

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्)

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Abstract

E-learning increases the level of teaching and learning, literacy and economic development in countries. Information Technology (IT) has fundamentally changed the methods of teaching and learning. In this age of IT education system is converting into Digital. E-Learning may play very important role to innovation in classroom teaching and it boosts teaching and learning process. There are an online learning tool called Swagatam (स्वगतम्) has been developed for teaching and learning Sanskrit Grammar in Higher education. Swagatam (स्वगतम्) is based on University of Delhi BA and MA Sanskrit syllabus. Swagatam is available at <http://sanskrit.du.ac.in>. Swagatam includes *taddhita* and *sanadyanta analyzer* under Language analysis tools, *subanta*, *tinanta*, *sandhi* and *prtyahar generator* under Language generation tools, *subanta siddhi*, *tinanta siddhi*, *taddhita siddhi*, *sandhi siddhi*, *kridanta siddhi* and *samasa siddhi generator*, *Sanskrit meter* and *samkhyā-yoga technical word information system* under e-learning tools and *Vedic literature and pauranic search* under Sanskrit literature search tools.

Keywords: E-learning, E-Learning tools for Sanskrit, Innovative Learning, Online Learning, Sanskrit Grammar, Word Formation Process

1. Introduction

Grammatical tradition of Sanskrit is very rich. It was researched, compiled and programmed by Sanskrit grammarians from the later Vedic period. It was robustly programmed in

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Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhupendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 278

the Pāṇinian grammar about the 6th century BCE (Manji, et al., 2008; Girish, et al., 2009 and Subhash, 2010). The grammar of the Sanskrit language has a very complex and huge morphological system like verbal, rich nominal declension, and extensive use of compound nouns (Lennart, 2005; Subhash, 2010 & Chandra and Jha, 2011). Kātyāyana composed vārtikas (explanations) on the Pāṇinian sutras (Chandra, 2010; Chandra & Jha, 2011). The most important work based on word formation process was done by Bhaṭṭoji Dīkṣita in about 17th century in his Siddhānta Kaumudī. Sanskrit taught almost all Indian universities at under graduate (UG), post graduate (PG) and research level (Chandra et al, 2016). Therefore, Swagatam may play very important role in teaching learning process because there are no effective online tools are existing which cover courses of Sanskrit in higher education (Shopova, 2011 and Kalaivani, 2014).

Information technologies (IT) effected and impacted higher education teaching and learning (Gaebel, Kupriyanova, Morais & Colucci, 2004). Government of India has also launched Digital India (Digital India, 2016) scheme with the objective of making each government services digital. There is a complicated task to make available digital contents online in various Indian languages medium for the students and teachers. Many Indian researchers have been initiated various e-learning tools and techniques (Bijlani, Manoj & Rangan, 2008 and Bhatia, 2011; Chandra et al, 2016). Asthadhyayi (AD) of Panini is development of about 4000 rules of Sanskrit morphology, syntax and semantics. These rules are organized such a way like any computer programming languages (Jha, 2004; Chandra & Jha, 2011; Kulkarni & Shukl, 2009 and Jha et al, 2009).

Objective of this paper is to announce an innovative teaching and learning tools for Sanskrit Grammar called Swagatam (स्वगतम्) developed by Computational Linguistics Research group, Department of Sanskrit, University of Delhi, Delhi. Details of the each tools are discussed in section 2.

2. Features of Swagatam (स्वगतम्)

SWAGATAM is an online system for Sanskrit grammar teaching in higher education based on UG and PG Sanskrit syllabus of University of Delhi, Delhi. It provides an e-learning platform

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Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 279

through online web based e-contents and tools in Sanskrit. The mission of SWAGATAM is to enhance the quality of Sanskrit education in the higher education in India by providing free online courseware for Sanskrit in various Indian language medium. Details description of the Swagatam is given below:

2.1 Language Analysis Tools

Currently, this tab has following two major tools are developed:

2.1.1 Taddhita Analyzer

This system does analysis of Sanskrit secondary derived nouns (taddhitanta). System accepts input in Devanagari Unicode and print the analyzed result in same format. Screen shot with result is shown in figure 1. This helps to learn taddhita analysis which is very essential for meaning.

