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Web-based System for Derivational Process of Kṛdanta based on Pāṇinian Grammatical Tradition

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Abstract

Each text of the Sanskrit literature is wadded with the uses of Sanskrit kṛdanta (participles). The knowledge and formation process of Sanskrit kṛdanta play a key role in understanding the meaning of a particular kṛdanta word in Sanskrit. Without proper analysis of the kṛdanta, the Sanskrit text cannot be understood. Currently, the model of Sanskrit learning is traditional classroom teaching which is accessible to the students but not to general Sanskrit learners. The acute growth of Information Technology (IT) is changed the educational pedagogy and web-based learning systems evolved to enhance the teaching-learning process. Though many online tools are being developed by researchers for Sanskrit these are still scarce and untasted. Globe genuinely demands the high-impacted tools for Sanskrit. Undoubtedly, Sanskrit kṛdanta is part of the syllabus of all universities offering Sanskrit courses. Approximately 100 plus kṛt suffixes are added with verb roots to generate kṛdanta forms and due to complexity, learning these forms is a challenging task. Therefore, the objective of the paper is to present an online system for teaching the derivational process of kṛdantas based on Pāṇinian rules and generate a complete derivational process of the kṛdantas for teaching and learning. It will also provide a platform for e-learning for the derivational process of Sanskrit kṛdantas.

Keywords : Computation and Digital Access of Sanskrit Grammar, kṛdanta, Pāṇinian Grammatical Tradition, Sanskrit Grammar, Derivational Process.

1. Background and Introduction

Sanskrit grammar is exigent to develop an elementary understanding of the ancient Indian philosophy, religious views, social issues, community laws, etc. as they are indicted in the Sanskrit language. Disparate grammars based on Sanskrit have been authored, but *Pāṇinīan* grammar *Aṣṭādhyāyī* (AD) is considered to be cardinal. It is a model of exhaustive grammar for any natural language yet small enough to memorize (Kulkarni, Sanskrit and Computational Linguistics, 2007). As the name of the AD suggests itself, there are eight chapters in AD (Pandey, 2017). Each chapter of AD is further divided into four sub-chapters, so there are a total of 32 (8*4) sub-chapters in AD. It consists of about 4000 aphoristic rules, which are called *sūtras*. Written in less than 4000 *sūtras*, this grammar structure is similar to that of a modern computer programming language. AD contains special sections on the phonological changes, morphological generator (Kulkarni & Shukl, Sanskrit morphological analyzer: Some issues, 2009), syntax, and semantics. The rule of *kṛt* suffixes is discussed in chapter third and other operational rules related to the derivational process of *kṛt* are discussed in the fourth and fifth chapters.

Around 1,190 *sūtras* are dealing with secondary nouns derived by *taddhita* suffixes and 631 *sūtras* are dealing with secondary nouns derived by *kṛt* suffixes. In this way, 1,821 i.e almost half of AD's *sūtras* discuss the derivational process of secondary nouns derived by *taddhita* and *kṛt* suffixes. The sixth, seventh and eighth chapters refer to the phonological changes that occur in the word's phonemes. These changes are either due to the addition of suffixes to the root word/verb or due to the sandhi. From the fourth sub-chapter of the sixth chapter to the end of the seventh chapter, there is a specific subject called *aṃgādhikāra*, which describes the changes that occur in the root words due to the suffix or in the suffix due to the root word. These changes are also seen as phonological changes. *Kātyāyanamuni* wrote 4300 *vārtikas* and *maharṣi Patañjali* wrote *Mahābhāṣya* on these *sūtras* of AD. Together they are called the *Trimuni* of Sanskrit Grammar. Albeit, based on their compositions, an infinite number of scholars wrote multiple scriptures and commentaries, yet, it is very challenging to understand Sanskrit grammar in the sequence of AD. This technical complexity diminished the understanding capabilities of the learners. Therefore, an emergent need for procedural texts, in which the different *sūtras* of AD were classified into different topics based on the subjects like Sandhi, *samāsa,* karaka, etc. to enhance understanding, and grasping of the concepts and kept in order with the point of view of their potential use. Keeping this in mind, a grammarian named *Bhaṭṭojidīkṣita* composed a procedural text called *Vaiyākaraṇasiddhāntakaumudī*. His disciple *Varadarāja* wrote the texts named *Madhyasiddhāntakaumudī* and *Laghusiddhāntakaumudī* in the concise form of the aforementioned text. Presently, the teaching-learning method (Chandra, Kumar, Sakshi, & Kumar, 2017) of Sanskrit grammar is of two types - ancient and modern. Where in ancient grammar, the *Kashika*, *Mahabhashya*, etc. are read and taught in the AD sequence, whereas, in the modern grammar, various subjects are taught through procedural texts like *vaiyākaraṇasiddhāntakaumudī, laghusiddhāntakaumudī, madhyasiddhāntakaumudī*, etc.

