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HamNoSys to SiGML Conversion System for Sign Language Automation

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Abstract

Sign language is a visual gesture language. Deaf people use sign language as their main source for communication. They use their hands, face and arms for conveying thoughts and meanings. Sign language is not having any written form and generating signs using video approach is very expensive, so, sign animation is the best solution. Research on Indian Sign Language (ISL) Automation is limited because of lack of Indian Sign Language knowledge and the unavailability of such tools which provide any education for Indian Sign Language. An automation system is designed in which HamNoSys is generated corresponding to the ISL words. HamNoSys is further converted into XML form known as SiGML. A virtual human in tool JA SiGML URL APP takes input as SiGML and generates signs corresponding to the given words. The existing tool available for generation of SiGML is eSIGNEditor which contains a database of words for American and British Sign Language while sign language in India is different from that in America and Britain. So a system is designed to convert the HamNoSys to SiGML, so as to process it further to the SiGML player to animate the signs for ISL words.

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Keywords: HamNoSys; ISL; JASigning URL App; SiGML.

1. Introduction

Sign language (SL) is a visual gesture language which includes face, hands and arms to convey thoughts and meanings. It is used by deaf communities for the sake of communication, which is done by using hands, face, arms and body. Sign language is not universal. It changes from one region to another. Every country has its own sign language which varies from other countries in terms of syntax and grammar.

Indian sign language

Deaf people in India use Indian Sign Language (ISL) as the main mode of communication among them. ISL is a natural sign language which has its own phonology, morphology, syntax, and grammar[12]. The research on Indian Sign Language linguistics and phonological studies is limited because of lack of linguistically annotated and well documented data on Indian Sign Language. Indian Sign Language is used in deaf communities which include deaf people, hearing children of deaf adults, hearing parents of hearing-impaired children and hearing educators for deaf people. So, there is a need to build an automation system which can generate signs corresponding to the ISL words which are used while communicating with deaf people.

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1.1 HamNoSys: A notation system for sign language

The Hamburg Notation System (HamNoSys) is a system which is used to transcribe signs, like phonetic alphabets used for spoken languages. HamNoSys is capable of describing all signs used in all sign languages. It does not rely on the sign language conventions differing from country to country and thus can be used internationally[2].

1.1.1 General structure of HamNoSys

HamNoSys for a given sign consists of transcription of the non-manual features, describing hand-shape, hand-orientation, location and movement of hand[1].

a) Hand shapes

The Hand Shapes are mainly grouped as Fist, Flat-Hand, Separated Fingers and Thumb combinations. These four basic forms along with thumb variations (thumb extended or across the hand) and bending of fingers allows the user to write HamNoSys for any given Hand Shape[1]. Some of the fundamental Hand Shapes with flat and rounded hands are shown below in Fig. 1.

b) Hand orientation

HamNoSys describes the orientation of the hand for a given sign by combining two components: extended finger direction and palm orientation. There are three perspectives (signer's view, birds' view, and view from the right) which are used to show the direction of extended finger with respect to the signer's body. The palm orientation is also described with the same model for a given extended finger direction[1].

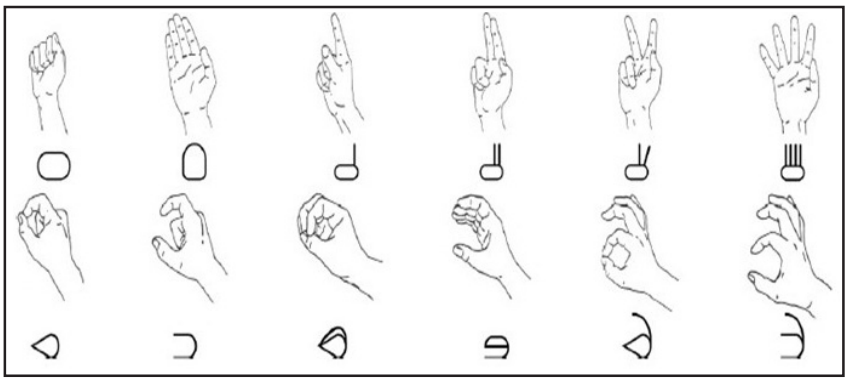


Fig. 1. Basic Hand Shapes[1].