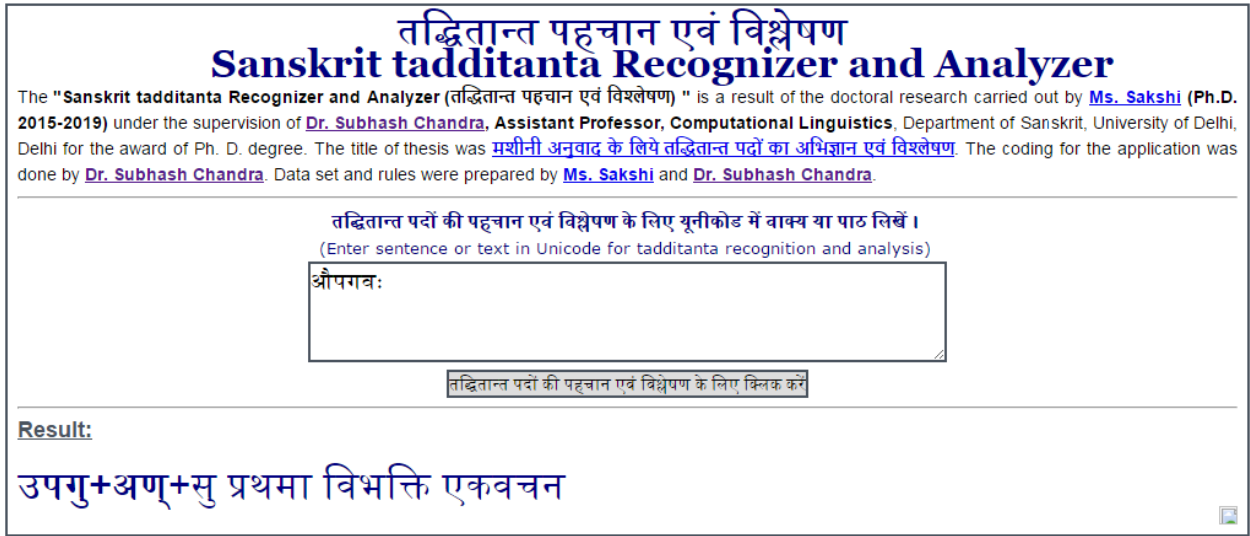


Figure 1: Screen Shot of taddhita Analyzer

2.1.2 sanadyanta Analyzer

This is very important component of the Swagatam. Sanskrit has approximately 2014 verb roots (including kandvādi (agroup of Sanskrit verb roots), classified in 10 groups (ganas). Secondary verbs derive with 12 derivational suffixes called sanadyanta. This system analyze sanadyanta in Sanskrit text. Screen shot with input and output of the interface is shown in figure 2.

Language in India www.languageinindia.com ISSN 1930-2940 17:1 January 2017

Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhupendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 280