2. Scope and Objective of the Paper

AD is opined and envisaged as the idol grammar written in any language by scholars of Sanskrit and linguistics in India and abroad. *kṛdanta* words use and derivational process are precisely taught as a component subject at undergraduate and postgraduate levels in all major universities worldwide having Sanskrit or Indic languages departments and Sanskrit Universities. According to the sutra, *'kṛdatiṅ'* except the 18 tiṅ suffixes all those suffixes prescribed from the main verb is called kṛt, i.e., all those nominal words derived from the verbs are *kṛdanta* (Singh & Jha, Primary Derivational process in Sanskrit: A Computational Approach to Analysis of *Kridanta*, 2011). Hereby, without any verb phrase in Sanskrit sentence

behavior becomes possible only with *kṛdanta* words like-*snānīyam cūrṇam*, etc. according to AD, there are hundreds of kṛt suffixes which represent different situations and conditions. But it is also not necessary that all the *kṛdanta* words should be used as verbs. Most are used as nominal words even some *kṛt* suffixes denote the meaning of helping verbs, and prepositions too. So, it is clear that *kṛdanta* words are superabundantly used in Sanskrit texts. Without the knowledge of *kṛt* suffixes, Sanskrit texts cannot be understood. Consequently, identifying and analyzing these *kṛdanta* words is exacting.

In today's era of globalization of information technology, where the entire world is connected by a click of a button, world news is generated, accessible, and received through web organizations. There has also been a change in the medium of exchange of knowledge traditions. Online tools and content have taken the place of traditional access to the content. There is a lot of deficiency in the Sanskrit language. Many institutions are working to bring Sanskrit on the platform yet, to date, any online derivational process system for secondary nouns is not available where a person can find a complete derivational process of the given secondary noun as an output.

The purpose of this paper is to develop an online system for the analysis and derivational process according to AD by digitizing the *sūtras* related to *kṛdanta.* Through which anyone can easily solve their doubts and queries online related to the *kṛdanta* words according to *Pāṇinīan* grammar. As of now, the system accepts input in Devanagari and generates output in Devanagari.

Figure 1: User Interface

3. Data Collection and Digitization

The morphological analyzer and generator System is a web-based system for kṛdanta words, Sūtras of AD and vārtikas of Kātyāyana are stored in a text file/database with its reference, meaning, type, and explanation in UTF-8 format in Devanagari script. The sūtras and vārtikas are digitized, proofread, and stored in text files. Around 600 Sūtras of AD-related to kṛdanta are digitalized. The entire programming of the developed system is based on the pāṇinīya grammatical tradition (Pandeya & Pandeya, 1938).

3.1 Databases and Rules

The system uses various rules and databases to execute the result. Major rule files are listed below:

1. **Kṛt Recognition Rules**: It contains two major rules one is verb roots database and the other is recognition rules. The sample is shown in Tables 1 and 2.

