskrit Literature: Spanning a Period of Over Three Thousand Years, Containing Brief Accounts of Authors, Works, Characters, Technical Terms, Geographical Names, Myths, Legends and Several Appendices*. Motilal Banarsidas Publisher, 1989.
9. Bharati, Akshar, et al. *Anusaaraka: Machine translation in stages*. Vivek-Bombay, 1997.
10. Bharati, Akshar, et al. *Anusaaraka: machine translation in Stages*. 2003.
11. Bharati, Akshar. et al. *Pāṇinian grammar framework applied to english*. Department of Computer Science and Engineering, Indian Institute of Technology, Kanpur. 1996.
12. Bharati, Akshar, et al. *Natural language processing: a Pāṇinian perspective*. New Delhi: Prentice-Hall of India, 1995.
13. Bhate, Saroja, and Subhash Kak. *Pāṇini's grammar and computer science*. *Annals of the Bhandarkar Oriental Research Institute*, Poona. 1991.
14. Bhate, Saroja. *Some primary and secondary suffixes known to Yāska*. University of Poona, 1968.
15. Bhate, Saroja. *Pāṇini*. Sahitya Akademi, 2002.
16. Bhatt, Arunkishor. *Siddhahaimaśabdānuśāsana evaṃ pāṇini vyākaraṇa ke strī prakaraṇoṃ kā tulanātmaka adhyayana*. M.Phil. Dissertation, Department of Sanskrit, University of Delhi, Delhi, 2017.

17. Bhattacharjya, Sudeshna. *The paribhāsha prakarana of siddhāntakaumudī an extensive study*. Ph.D thesis, Gauhati University, 2006.
18. Bird, Steven, Ewan Klein, and Edward Loper. *Natural language processing with Python: analyzing text with the natural language toolkit*. "O'Reilly Media, Inc. 2009.
19. Briggs, Rick. *Knowledge representation in Sanskrit and artificial intelligence*. AI magazine. 1985.
20. Cardona, George. *Pāṇini Re-Interpreted*. 1991: 839-839.
21. Cardona, George. *Still Again on the History of the Mahābhāṣya*. *Annals of the Bhandarkar Oriental Research Institute* 58, 1977: 79-99.
22. Cardona, George. *Pāṇini: A survey of research*. Motilal Banarsidass Publishers, 1997.
23. Chandra, Subhash, and Girish Nath Jha. *Computer Processing of Sanskrit Nominal Inflections: Methods and Implementation*. Cambridge Scholars Publishing, 2011.
24. Chandra, Subhash. *Machine recognition and morphological analysis of subanta-padas*. M.Phil. Dissertation. Jawaharlal Nehru University, New Delhi, 2007.
25. Chandra, Subhash. *Ontological Knowledge Base for selected verbs of Sanskrit and Bangla*. Ph.D. thesis. Jawaharlal Nehru University, New Delhi, 2011.
26. Chandra, Subhash. *Knowledge Representation for Sanskrit Verb Argument Valence Authentication: An Ontological Approach*. Scholars' Press, 2016.
27. Chaudhury, Sriram, Ankitha Rao, and Dipti M. Sharma. *Anusaaraka: An expert system based machine translation system*. *Proceedings of the 6th International Conference on Natural Language Processing and Knowledge Engineering (NLPKE-2010)*. IEEE, 2010.
28. Coward, Harold G., and K. Kunjunni Raja. *The Encyclopedia of Indian Philosophies, Volume 5: The Philosophy of the Grammarians*. Vol. 1235. Princeton University Press, 2015.
29. Devasthali, Govind Vinayak. *Anubandhas of Pāṇini*. No. 2. University of Poona, 1967.
30. Durgasiṃha. *Liṅgānuśāsana: Crit. Ed. by Dattatrey Gangadhar Koparkar*. Deccan College, 1952.
31. Dwivedi, Kapil Dev. *Vaidic Sahitya Evam Sanskriti*. Vishwavidyalaya Prakashan, Varanasi, 2010.
32. Dwivedi, Parasnath. *Vaidik Sahitya Ka Itihas*. Chowkhamba Surabharti Prakashan, 2017.
33. Dwivedi, Vidyadhar. *Prakriyākaumudīsiddhāntakaumudyo: strīpratyayāntabhāgasya tulanātmakamadhyayanam*. Ph.D thesis, Rāṣṭriya saṃskṛta saṃsthāna, Allahabad parisar, 1992.
34. Esterbrook, Charles. *Comparison to Python. cobra-language. Com*, 2010.

35. Ganeri, Jonardon. *Artha: Meaning*. Oxford University Press, 2013.
36. Ghosh, Mano Mohan. *Pāṇiniya Shiksha (Critical Edition) with Translation*. University of Calcutta, 1938.
37. Gokhale, Shreyas. *A survey on the ongoing and future research in Sanskrit Computational Linguistics*.
38. Govindacharya and Sharma, Laxmi. *Vyakaran Siddhant Kaumudi*. Chaukhambha Surbharati Prakashan. 2015.
39. Govindacharya. *Laghu Siddhanta Kaumudi (Sanskrit & Hindi Translation)*. Chaukhambha Surbharati Prakashan. 2010.
40. Gupta, Abhijeet, et al. *A novel approach towards building a portable system using the computational Pāṇinian grammar framework*. 2012 International Conference on Asian Language Processing. IEEE, 2012.
41. Haag, Pascale, and Vincenzo Vergiani, eds. *Studies in the Kāśikāvṛtti: The Section on Pratyāhāras: Critical Edition, Translation and Other Contributions*. Anthem Press, 2011.
42. Harṣavardhana, Pṛthivīśvara, and V. Venkatarama Sharma. *Liṅgānuśāsana by Harṣavardhana with the Commentary Sarvalakṣaṇā by Pṛthivīśvara: Crit. Ed. from Orig. Mss., and with and Intr., Indices and Appendices by V. Venkatarama Sharma*. University of Madras, 1931.
43. Hetland, Magnus Lie. *Python and the Web. Beginning Python: From Novice to Professional*, 2005.
44. HTML5 is a W3C recommendation. *W3C Blog*. World Wide Web Consortium (W3C). 28 October 2014. Retrieved 28 January 2020.
45. HTML5: A vocabulary and associated APIs for HTML and XHTML. W3.org. W3C. 22 January 2008. Retrieved 10 January 2020.
46. Jha, Girish N. *Morphology of Sanskrit Case Affixes: A Computational analysis*. M.Phil. Dissertation. Jawaharlal Nehru University, New Delhi, 1993.
47. Jha, Girish N. *The system of Pāṇini. Language in India* 4.2, 2004.
48. Johnson, W. J. *A Dictionary of Hinduism*. Oxford University Press, 2009.
49. Joshi, Dayashankar M. *Pāṇini's 'taddhita' affixation Rules*. 1969.
50. Joshi, S. D. *Two methods of interpreting Pāṇini*. 1966.
51. Joshi, Shivram Dattatray, and Saroja Bhate. *The Role of the Particle Ca in the Interpretation of the Aṣṭādhyāyī*. University of Poona, 1983.
52. Joshi, Shivram Dattatray. *The fundamentals of anuvṛtti*. No. 9. University of Poona, 1984.
53. Kadvany, John. *Pāṇini's Grammar and Modern Computation, History and Philosophy of Logic*. 2016.
54. Kak, Subhash C. *The Pāṇinian approach to natural language processing. International Journal of Approximate Reasoning*. 1987.
55. Kak, Subhash C. *The Pāṇinian approach to natural language processing, International Journal of Approximate Reasoning*, 1987.