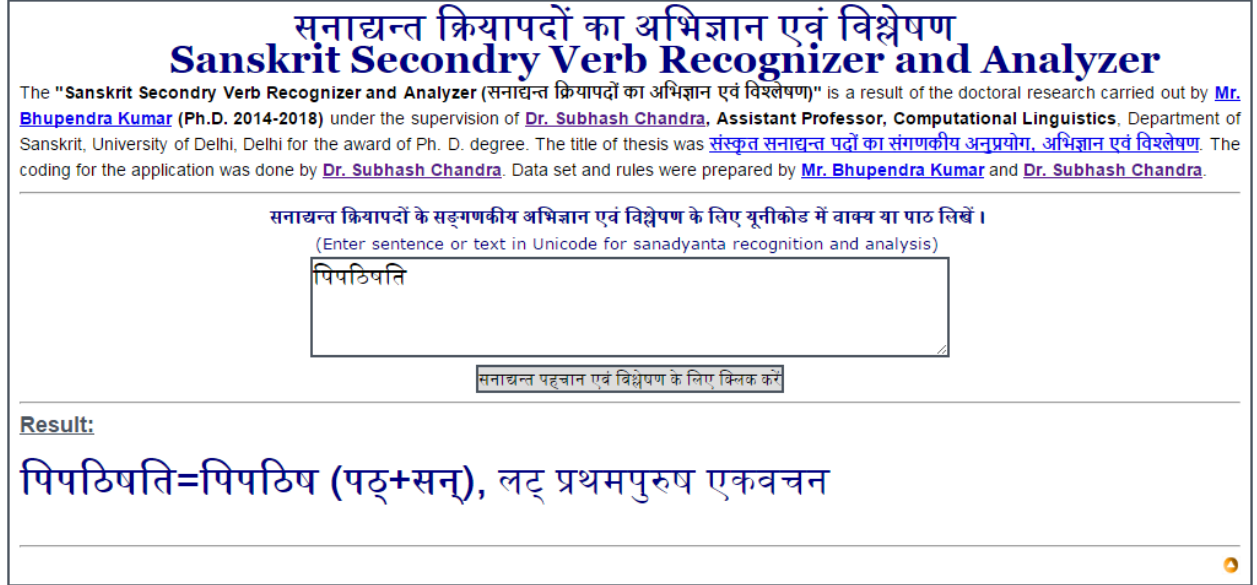


Figure 2: Screen shot of sanadyanta system

2.2 Language Generation Tools

subanta, tinanta, sandhi and prtyahar generator are the main tools in this tab:

2.2.1 Subanta form Generator

This component generate nominal word forms from a base word. User need to give the input word and select the gender of the stem. Then it generates 24 forms of the given stem.

2.2.2 Tinanta form Generator

This tools has two components. One is primary verb form generator which generates verb forms from a verb root. User gives the verb roots as an input in given text area. Then this system generates verb forms in 10 lakaras. Second component is secondary verb form generator which generates sanadyanta verb forms in in 10 lakaras of given verb and suffix. Screen shot of the sanadyanta generator is shown in figure 3.

Language in India www.languageinindia.com ISSN 1930-2940 17:1 January 2017

Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhupendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 281

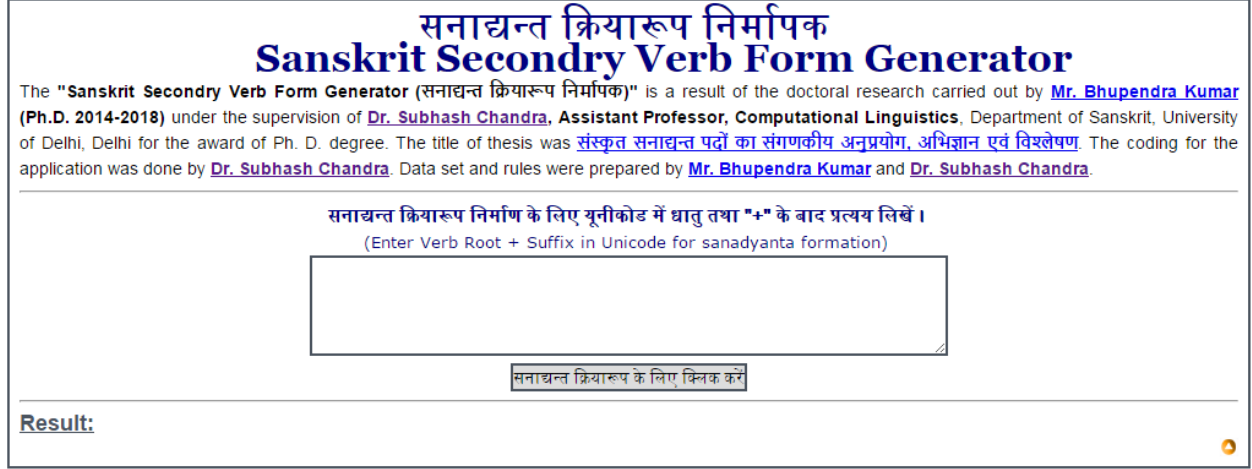


Figure 3: Screen Shot of Verb Generator

2.2.3 Sandhi Generator

Taddhita analyzer is a string set of two alphabets which contains a group of alphabets based on Pāṇini alphabets system. Panini has explained the make and expansion of the pratyāhāras in AD rule 1.1.71. Pratyāhāras can be compared with a variable in any computer programming languages.

2.2.4 Pratyahar Generator

Taddhita analyzer is a string set of two alphabets which contains a group of alphabets based on Pāṇini alphabets system. Panini has explained the make and expansion of the pratyāhāras in AD rule 1.1.71. Pratyāhāras can be compared with a variable in any computer programming languages.