MainRootVerb	kṛtDhatu
भू	भू
भू	भव
भू	भाव
ष्वद्	स्वद
ष्वद्	स्वाद
षूद्	सूद्

Table 1: verb roots database

SR	Start	Mid	End	Suffix
1		ि	तव्य	तव्यत्
2			तव्य	तव्यत्
3		ि	तव्य	तव्य
4			तव्य	तव्य
5			णीय	अनीयर्
6			नीय	अनीयर्
7			एलिम	केलिमर्

Table 2: recognition rules

2. Kṛt Siddhi Generation Rules: It contains two major rules one *kṛt* siddhi generation rules and the other AD rules. The sample is shown in Tables 3 and 4.

RecCode	Rule
तव्य_2_RB	Rule_01254#VF+तव्य Rule_153#VF+तव्य Rule_151#VF+तव्य Rule_157#VF+तव्य Rule_2541#VF+ितव्य Rule_0#
तव्यत्_1_RB	Rule_1308#VF+तव्यत् Rule_1254#VF+तव्यत् Rule_153#VF+तव्यत् Rule_151#VF+तव्यत् Rule_157#VF+तव्य Rule_2541#VF+ितव्य Rule_0#
यत्_1_EB	Rule_1254#VF+यत् Rule_153#VF+यत् Rule_151#VF+यत् Rule_157#VF+यत् Rule_3441#MF+य Rule_2541#MF+ेय Rule_0#

Table 3: kṛt siddhi generation rules

AD-SR	RULE	MEAN	TYPE	WORK
3.1.93	कृदतिङ्		सञ्ज्ञा	
3.1.94	वाऽसरूपोऽस्त्रियाम्		परिभाषा	
3.1.95	कृत्याः		अधिकार	
3.1.96	तव्यत्तव्यानीयरः		विधि	
3.1.97	अचो यत्		विधि	
3.1.98	पोरदुपधात्		विधि	
3.1.99	शकिसहोश्च		विधि	

3.2 Computational Platform and Techniques

The online derivational process system for words ending with *kṛt* suffixes is a cohesive mechanism as it works with the help of many small self-built digital components. To develop the system, computational rules were developed for analysis and derivational processes based on the *sūtras* of AD. The major components are User Interface, Preprocessor, Analyzer, Output Generator, and Table Generator. The computational environment for developing

this morphological mechanism was created through building various databases and modules.\

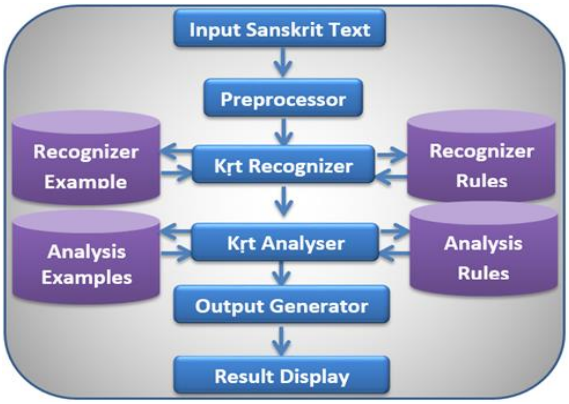

Figure 2: Flow Chart of the System

Databases and Text files are used for storing the data and rules. Any web-based system has two major parts: Front-End and Back-End. The front-end is developed using HTML, CSS, and JS codes embedded in HTML codes for page decoration and beautification of the User Interface. The back-end contains a lot of programming languages, databases, and servers. For this, the Python programming language, Text files, and Flask as a server have been used.

3.3 Methodology

The elevated system is an input-output generating system. It works with a reverse *Pāṇinian* approach. The methodology accepted to create a database is clearly in line with the well-defined and structured process of AD stated by *Pāṇini*. It takes input from the user and generates the corresponding output. The user can give input in Hindi (Devanagari). Once the input is given, a lot of self-built functions work simultaneously to give the output. The preprocessor initially runs the query at the back end syncing it with the digital analyzer. Then the following query is searched one by one from different databases and the corresponding result is generated. The generated result is formatted according to the users' query input and then displayed on the client's end. The methodology can be understood in Figure 1.