56. Kale, Moreshwar Ramchandra. *A Higher Sanskrit Grammar: for the Use of Schools and Colleges*. Motilal Banarsidas Publishers, 1972.
57. Kanschiram. *The Laghusiddhanta Kaumudi of Varadaraja: A Primer of Pāṇini's Grammar*. Motilal Banarasidas, New Delhi. 2012.
58. Katre, Sumitra Mangesh. *Pāṇinian Studies: Dictionary of Pāṇini: Gaṇapātha*. Vol. 52. Deccan College Postgraduate and Research Institute, 1971.
59. Kavita, S. *Sārasvatavyākaraṇe strīpratyaṅakārayo: bhāṣāvijñānadr̥ṣṭyāsamīkṣātmakamadyayanam*. Ph.D. thesis, Rāṣṭrīya saṃskṛta saṃsthāna, Guruvayur Campus, 1999.
60. Kielhorn, F. *Vyākaraṇa-Mahābhāṣya of Patañjali*. Bhandarkar Oriental Research Institute, Poona. 1992.
61. Kielhorn, Franz, ed. *The Vyākaraṇa-Mahābhāṣya of Patañjali*. No. 18-22. Government central book depot, 1906.
62. Kielhorn, Franz. *Katyayana and Patanjali: their relation to each other and to Pāṇini*. The Education Society's Press, 1976.
63. Kuhlman, Dave. *A python book: Beginning python, advanced python, and python exercises*. Lutz: Dave Kuhlman, 2009.
64. Kulkarni, Amba P. *Design and Architecture of 'Anusaaraka'-An Approach to Machine Translation*. Satyam Technical Review 3 (2003): 57-64.
65. Kuntal, Archana. *Pāṇinīya tathā vāmanīya liṅgānuśāsanam meṃ liṅganirdhāraṇa kī vyākaraṇika pravidhiyāṃ*. M.Phil. Dissertation, Department of Sanskrit, University of Delhi, Delhi, 2017.
66. Lochtefeld, James G. *The Illustrated Encyclopedia of Hinduism, Volume 1*. Vol. 1. The Rosen Publishing Group, Inc, 2001.
67. Matilal, Bimal Krishna. *The Word and the World India's Contribution to the Study of Language*. 1990.
68. McDonald, James C. *Python Web Developer Appliance Users Guide*. 2006.
69. Mehto, Damodar. *Pāṇinīya Shiksha*. Motilal Banarasidas, India, 2005.
70. Mijailovic, Zarko, and Dragan Milicev. *A retrospective on user interface development technology*. *IEEE software* 30.6, 76-83. 2013.
71. Mimansak, Yudhishtir. *Sanskrit Vyakaran Shastra Ka Itihas*. Vol. 3, Ramlal Kapoor Trust Press, Bahalgarh, Sonipat, Haryana, 2014.
72. Mishra, Madhusudan. *Critical study of the vartikas of katyayana*. 1992.
73. Mishra, Vidya Niwas. *The descriptive technique of Pāṇini: An introduction*. Vol. 18. Walter de Gruyter GmbH & Co KG, 2017.
74. Morgan, Kenneth W., ed. *The religion of the Hindus*. Motilal Banarsidas Publishers, 1987.
75. Palasule, Gajānana Bālakṛṣṇa. *The Sanskrit Dhātupāṭhas: A Critical Study*. Diss. Deccan College Postgraduate and Research Institute, 1961.
76. Palsule, G. B. *The Role of k-r in the Sanskrit Grammatical Terms*. University of Poona. 1969.