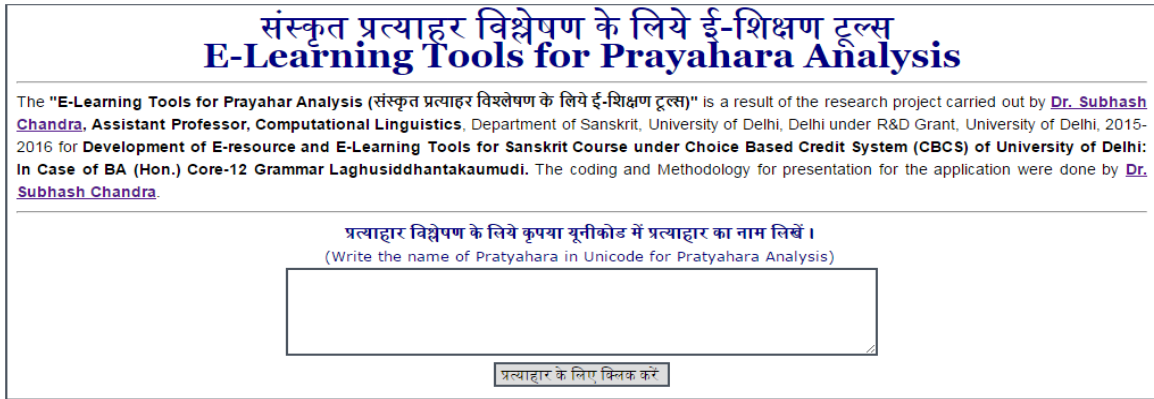


Figure 4: Pratyāhāra Generator

Language in India www.languageinindia.com ISSN 1930-2940 17:1 January 2017

Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhupendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 282

2.3 E-Learning Tools

This tab includes *subanta siddhi*, *tinanta siddhi*, *taddhita siddhi*, *sandhi siddhi*, *kridanta siddhi* and *samasa siddhi generator*, *Sanskrit meter* and *samkhya-yoga technical word information system* etc.

2.3.1 Subanta siddhi Generator

This is very important component which generates complete word *rūpasiddhi* with Panini rules. This system first recognizes the input words with the help of recognition rule and example database then analyzes the input words with the help of analysis rule and example database. After this it generates Word Formation Process (WFP) based on Pāṇin Rules. The screenshot with the input and output result is shown in figure 5.

सुबन्त रूपसिद्धि निर्मापक Word Formation Generation for Sanskrit Nominal Inflections

The "Expert System for Sanskrit Grammar for E-learning (संस्कृत व्याकरण ई-शिक्षक)" is a result of the research project carried out by [Dr. Subhash Chandra](#), Assistant Professor, Computational Linguistics, Department of Sanskrit, University of Delhi, Delhi under R&D Grant, University of Delhi, 2014-2015 for the development of E-learning tools for Sanskrit. The coding for the application was done by [Dr. Subhash Chandra](#). Data set and rules were prepared by Ph.D. Research Scholars ([Mr. Bhupendra Kumar](#), [Mr. Madhav Prasad Wosti](#), [Mr. Vivek Kumar](#), [Ms. Sakshi](#)) under supervision of [Dr. Subhash Chandra](#).

सुबन्त रूपसिद्धि प्रक्रिया के लिए कृपया यूनिकोड में पद लिखें।
(Enter Word/s in Unicode for Sup Generation Process)

रामः

रूपसिद्धि के लिए क्लिक करें

Result:

| | |
|---|---|
| शब्दरूप/पद = रामः | |
| पद पहचानानिङ्ग विभक्ति एवं वचन = राम पुल्लिङ्ग प्रथमा एकवचन | |
| Recognition Code = अ_M_1.1 | |
| अर्थवदधातुरप्रत्ययः प्रातिपदिकम् | सूत्र से राम की अव्युत्पन्न पक्ष में प्रातिपदिक मञ्जा |
| प्रत्ययः | राम |
| परस्मै | राम |
| ङ्याप्रातिपदिकात् | राम |
| स्वोचसर्गोद्घाभयामि | राम |
| द्विकयोद्विचनैकवचने | राम + सु |
| उपदेशेऽजनुनासिक इत् | राम + सु |
| तस्य लोपः | राम + सु |
| सुसिद्धन्तं पदम् | राम + सु |
| समञ्जसो रुः | राम + रु |
| उपदेशेऽजनुनासिक इत् | राम + रु |
| तस्य लोपः | राम + र् |
| विरामोऽवसानम् | राम + र् |
| हरवसानवोर्विसर्जनीयः | राम + ः |
| हरवसानवोर्विसर्जनीयः | राम + ः |
| वर्ण सम्मेलन करने पर रामः रूप सिद्ध होता है। | रामः |

अष्टाध्यायी के 4.1.1 से लेकर पांचवें
अध्याय की समाप्ति तक जितने प्रत्यय
कहे गए हैं वे ङ्यन्त, आबन्त एवं
प्रातिपदिक से परे हों।

औ, जस् आदि ङ्कीस प्रत्यय

Figure 5: Screen shot of the Subanta Word formation System

2.3.2 Tinanta siddhi Generator

It generates verb formation process with the help of rules and relational databases. It accepts Unicode Devanagari texts in the input text area and generates output in same format. User interface can be seen in Figure 6 and 7.