4. Major Features of the Developed System

The developed system has a very user-friendly and easy approach. This web-based matured system consists of a variety of features, it accepts the input query in Devanagari UTF-8 format. It further has the scope for creating multi-script input systems such as Roman, Gurumukhi, etc. Since the system is available online, it is widely accessible. *Kṛdanta* analyzer is a key feature of this system. We get the analysis of the given word as the main verb + suffixes added in the word. The main verb and suffix are also hyperlinked with their specifications like the verb's meaning, *gaṇa*, etc. The complete derivational process according to AD is the major highlight of this system. The whole process is quick and error-free. The system works on Rule and example base, which is similar to *Pāṇini's utsarga* and *apavāda* method. All digitize *sūtras/ vārtikas* are hyperlinked with their meaning and explanation in Hindi. The entire system will be available for public access over the web. Users can get a derivational process by using it from anywhere at any time.

5. Proposed Result and Future Direction

Kṛdanta analyzer and generator is a very useful system in teaching-learning pedagogies (Chandra, Kumar, Sakshi, & Kumar, 2017) for students, teachers, or researchers for immediate analysis or derivational process. In Sanskrit grammar derivational process has a key role in determining the meaning of any word because different suffixes conjoined with verbs denote exclusive meanings. So, learners can enhance their Sanskrit learning skills by assimilating the information, which can be easily obtained on this system. As this system is developed for E-learning, so it will be available 24*7 and with help of this system, more and more interested persons can receive education according to their desire and convenience. Users can get the *sūtras* used in the derivational process along with their AD number, Hindi meaning, type, and as well as explanation. Therefore, any teacher can easily teach this aspect by this system in online or offline mode. Currently, this system is under development. The prototype of the system has been developed. In the future, it is planned to make a morphological analyzer and generator for all major parts of *pāṇinīya* grammar such as *ṇijanta, yaṅanta, subanta* (Chandra, Sanskrit Subanta Recognizer and Analyzer, 2006), *sanādyanta, samāsa, sandhi, taddhita,* etc. Later on, the separate morphological analyzers can be combined into a single system of sentence analysis with karaka elucidation. This system is developed only for Hindi medium and Devnagari script. Developing this system further can be outbid for input/output in other languages and scripts like Sanskrit, English, Punjabi, Bangla, Tamil, Telugu, Roman, Gurumukhi, etc. It is hoped that this web-equipped system will play an important role in the Digital India scheme and new education policy run by the Government of India in the field of education. Also, in the field of e-learning, it will prove to be very useful for teachers and learners. It can be hortative for Computational Linguists.

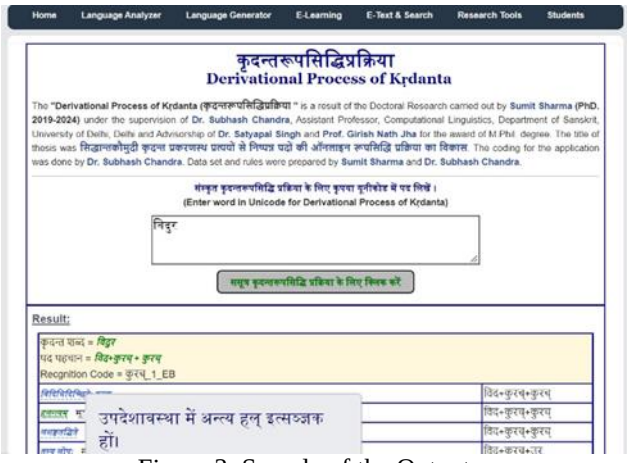

Figure 3: Sample of the Output

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