77. Palsule, Gajanan Balkrishna. *Some Primary Nominal Formations Missing in Pāṇini*. University of Poona, 1968.
78. Palsule, Gajanan Balkrishna. *Some Views of Pāṇini and His Followers on Object Language and Meta-language*. University of Poona, 1970.
79. Panchal, Bhavin, Vishvajit Bakrola, and Dipak Dabhi. *An efficient approach of knowledge representation using Pāṇinian rules of Sanskrit grammar. Recent Findings in Intelligent Computing Techniques*. Springer, Singapore, 199-206, 2018.
80. Pandey, Ramji. *Pāṇiniśākaṭāyana sārasvata vyākaraṇeṣu strīpratyayavidhāyakāṇām sūtrāṇām tulanātmakamadyayanam*. Ph.D thesis, Rāṣṭriya saṃskṛta saṃsthāna, Jammu parisar, 1992.
81. Pandit, M. D. *Pāṇini: Statistical Study of Sanskrit Formations*. Bhandarkar Oriental Research Institute, 1971.
82. Pandit, M. D. *Pāṇinian it-aamjñā—A symbolic zero*: Deccan College Research Institute, 1966.
83. Pandit, M. D. *Mathematical Representation of Some Pāṇinian Sūtras*. University of Poona, 1966.
84. Pataskar, B. A., and Vashishtha Narayan Jha. *Bibliography of Vyakarana*. Centre of Advanced Study in Sanskrit, University of Poona, 1997.
85. Peter, M. Scharf. *Early Indian grammarians on a speaker's intention*. Journal of the American Oriental Society, pages 66–76, 1995.
86. Peter, M. Scharf. *The denotation of generic terms in ancient indian philosophy: Grammar. Nyāya, and Mimāṃsā*, American Philosophical Society, Philadelphia, 1996.
87. Petersen, Wiebke, and Oliver Hellwig. *Annotating and analyzing the Aṣṭādhyāyī*. Proceedings of CILC, 2014.
88. Puder, Arno. *Construction of generic Web-based user interfaces. OTM Confederated International Conferences: On the Move to Meaningful Internet Systems*. Springer, Berlin, Heidelberg, 2003.
89. Raggett, Dave. *HyperText Markup Language Specification Version 3.0. HTML 3.0 Internet Draft Expires in six months*. World Wide Web Consortium. 28 March 1995, Retrieved 17 January 2020.
90. Rajeev Sangal and Vineet Chaitanya. *An intermediate language for machine translation: An approach based on Sanskrit using conceptual graph notation*. *Computer Science and Informatics Journal, Computer Society of India*, 1987.
91. Ramanujan, P. *Computer processing of Sanskrit*. *Computer Processing Of Asian Languages CALP-2*, IIT Kanpur, 1992.
92. Rani, Vandana. *Prakriyāsamgraha tathā laghusiddhāntakaumudī ke strīpratyaya prakaraṇa kā tulanātmaka adhyayana*. M.Phil. Dissertation, Department of Sanskrit, University of Delhi, Delhi, 2013.

93. Rao, T. R. N., and Kak Subhash. *The Pāṇini-Backus Form in Syntax of Formal Languages*. Center for Advanced Computer Studies, University of Southwestern Louisiana, 1998.
94. Reddy, P. *Fuzzy Modeling and Natural Language Processing for Pāṇini's Sanskrit Grammar*. 2010.
95. 'Rishi', Umashankar Sharma. *Sanskrit Sahitya Ka Itihas*. Chowkhamba Bharati Academy, 2016.
96. Rocher, Rosane. *The Descriptive Technique of Pāṇini: An Introduction*. 1970.
97. Ruslan Mitkov. *The Oxford handbook of computational linguistics*. Oxford University Press, 2005.
98. Saxena, Shashank, and Raghav Agrawal. *Sanskrit as a programming language and natural language processing*. Global Journal of Management and Business Studies. 2013.
99. Scharf, Peter M. *The denotation of generic terms in ancient Indian philosophy: Grammar, Nyāya and Mīmāṃsā*. Vol. 83. American Philosophical Society, 1996.
100. Scharfe, Hartmut. *Grammatical literature*. Vol. 2. Otto Harrassowitz Verlag, 1977.
101. Schubert, Lenhart. *Computational Linguistics*. The Stanford Encyclopedia of Philosophy, spring 2019.
102. Selot, Smita, Neeta Tripathi, and A. S. Zadgaonkar. *Knowledge representation in Pāṇini framework using neural network model*. BVICA M's International Journal of Information Technology. 2013.
103. Sen, Samarendra Nath, Bag, Amulya Kumar. *The Śulbasūtras of Baudhāyana, Āpastamba, Kātyāyana and Mānava: with text, English transl. and comm. by SN Sen and AK Bag*. Indian National Science Academy, 1983.
104. Sharma, Aryendra. *Kasika - a commentary on Pāṇini's grammar by Vamana and Jayaditya*. Hyderabad: Osmania University, Sanskrit Academy, 1985.
105. Sharma, Rama Nath. *The Aṣṭādhyāyī of Pāṇini*. Munshiram Manoharlal Publishers Pvt. Ltd. 2008.
106. Sharma, Rama Nath. *Astadhyayi of Pāṇini, Volume 1 Introduction to the Astadhyayi as a Grammatical Device*. Munshirm Manoharlal, Delhi, 2002.
107. Shastri, Bhimsen. *Laghusiddhanta Kaumudi*. Bhaimi Prakashan, Delhi. 1983.
108. Shastri, Bhimsen. *Laghusiddhanta Kaumudi*. Bhaimi Prakashan, Delhi. 2009
109. Shastri, Charudev. *Vyākaraṇa-mahābhāṣya-bhagavatpatañjali viracita: prathama navāhnik*. Motilal Banarsidas Publishers, 2017.
110. Shastri, Kapiladeva. *The Gaṇapāṭha*. Department of Sanskrit, Kurukshetra University, 1967.
111. Staal, J. F. Euclid. *Philosophy East and West*, 1965.
112. Sudha A., *Siddhantakaumudi and Sarasvatavyakarana. A Comparative Study with reference to Samjna and Sandhi Prakaranas*. Ph.D thesis, University of

- Kerala, 2005. Spyce - Python Server Pages (PSP) User Documentation, Release 2.1, retrieved February 10, 2020.
113. Spyce - Python Server Pages, URL: <http://spyce.sourceforge.net/docs/license.html>, Obtained on February 10, 2020.
 114. Upadhyaya, Acharya Baldev. *Sanskrit Shastron Ka Itihas*. Chowkhamba Vidyabhawan, Varanasi, 2010.
 115. Upadhyaya, Baldev, et al. *Sanskrit Vangmaya Ka Brihad Itihas*. Vol. 17, Uttar Pradesh Sanskrit Sansthan, Lucknow, 2012.
 116. Van Rossum, Guido. *Python Programming Language*. USENIX annual technical conference. Vol. 41. 2007.
 117. Varmā, Satyakāma. *Vākyapadīyam: Brahmakāṇḍa*. Munshiram Manoharlal, New Delhi, 1970.
 118. Vasu, S. *The Siddhānta kaumudī of Bhaṭṭojī Dīkṣita*. Motilal Banarasidas, New Delhi. 2017.
 119. Witzel, Michael. *On the Archetype of Patañjali Mahabhasya*. Indo-Iranian Journal, 1986. W3Schools, URL: https://www.w3schools.com/Python/python_getstarted.asp, Obtained on February, 10, 2020.
 120. What is CSS? World Wide Web Consortium. Retrieved 20 January 2020.
 121. Yagi, T., Joshi SD and SD Laddu. *Proceedings of the International Seminar on Studies in the Astadhyayi of Pāṇini* (Book Review). Orientalistische Literaturzeitung.1988.