Language in India www.languageinindia.com ISSN 1930-2940 17:1 January 2017

Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhupendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 284

वेब आधारित संस्कृत तिङन्त रूपसिद्धि प्रक्रिया Web based Sanskrit Verb Forms Generation Process

The "Web based Sanskrit Verb Forms Generation Process (वेब आधारित संस्कृत तिङन्त रूपसिद्धि प्रक्रिया)" is a result of the doctoral research carried out by **Vivek Kumar** (Ph.D. 2015-2019) under the supervision of **Dr. Subhash Chandra**, Assistant Professor, Computational Linguistics, Department of Sanskrit, University of Delhi, Delhi for the award of Ph. D. degree. The title of thesis was **वेब आधारित संस्कृत तिङन्त रूपसिद्धि प्रक्रिया**. The coding for the application was done by **Dr. Subhash Chandra**. Data set and rules were prepared by **Vivek Kumar** and **Dr. Subhash Chandra**.

तिङन्त रूपसिद्धि प्रक्रिया के लिए कृपया यूनिकोड में पद लिखें ।
(Enter verb form/s in Unicode for Dhatu roop Generation Process)

समूह धातुरूपसिद्धि प्रक्रिया के लिए क्लिक करें

Figure 6: User Interface of Verb Formation System

Result:

पठ् परस्मैपद लट् प्रथम पुरुष एकवचन तिप्
पठ् परस्मैपद लट् प्रथम पुरुष एकवचन तिप्

| | |
|---|---------------------------|
| भूवादयो धातवः सूत्र से 'पठ्' अक्षर समूह की धातु संज्ञा | पठ् |
| लः कर्मणि च भावे चाकर्मकेभ्यः सूत्र से लकार कर्तृवाच्य में हो ऐसी विधि होने पर | पठ् |
| वर्तमाने लट् सूत्र से वर्तमान काल की विवक्षा में धातु से लट् लकार हुआ | पठ् + लट् |
| उपदेशेऽजन्तासि इत् सूत्र से उपदेशावस्था में अनुनासिक अच् (स्वर) की इत्संज्ञा । | पठ् + लट् |
| हलन्त्यम् सूत्र से अन्त्य हल् की इत्संज्ञा | पठ् + लट् |
| तस्य लोपः सूत्र से इत्संज्ञक वर्ण का लोप होने पर | पठ् + ल् |
| तस्य के अधिकार में | पठ् + ल् |
| तिमस्मिन्ति सूत्र द्वारा 'ल्' के स्थान में 'तिमस्मिन्ति...'महिष्' अठारह प्रत्यय हुए | पठ् + तिमस्मिन्ति...महिष् |
| लः परस्मैपदम् सूत्र से 'ल्' के स्थान में होने वाले 'तिमस्मिन्ति...'महिष्' प्रत्ययों की परस्मैपद संज्ञा हुई | पठ् + तिमस्मिन्ति...महिष् |
| तडानावात्मनेपदम् सूत्र से तड् (त...महिष्) की आत्मनेपद संज्ञा | पठ् + तिमस्मिन्ति...महिष् |
| शेषात्कर्तृ परस्मैपदम् सूत्र से कर्तृविवक्षा में परस्मैपद संज्ञक नौ प्रत्यय हुए | पठ् + तिमस्मिन्ति...मस् |
| तिङ्स्त्रीणि त्रीणि प्रथममध्यमोत्तमाः सूत्र से तिङ् की प्रथम, मध्यम, उत्तमपुरुष संज्ञा होकर | पठ् + तिमस्मिन्ति...मस् |
| ताः-प्रेकवचनद्विवचनबहुवचनान्-प्रेकशः सूत्र से तिङ् प्रत्ययों की क्रमशः एकवचन, द्विवचन और बहुवचन संज्ञा हुई | पठ् । तिमस्मिन्ति...मस् |
| शेषे प्रथमः सूत्र द्वारा प्रथमपुरुष की विवक्षा वाले तीन प्रत्यय हुए | पठ् + तिमस्मिन्ति |
| द्व्युक्तयोर्द्विवचनैकवचने सूत्र से एकत्व की विवक्षा में एकवचन / द्वित्व की विवक्षा में द्विवचन का प्रत्यय होने पर | पठ् + तिप् |
| हलन्त्यम् सूत्र से अन्त्य हल् की इत्संज्ञा | पठ् + तिप् |
| तस्य लोपः सूत्र से इत्संज्ञक वर्ण का लोप होने पर | पठ् + ति |
| तिङ्शित्सार्वधातुकम् सूत्र से सार्वधातुक संज्ञा होकर | पठ् + ति |
| कर्तरि शप् सूत्र द्वारा शप् विकरण हुआ | पठ् + शप्+ति |
| हलन्त्यम् सूत्र से अन्त्य हल् की इत्संज्ञा | पठ् + शप्+ति |
| लशक्वतद्धिते प्रत्यय के आदि में ल् आ/कवर्ण की इत् संज्ञा | पठ् + शप्+ति |
| तस्य लोपः सू | पठ् + अ+ति |