Bibliography

1. Acharya, Sudarshandev. *Pāṇiniya Ashtadhyayi Pravachanam*. Brahamarshi Swami Virajanand Arsh Dharmaarth nyas Gurukul Sansthan, Haryana. 1997.
2. Aggarwal, Piyush. *Pāṇinian Samasa Recognition and Processing: A rule based approach*. Ph.D Thesis Department of Sanskrit, Panjab University, Chandigarh. 2015.
3. Agrawal, Muktanand. *Computational identification and analysis of Sanskrit verb-forms of bhvaadigana*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2007.
4. Basu, SC. *The astadhyayi of Pāṇini*. Motilal Banarsidass Publication, New Delhi. 1980.
5. Belvalkar, Shripad Krishna, *The Systems of Sanskrit Grammar*, Poona. 1915.
6. Bhadra, Manji. *Computational analysis of gender in Sanskrit noun phrases for Machine Translation*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2007.
7. Bhadra, Manji. *knowledgebase for karma-kaaraka*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2012.
8. Bhowmik, Priti. *Evolving e-learning methods for Sanskrit elearning in the context of secondary syllabus of CBSE*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2009.
9. Cardona, George, *Pāṇini a survey of Research*, Motilal Banarasidas, Delhi. 1976.
10. Cardona, George, *Recent Research in Pāṇinian studies*, Motilal Banarsidas, Delhi. 1999.
11. Cardona, George. *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*. Springer Netherlands. 2008.
12. Cardona, George. *Pāṇini: A survey of research*. Motilal Banarsidass Publication, New Delhi. 1997.
13. Chadrashekar, R. *Part-Of-Speech Tagging for Sanskrit*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2007.
14. Chakraborty, Deepro. *Critical Edition of the Atreya-Shiksha*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2013.
15. Chandra, Subhash. *Machine recognition and morphological analysis of subantapadas*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2007.
16. Chandra, Subhash. *Ontological Knowledge Base for selected verbs of Sanskrit and Bangla*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2011.
17. Chaudhury, Narayan, Kumar. *Great Andamanese Verb Analyzer*. M.Phil Diss. Center for Linguistics, School of Language Literature & Culture Studies, Jawaharlal Nehru University of Delhi, Delhi. 2007.

18. Das, Paritosh. *Index Based Search for Brhadaranyaka Upanisad*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2011.
19. Dash, Siniruddha (Ed.), *New Catalogus Catalogorum (An Alphabetical Register of Sanskrit and Allied works and Authors- Vol. XXVIII)*, University of Madras. 2013.
20. Gopal, Madhav. *Computational Methods for Anaphora and Cataphora Resolution in the Sanskrit Text Panchatantra*. M.Phil Diss. Center for Linguistics, School of Language Literature & Culture Studies, Jawaharlal Nehru University of Delhi, Delhi. 2011.
21. Joshi, Shivram Dattatray, and J. A. F. Roodbergen. *The Aṣṭādhyāyī of Pāṇini with translation and explanatory notes*. Vol. 11. Sahitya Akademi. 1991.
22. Karl H., Potter, *Encyclopaedia of Indian Philosophies (vol-v)*, Motilal Banarsidas, Delhi. 1990.
23. Katre, Saumitra M. *Aṣṭādhyāyī of Pāṇini*. Motilal Banarasidas, New Delhi. 1989.
24. Khandoliyan, Baldev. *Vanaushadhi-varga of Amarakosha: A computational study*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2011.
25. Kumar, Sachin. *Sandhi splitter and analyzer for Sanskrit (with special reference to aC Sandhi)*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2007.
26. Kumar, Sachin. *Named Entity Recognition for Sanskrit: a hybrid approach*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2012.
27. Mandal, Anusrita. *Critical Edition of Itihaasottama*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2014.
28. Meena, Geeta Kumari. *Sanskrit loan words in Bahasa Indonesia: a lexicographic approach*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2017.
29. Mishra, Diwakar. *Issues and challenges in computational processing of vyanjana sandhi*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2009.
30. Mishra, Diwakar. *Samvacaka - A Speech Synthesis System for Sanskrit Prose*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2013.
31. Mishra, Mukesh, Kumar. *Computational analysis of Sanskrit homonyms in the context of naanaartha varga of Amarakosha*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2010.
32. Mishra, Sudhir Kumar. *Sanskrit karaka analyzer for Machine Translation*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2007.

33. Niranjana, T. R. *Ashtadhyayi mein adesh vidhayak sūtra-ek samikshatamak adhyayan*. 2005.
34. Pandey, Rajneesh. *Online Indexing of Sushruta Samhita*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2011.
35. Pandey, Rajneesh. *Sanskrit-Hindi Statistical Machine Translation: Perspectives & Problems*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2015.
36. Pathak & Chitrao (comp.), *Word Index to Pāṇini-Sūtra-Path and Parisistas*, B.O.R.I., Poona. 1985.
37. Pathak, Kumar Nripendra. *Verb Mapping for Sanskrit Hindi Translator (SaHiT)*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2015.
38. Pathak, Nripendra. *Challenges in Sanskrit Hindi Noun Phrase Mapping*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2011.
39. Rajput, Devendra. *E-book on Shrimadbhagavadgita: with special reference to chapter 1*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2013.
40. Sharma, Rama Nath. *The aṣṭādhyāyī of Pāṇini: english translation of adhyāyas seven and height with sanskrit text, transliteration, word-boundary, anuvṛtti, vṛtti, explanatory notes, derivational history of examples, and indices*. Vol. 6. Munshirm Manoharlal Pub Pvt Limited. 2003.
41. Sil, Parthasarathi. *Critical Edition of The Vaidikacchandahprakāśa*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2014.
42. Singh Surjit, Kumar. *Kridanta recognition and processing for Sanskrit*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2008.
43. Soni, Chitresh. *Issues and challenges in Sanskrit to English machine Translation*. Ph.D Thesis Department of Sanskrit, MLSU, Udaipur, Rajasthan. 2015.
44. Tiwari, Archana. *Automatic Indexing of Carakasamhita*. M.Phil Diss. Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2011.
45. Tiwari, Archana. *Statistical POS Tagger for Sanskrit: Methods, Modality & Challenges*. Ph.D Thesis Special Centre for Sanskrit Studies, Jawaharlal Nehru University, New Delhi. 2015.

Bibliography in Hindi Language-

1. आर्य, करमवीर. 2005. महाभाष्य के परिप्रेक्ष्य में तद्धित प्रत्ययों की समीक्षा. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
2. आर्य, कुलदीप. 2007. धातुपाठों में हिंसार्थक एवं शब्दार्थक धातुओं का अर्थज्ञानिक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
3. हरीश. 1994. धात्वर्थनिर्णय एवं धात्वर्थनिरूपण का तुलनात्मक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
4. कुमारी, सुमन. 1988. संस्कृत धातुओं का विकास. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
5. नीलम. 2012. हरविजयम महाकाव्य में प्रयुक्त क्रियारूपों का संरचनात्मक एवं अर्थमूलक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
6. रामचन्द्र. 2008. सरस्वतीकण्ठाभरण और सिद्धान्तकौमुदी के तद्धित प्रकरण का तुलनात्मक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
7. सेठ, अनुपमा. 1997. हेमचन्द्र के धातुपरायण का समालोचनात्मक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
8. त्रिपाठी, सुजाता. 2001. पाणिनीय धात्वाधिकार का समीक्षात्मक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
9. विमल, कामना. 2006. कृतप्रत्ययों का संरचनात्मक एवं अर्थमूलक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
10. ईश्वरचन्द्र (व्या.). 2004. पाणिनीयं लिङ्गानुशासनम् (आशुबोधिनी संस्कृत-हिन्दी टीका सहित). चौखम्बा संस्कृत प्रतिष्ठान, दिल्ली.
11. उदयभानु. 1995. पाणिनीय लिङ्गानुशासन के आधार पर लिङ्ग निर्धारण के सिद्धान्त. लघु शोधप्रबन्ध, संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
12. उदयभानु. 2002. संस्कृत व्याकरणों में उपलब्ध लिङ्गानुशासनों का तुलनात्मक अध्ययन. पी.एचडी. संस्कृत विभाग, दिल्ली विश्वविद्यालय, दिल्ली.
13. उपाध्याय, बलदेव. 2013. संस्कृत शास्त्रों का इतिहास (तृतीय परिच्छेद). सोनीपत, हरियाणा.
14. उपाध्याय, रामजी (सम्पादक). 1986. भासनाटकचक्रम्. भारतीय संस्कृत संस्थान, वाराणसी.

15. ऋग्वेद (सायणभाष्यसहित). शकसंवत् 1868. वैदिक संशोधन मण्डल, पूना.
16. गुप्त, क्षेमेन्द्र कुमार. 1973. काव्यादर्श. मेहरचन्द्र लक्ष्मणदास प्रकाशन, दिल्ली.
17. गोयल, प्रीतिप्रभा. 1998. संस्कृत साहित्य का इतिहास. राजस्थानी ग्रन्थागार, जोधपुर.
18. गोविन्दाचार्य (व्या.) एवं शर्मा, लक्ष्मी (संपा.). 2011. वैयाकरणसिद्धान्तकौमुदी श्रीधरमुखोल्लासिनी हिन्दी व्याख्या समन्विता. चौखम्बा सुरभारती प्रकाशन, वाराणसी.
19. चौबे, ब्रजबिहारी. 1972. वैदिक वाङ्मयः एक अनुशीलन, कात्यायन वैदिक साहित्य प्रकाशन, होशियारपुर.
20. जिज्ञासु, ब्रह्मदत्त (सम्पा.). 1974. धातुपाठः. श्री रामलाल कपूर ट्रस्ट, सोनीपत.
21. जिज्ञासु, ब्रह्मदत्त (सम्पा.). 2010. अष्टाध्यायी सूत्रपाठः. श्री रामलाल कपूर ट्रस्ट, सोनीपत.
22. जिज्ञासु, ब्रह्मदत्त. 1952. काशिकावृत्ति. चौखम्बा संस्कृत सीरीज, वाराणसी.
23. जिज्ञासु, ब्रह्मदत्त. 1998. अष्टाध्यायी. रामलाल कपूर ट्रस्ट, रेवली.
24. जिज्ञासु, ब्रह्मदत्त. 2000. प्रथमावृत्ति भाग -2. रामलाल कपूर ट्रस्ट, रेवली.
25. झा, तारिणीश (व्या.). 1982. उत्तररामचरित. रामनारायण लाल वेणीप्रसाद, इलाहाबाद.
26. झा, नरेश (व्या. एवं सम्पा.). 2008. लिङ्गानुशासनम्. चौखम्बा सुरभारती प्रकाशन, वाराणसी.
27. झा, वेचन. 1991. काव्यालङ्कार-सूत्रवृत्ति. चौखम्बा संस्कृत संस्थान, वाराणसी.
28. तारानाथ, तर्कवाचस्पति. 1812-1885. वाचस्पत्यम्. काव्यप्रकाश प्रेस, कलकत्ता.
29. त्रिपाठी, रामशंकर(सम्पा.). 1969. मृच्छकटिकम्. मोती लाल बनारसीदास, दिल्ली.
30. त्रिपाठी, रामसुरेश. 1972. संस्कृत व्याकरण दर्शन. राजकमल प्रकाशन, दिल्ली.
31. त्रिपाठी, शंकरलाल (सम्पा०). 1954. मृच्छकटिकम्. कृष्णदास अकादमी, वाराणसी.
32. त्रिपाठी, शम्भुनाथ (सम्पा.). 2013. नाममाला. भारतीय ज्ञानपीठ, नई दिल्ली.
33. त्रिपाठी, शम्भुनाथ (सम्पा.). सं. 2040. विश्वप्रकाश. भारतीय ज्ञानपीठ, नई दिल्ली.
34. दधीचि, शिवदत्त (सम्पा.). 1986. शिशुपालवधम्. कृष्णदास अकादमी, वाराणसी.
35. दीक्षित, पुष्पा. 2011. अष्टाध्यायी सहजबोध. प्रतिभा प्रकाशन, दिल्ली.
36. देव, आचार्य सुदर्शन (व्या.). 1971. लिङ्गानुशासनवृत्ति : आचार्य पाणिनि. साहित्य संस्थान, गुरुकुल झज्जर, रोहतक.
37. द्विवेदी, कैलाशनाथ. 2005. अभिज्ञान-शाकुन्तलम्, महाकवि कालिदास प्रणीतम्. संस्कृत-हिन्दी-व्याख्या सहित, सब्लाइम प्रकाशन.