इत्संज्ञक वर्णों का लोप होता है ।

Figure 7: Result of the Verb Formation System

2.3.3 Taddhita siddhi Generator

Language in India www.languageinindia.com ISSN 1930-2940 17:1 January 2017

Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhubendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 285

This system generates *taddhita siddhi* with the help of rules and relational databases. It accepts Unicode Devanagari texts in the input text area and generates output in same format. This system is under development.

2.3.4 Sandhi siddhi Generator

This component do *sandhi* and generates its *siddhi* with the help of rules and data set. This system is also under development. Demo version of the system is available till now.

2.3.5 Kridanta siddhi Generator

We have also proposed to develop *kridanta siddhi* in future because *kridanta* is very essential component of Sanskrit Grammar and play very important role in translation from other language to Sanskrit.

2.3.6 samasa siddhi Generator

This system if not completed right now. It will be added with the Swagatam. This will generate complete *samasanta* (compound words) *siddhi* as per Panini rules.

2.3.7 Sanskrit Meter Information System

Sanskrit meters are being taught in all Indian Universities offering Sanskrit courses. Therefore, a system called Sanskrit Meter Information is also added with Swagatam. It produce all information of selected meters (Meena, 2016).

Figure 8: Sanskrit Meter Information System

Language in India www.languageinindia.com ISSN 1930-2940 17:1 January 2017

Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 286

2.3.8 Sankhya-yoga technical word Information System

Technical terms informations and definitions of any discipline are very important to learn further. So we are also developing a database of Samkhya-Yoga technical word information. Which will produce whole information of any technical terms belongs to the Samkhya-yoga philosophy. Proposed interface for this system is shown in figure 9.

साङ्ख्य-योग पारिभाषिक शब्द सूचना तन्त्र

Sankhya-Yoga Technical Word Search System

The "Sankhya-Yoga Technical Word Search System (साङ्ख्य-योग पारिभाषिक शब्द सूचना तन्त्र)" is a result of the research (R&D) carried out by [Anju](#) (Ph.D. 2016-2020) under the supervision of [Dr. Subhash Chandra](#) for the award of Ph.D. Degree. The title of thesis is [साङ्ख्य-योग दर्शन के पारिभाषिक शब्दों का विश्लेषणात्मक अध्ययन एवं वेब तंत्र का विकास](#). The coding for the application was done by [Dr. Subhash Chandra](#). Data set and rules were prepared by Research Scholar [Ms. Anju](#) and [Dr. Subhash Chandra](#).

साङ्ख्य-योग दर्शन-पारिभाषिक शब्द विश्लेषण के लिये कृपया यूनीकोड में पारिभाषिक शब्द का नाम लिखें या ड्रॉपडाउन मेनू से पारिभाषिक शब्द चुनें ।
(Write the technical term name in Unicode in the text box or choose technical term from the dropdown menu for technical term Analysis)

अथवा
(OR)

कृपया पारिभाषिक शब्द यहाँ से चुनें ▼

Result:

Figure 9: Screen Shot of the Samkhya-yoga technical terms information system

2.4 Sanskrit Literature Search

This component includes *Vedic literature and pauranic* search engine for Sanskrit texts.

2.4.1 Vedic Literature Search

This system is an advance search engine for vedic literature. User can search any words occurred in Veda and get complete reference for the input words. Screen shot of the system is shown in figure 10.