38. भट्टाचार्य, रामशंकर (सम्पा.). 1963. *गरुडपुराण*. बम्बई.
39. मणि, रविकान्त (सम्पा.). 2008. *रघुवंशमहाकाव्यम्*. हंसा प्रकाशन, जयपुर.
40. योगी, सत्यभूषण (सम्पा.). 1966. *मनुस्मृति*. मोतीलाल बनारसीदास, दिल्ली.
41. लाल, कृष्ण. 2001. *वैदिकसंग्रह*. ईस्टर्न बुक लिंकर्स, दिल्ली.
42. वर्मा, सत्यकाम. सं. 1971. *व्याकरण की दार्शनिक भूमिका*. मुंशीराम मनोहरलाल, दिल्ली.
43. विद्याभास्कर, रामावतार. 2014. *पञ्चदशी*. भारतीय विद्या संस्थान, वाराणसी.
44. वी., उपाध्याय (सम्पा.). 1981. *अभिधानसंग्रह*. एस.एन. पब्लिकेशन, दिल्ली.
45. शर्मा, दीप्ति. 1975. *व्याकरणिक कोटियों का विश्लेषणात्मक अध्ययन*. बिहार हिन्दी ग्रन्थ अकादमी, पटना.
46. शर्मा, देवीदत्त. 1974. *संस्कृत का ऐतिहासिक एवं संरचनात्मक परिचय*. हरियाणा हिन्दी ग्रन्थ अकादमी, हरियाणा.
47. शर्मा, देवीदत्त. 2000. *संस्कृत भाषा का इतिहास*. चौखम्बा विद्याभवन, वाराणसी.
48. शर्मा, शुकदेव (सम्पा.). 2015. *नैषधीयचरितम् (प्रदीपिका टीका सहित)*. भारतीय विद्या प्रकाशन, वाराणसी.
49. शर्मा, शेषराज (व्या.). 1992. *मेघदूत*. चौखम्बा विद्याभवन, वाराणसी.
50. शर्मा, शेषराज. 2012. *नैषधीयचरितम् : संस्कृत-हिन्दी-व्याख्या सहित*, चौखम्बा सुरभारती प्रकाशन, वाराणसी.
51. शर्मा, श्रीराम (सम्पा.). 1969. *अग्निपुराण*. संस्कृत संस्थान, ख्वाजा कुतुब, बरेली.
52. शर्मा, श्रीराम. 1967. *यजुर्वेद*. संस्कृत संस्थान बरेली, उत्तरप्रदेश.
53. शर्मा, सुब्राय. 2006. *वेदान्तसंवत्सर*. श्री नित्यानन्द प्रकाशन, बेंगलुरु.
54. शास्त्री, चारुदेव. 1973. *व्याकरण चंद्रोदय (पञ्चम खण्ड)*. मोतीलाल बनारसीदास, दिल्ली.
55. शास्त्री, द्विजेन्द्र. 1956. *संस्कृत साहित्य विमर्श*. भारती प्रतिष्ठानम्, मयराष्ट्रनगरम्, उत्तरप्रदेश.
56. शास्त्री, प्रभात (सम्पा.). 1979. *हर्षवर्धनकृत लिङ्गानुशासन*. देवभाषाप्रकाशन, दारागंज प्रयाग.
57. शास्त्री, राम त्रिपाठी (सम्पा.). 2015. *किरातार्जुनीयम्*. किताब महल, दिल्ली.
58. शास्त्री, श्रीकान्त. 1974. *अथर्ववेद (सनातन भाष्य सहित)*. माधव पुस्तकालय, कमला नगर, दिल्ली.

59. शास्त्री, सुरेन्द्रदेव (सम्पा.). 2012. *नैषधचरितमहाकाव्यम्*. चौखम्भा पब्लिशर्स, वाराणसी.
60. शास्त्री, हरगोविन्द. 2013. *शिशुपालवधम् संस्कृत-हिन्दी-व्याख्या सहित*. चौखम्भा सुरभारती प्रकाशन, वाराणसी.
61. सरस्वती, स्वामी दयानन्द (सम्पा.). 1969-70. *लिङ्गानुशासन (व्याख्या सहित)*. अजमेर.
62. सहाय, राजवंश. 1996. *संस्कृत साहित्य कोश*. चौखम्भा विद्याभवन, वाराणसी.
63. साहू, रामदेव. 2008. *अलङ्कारशास्त्र का इतिहास*. श्याम प्रकाशन, दिल्ली.
64. सिंह, लक्ष्मण एवं सिंह, हरदयालु. 1973. *रघुवंश महाकाव्य*. भारत प्रकाशन मन्दिर, अलीगढ़, उत्तरप्रदेश.
65. सी., राजगोपालाचारी (सम्पा.). 1958. *महाभारत*. भारतीय विद्या भवन, दिल्ली.
66. सेन, देवव्रत. 1987. *संस्कृत कोशों का उद्भव और विकास*. हरियाणा साहित्य अकादमी, चण्डीगढ़.

Internet source

1. <http://sanskrit.sai.uni-heidelberg.de/Chanda/HTML> (obtained on July 1, 2019)
2. <http://sanskrit.jnu.ac.in/subanta/generae.jsp> (obtained on September 5, 2019)
3. <http://sanskrit.jnu.ac.in/tinanta/tinanta.jsp> (obtained on September 8, 2019)
4. <http://sanskrit.jnu.ac.in/amara/index.jsp> (obtained on September 3, 2019)
5. <http://sanskrit.jnu.ac.in/sandhi/gen.jsp> (obtained on September 1, 2019)
6. <http://en.wikipedia.org/wiki/wikipedia> (obtained on January 15, 2020)
7. <http://sanskrit.du.ac.in/cl.html> (obtained on September 2, 2019)
8. <http://sanskrit.uohyd.ernet.in> (obtained on September 4, 2019)
9. <http://spyce.sourceforge.net/> (obtained on March 15, 2019)
10. <https://www.mysql.com/> (obtained on September 8, 2019)
11. <https://www.spyce.in> (obtained on September 8, 2019)
12. <https://www.mysql.com> (obtained on July 11, 2019)
13. <https://unicode.org/> (obtained on April 9, 2019)
14. <http://cdac.in> (obtained on September 1, 2019)

Dictionary

1. Williams, Monier. *Williams Monier Online Dictionary (2008 revision)*: University of Cologne: <http://www.sanskrit-lexicon.uni-koeln.de/monier/> Obtained on February 10, 2020.
2. अभ्यंकर, के० वी०. 1961. डिक्शनरी आफ् संस्कृत ग्रामर. ओरियन्टल इन्स्टीट्यूट, बडौदा.
3. आप्टे, वामन शिवराम. 1966. *संस्कृत-हिन्दी कोश*. मोतीलाल बनारसीदास पब्लिशर्स, दिल्ली.
4. आप्टे, 2009. *संस्कृत-हिन्दी कोश*. चौखम्बा संस्कृत सीरीज आफिस, वाराणसी.
5. राजा, राधाकान्तदेव. 1961. शब्दकल्पद्रुमकोष. मोतीलाल बनारसीदास, दिल्ली.
6. सिंह, अमर. 1968. *अमरकोष*. चौखम्बा संस्कृत सीरीज आफिस, वाराणसी.

Appendix-I

List of words in *ajādigana* (अजादिगण)

SR	Word	SR	Word	SR	Word
1	अजा	12	पूर्वापहरणा	23	प्रान्तपुष्पा
2	एडका	13	अपरापहरणा	24	शतपुष्पा
3	चटका	14	संफला	25	एकपुष्पा
4	अश्व्रा	15	भस्त्रफला	26	कुन्चा
5	मूषिका	16	अजिनफला	27	उष्णिहा
6	बाला	17	शणफला	28	देवविशा
7	होढा	18	पिण्डफला	29	ज्येष्ठा
8	पाका	19	सत्पुष्पा	30	कनिष्ठा
9	वत्सा	20	प्राक्पुष्पा	31	मध्यमा
10	मन्दा	21	प्रत्यक्पुष्पा	32	कोकिला
11	विलाता	22	काण्डपुष्पा	33	अमूला

Appendix-II
List of words in *gaurādigāṇa* (गौरादिगण)

SR	Word	SR	Word	SR	Word
1	गौर	40	मालक	79	एत
2	मत्स्य	41	मालत	80	अधिकार
3	मनुष्य	42	साल्वक	81	आग्रहायणी
4	शृंग	43	वेतस	82	प्रत्यवरोहिणी
5	हय	44	अतस	83	सुन्दर
6	गवय	45	पृस	84	मण्डल
7	मुकय	46	मह	85	पट
8	ऋष्य	47	मठ	86	पिण्ड
9	पुट	48	छेद	87	वितक
10	द्रुण	49	श्वन्	88	कुर्द्
11	द्रोण	50	तक्षन्	89	गूर्द्
12	हरिण	51	अनडुही	90	पाण्ट
13	कण	52	अनड्वाही	91	लोफाण्ट
14	पटर	53	देह	92	कन्दर
15	उकण	54	काकादन	93	कन्दल
16	आमलक	55	गवादन	94	तरुण
17	कुवल	56	तेजन	95	तलुन
18	बदर	57	रजन	96	बृहत्
19	बिम्ब	58	लवण	97	महत्
20	तकीर	59	पान	98	सौधर्म
21	शकीर	60	मेध	99	रोहिणी
22	पुष्कर	61	गौतम	100	रेवती
23	शिखण्ड	62	आप	101	विकल
24	सुषम	63	भौरि	102	निष्कल
25	सलन्द	64	भौलिक	103	पुष्कल
26	गड्गुज	65	भौलिंगि	104	पिंगल
27	आनन्द	66	औद्गाहमानि	105	भट्ट
28	सृपाट	67	आलिंगि	106	दहन
29	सृगेठ	68	आपिच्छिक	107	कन्द
30	आढक	69	आरट	108	काकण
31	शष्कुल	70	टोट	109	पिप्पली
32	सूर्म	71	नट	110	हरीतकी
33	सुव	72	नाट	111	कोशातकी
34	सूर्य	73	मूलाट	112	शमी

35	पूष	74	ज्ञातन	113	करीरी
36	मूष	75	पातन	114	पृथ्वी
37	घातक	76	पावन	115	क्रोष्ट्री
38	सकलूक	77	आस्तरण	116	मातामह
39	सल्लक	78	अधिकरण	117	पितामह

Appendix-III

List of words in *bahvādigaṇa* (बह्वादिगण)

SR	Word	SR	Word	SR	Word
1	बहु	11	गति	21	विशाल
2	पद्धति	12	अहि	22	विशंकट
3	अंकति	13	कपि	23	भरुज
4	अंचति	14	मुनि	24	ध्वज
5	अंहति	15	यष्टि	25	चन्द्रभागी
6	वहति	16	चण्ड	26	कल्याण
7	शकटि	17	अराल	27	उदार
8	शक्तिः	18	कमल	28	पुराण
9	शारि	19	कृपाण	29	अहर्
10	वारि	20	विकट		

Appendix-IV

List of words in *kroḍādigana* (क्रोडादिगण)

SR	Word	SR	Word	SR	Word
1	शोभनक्रोडा	6	बाल	10	नख
2	शोभनखुरा	7	शफ	11	मुख
3	पृथुजघना	8	गुद	12	भग
4	क्रोड	9	घोण	13	गल
5	खुर				

Appendix-V

List of words in *śārgaravādigaṇa* (शाङ्गरवादिगण)

SR	Word	SR	Word	SR	Word
1	शाङ्गरव	10	आशोकेय	18	आश्मरथ्य
2	कापटव	11	वात्स्यायन	19	औदपान
3	गौगुलव	12	माञ्जायन	20	अराल
4	ब्राह्मण	13	केकसेय	21	चण्डाल
5	गौतम	14	काव्य	22	वतण्ड
6	कामण्डलेय	15	शैव्य	23	भोगवती
7	ब्राह्मकृतेय	16	एहि	24	गौरिमती
8	आनिचेय	17	पर्येहि	25	नारी
9	आनिधेय				