ऋग्वेद के लिये अनुक्रमणिका तंत्र
Indexing System for Rigveda

The "Indexing System for Rigveda (ऋग्वेद के लिये अनुक्रमणिका तंत्र)" is a result of the Research and Development (R&D) carried out by [Jalaj Kumar](#) (M.Phil. 2014-2015) under the supervision of [Dr. Subhash Chandra](#), Assistant Professor, Computational Linguistics for the award of Master of Philosophy (M.Phil.) degree at [Department of Sanskrit, University of Delhi, Delhi](#). The title of dissertation was "वेद आधारित ऋग्वेदीय खोज एवं अनुक्रमणिका तंत्र का विकास". The coding for the application was done by [Dr. Subhash Chandra](#). Data set, rules etc. was prepared by [Mr. Jalaj Kumar](#) and [Dr. Subhash Chandra](#).

ऋग्वेदिक अनुक्रमणी एवं खोज के लिए यूनीकोड में शब्द लिखें ।
(Enter sentence or text in Unicode for Rigvedic search and Indexing)

| | | | |
|---|---|--|---|
| ऋग्वेद में खोज के लिये शब्द लिखें <input style="width: 90%;" type="text"/> | Search by देवता : देवता का नाम चुनें ▼ देवता का नाम चुनें अग्नि इन्द्र वरुण उपस् | Search by देवतागण : देवतागण यहाँ से चुनें ▼ | Search by देवतायुग्म : कृपया युग्म यहाँ से चुनें ▼ |
| Result: | | | |

Figure 10: User Interface of Vedic Literature Search

2.4.2 Pauranic Search

This system search reference of any words from the Puranas. User can search any words occurred in any puranas and get complete reference for the input words. Screen shot of the system is shown in figure 11.

पौराणिक साहित्य खोज
Puranic Literature Search

The "Search System for Puranas (पुराणों के लिये खोज तंत्र)" is a result of the student project carried out by [Anju Singh](#) (Ph.D. 2016-2020) under the supervision of [Dr. Subhash Chandra](#), Assistant Professor, Computational Linguistics. The coding for the application was done by [Dr. Subhash Chandra](#). Data Collection and Digitalization were prepared by [Ms. Anju Singh](#) and [Dr. Subhash Chandra](#).

पुराणों में किसी भी शब्द को खोजने के लिये यूनीकोड में लिखें तथा किसी विशेष पुराण के लिये सूची से पुराण का नाम का चुनाव भी करें ।
(Write word for search in any Puranas and also select the name of the puransa from the list)

| | |
|---|---|
| <input style="width: 95%;" type="text"/> पुराण में खोज के लिये यहाँ क्लिक करें | Search in specific पुराण पुराण का नाम चुनें ▼ पुराण का नाम चुनें अग्निपुराण गरुडपुराण भागवतपुराण ब्रह्माण्डपुराण |
| Result: | |

Figure 11: User Interface of Pauranic Search System

3. Conclusion and Future Direction

SWAGATAM (स्वगतम्) is result of an initiative taken by the Computational Linguistics Research Group, Department of Sanskrit, University of Delhi, Delhi with the objective of development of web based teaching and learning tools for Sanskrit in Higher Education. Swagatam is being used by the UG and PG Sanskrit students and teachers for teaching and learning Sanskrit grammar. Apart from this various language resources such as database for Ashtdhayayi (AD) rules with Hindi meaning and Explanation and other relevant information, Computation rules for

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Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhupendra Kumar, Ph.D. Candidate

identification and analysis, database for Pāṇini's Dhatupatha (DP), various small dataset for Sanskrit grammar are also developed.

In future, it is planned to digitalize all recommended Sanskrit text used in Delhi University Sanskrit syllabus. The instructions and input/output methods of Swagatam will be multilingual (Punjabi, Sanskrit, English, Bangla, Telugu, Tamil etc.) because Sanskrit teach in various language medium in India.

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Language in India www.languageinindia.com ISSN 1930-2940 17:1 January 2017

Subhash Chandra, M.Phil., Ph.D., Vivek Kumar, Ph.D. Candidate, Sakshi, Ph.D. Candidate and Bhupendra Kumar, Ph.D. Candidate

Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 289

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Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 290



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Innovative Teaching and Learning of Sanskrit Grammar through SWAGATAM (स्वगतम्) 291