Appendix-VI

List of words in *kraudyādigaṇa* (क्रौड्यादिगण)

SR	Word	SR	Word	SR	Word
1	क्रौडि	8	शैकयत	15	भौरिकि
2	लाडि	9	वैल्वयत	16	भौलिकि
3	व्याडि	10	वैकल्पयत	17	शाल्मलि
4	आपिशलि	11	सौधातकि	18	शालास्थलि
5	आपक्षिति	12	सूत्या	19	कापिष्ठलि
6	चौपयत	13	भोज्या	20	गौकक्ष्य
7	चैटयत	14	क्षत्रिया		

Appendix-VII

List of AD Rules used in Feminine Suffixes

SR	AD Ref	AD Sutra
1	4.1.4	अजाद्यतष्टाप्
2	4.1.28	अन उपधालोपिनोऽन्यतरस्याम्
3	4.1.14	अनुपसर्जनात्
4	4.1.12	अनो बहुव्रीहेः
5	4.1.32	अन्तर्वत्पतिवतोर्नुक्
6	4.1.40	अन्यतो ङीष्
7	4.1.22	अपरिमाणबिस्ताचितकम्बल्येभ्यो न तद्धितलुकि
8	7.3.48	अभाषितपुंस्काञ्च
9	4.1.53	अस्वाङ्गपूर्वपदाद्वा
10	7.3.49	आदाचार्याणाम्
11	7.1.2	आयनेयीनीयियः फढखछघां प्रत्ययादीनाम्
12	4.1.75	आवट्याञ्च
13	4.1.65	इतो मनुष्यजातेः
14	4.1.49	इन्द्रवरुणभवशर्वरुद्रमृडहिमारण्ययवयवनमातुलाचार्याणामानुक्
15	4.1.6	उगितश्च
16	7.3.46	उदीचामातः स्थाने यकपूर्वायाः
17	4.1.66	ऊङुतः
18	5.4.131	ऊधसोऽनङ्
19	4.1.69	ऊरुत्तरपदादौपम्ये
20	4.1.23	काण्डान्तात्क्षेत्रे
21	4.1.30	केवलमामकभागधेयपापापरसमानार्यकृतसुमङ्गलभेषजाञ्च
22	4.1.19	कौरव्यमाण्डूकाभ्यां च
23	4.1.51	क्तादल्पाख्यायाम्
24	4.1.50	क्रीतात्करणपूर्वात्
25	4.1.63	जातेरस्त्रीविषयादयोपधात्
26	4.1.42	जानपदकुण्डगोणस्थलभाजनागकालनीलकुशकामुककबराद्वृत्यम त्रावपनाकृत्रिमाश्राणास्थौल्यवर्णानाच्छादनायोविकारमैथुनेच्छाके शवेशेषु
27	4.1.9	टावृचि
28	4.1.15	टिड्ढाणञ्द्वयसज्दघ्नञ्मात्रचतयष्ठकठञ्कञ्करपः
29	4.1.13	डाबुभाभ्यामन्यतरस्याम्
30	4.1.76	तद्धिताः
31	4.1.27	दामहायनान्ताञ्च
32	4.1.60	दिक्पूर्वपदान्ङीप्

33	4.1.21	द्विगोः
34	4.1.56	न क्रोडादिबह्वचः
35	7.3.45	न यासयोः
36	4.1.58	नखमुखात्सञ्जायाम्
37	4.1.55	नासिकोदरौष्ठजङ्घादन्तकर्णशृङ्गाच्च
38	4.1.29	नित्यं सञ्जाछन्दसोः
39	4.1.35	नित्यं सपत्न्यादिषु
40	4.1.68	पङ्गोश्च
41	4.1.33	पत्युर्नो यज्ञसंयोगे
42	4.1.64	पाककर्णपर्णपुष्पफलमूलवालोत्तरपदाच्च
43	4.1.8	पादोऽन्यतरस्याम्
44	4.1.48	पुंयोगादाख्यायाम्
45	4.1.24	पुरुषात्प्रमाणेऽन्यतरस्याम्
46	4.1.36	पूतक्रतोरै च
47	7.3.44	प्रत्ययस्थात्कात्पूर्वस्यात् इदाप्यसुपः
48	4.1.17	प्राचां ष्फ तद्धितः
49	4.1.25	बहुव्रीहेरुधसो डीष्
50	4.1.52	बहुव्रीहेश्चान्तोदात्तात्
51	4.1.45	बह्वादिभ्यश्च
52	4.1.67	वाह्वन्तात्सञ्जायाम्
53	7.3.47	भस्त्रैषाजाज्ञाद्वास्वा नञ्पूर्वाणामपि
54	4.1.11	मनः
55	4.1.38	मनोरौ वा
56	4.1.74	यङश्चाप्
57	4.1.16	यञश्च
58	4.1.77	यूनस्तिः
59	4.1.7	वनो र च
60	4.1.20	वयसि प्रथमे
61	4.1.39	वर्णादिनुदात्तात्तोपधात्तो नः
62	4.1.61	वाहः
63	4.1.34	विभाषा सपूर्वस्य
64	4.1.37	वृषाकप्यग्निकुसितकुसिदानामुदात्तः
65	4.1.44	वोतो गुणवचनात्
66	4.1.73	शाङ्गर्गवाद्यञो डीन्
67	4.1.43	शोणात्प्राचाम्
68	1.3.6	षः प्रत्ययस्य
69	4.1.41	षिद्वौरादिभ्यश्च
70	4.1.70	संहितशफलक्षणवामादेश्च
71	4.1.62	सख्यशिञ्चीति भाषायाम्

72	4.1.26	सङ्ख्याव्ययादेर्डीप्
73	4.1.72	सञ्ज्ञायाम्
74	4.1.18	सर्वत्र लोहितादिकतन्तेभ्यः
75	4.1.57	सहनञ्विद्यमानपूर्वाच्च
76	6.4.149	सूर्यतिष्यागस्त्यमत्स्यानां य उपधायाः
77	4.1.3	स्त्रियाम्
78	4.1.54	स्वाङ्गाच्चोपसर्जनादसंयोगोपधात्
79	6.4.150	हलस्तद्धितस्य