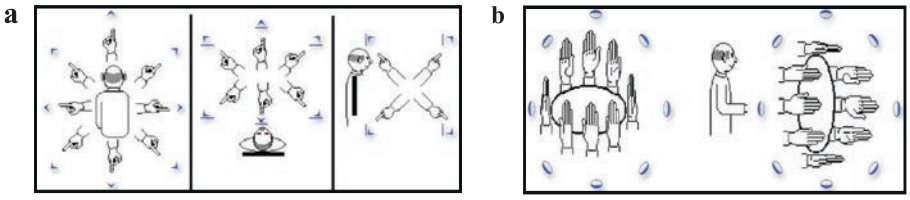


Fig. 2. (a) Extended Finger Direction[1]; (b) Palm Orientation[1].

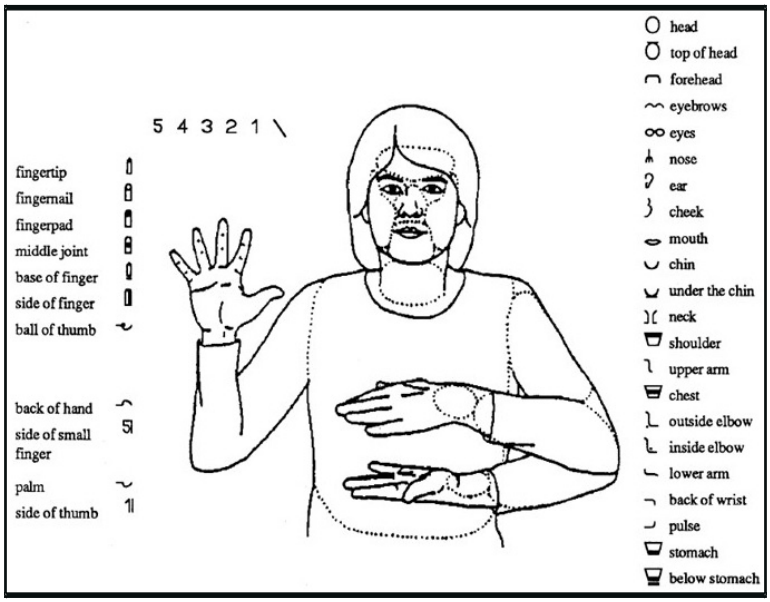


Fig. 3. Hand Location with Respect to Body Parts[2].

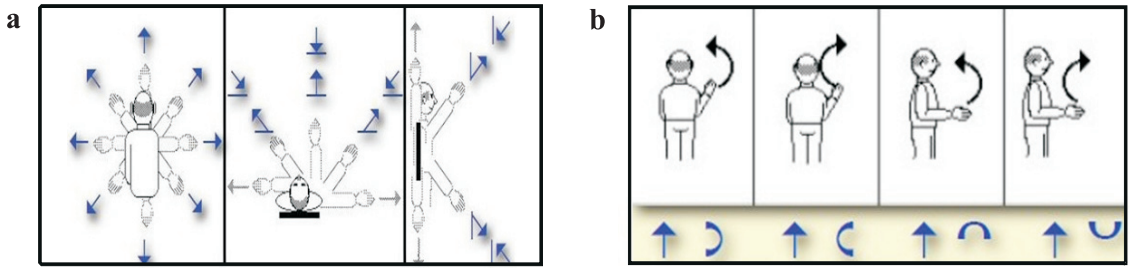


Fig. 4. (a) Straight Hand Movements[1]; (b) Curved Hand Movements[2].

c) Hand location

The location specifications are used to tell the location of the hands of the signer, these are split into two parts: The first part determines the location of the hand with respect to the body parts, where as the second part determines the distance of the hand with respect to the selected body part[2].

d) Hand movement

The movement types are distinguished as straight, curved, wavy, zigzag, circular and spiral movements. The straight movements are either parallel to the body or with referent to the body of the signer. The circular movements of the hand can either be clockwise or counter clockwise. The manner of the movements can be any of the three degrees of size, *i.e.*, large (expansive movement), normal size movement and small movement[2].

e) Non-manual components

The components which make the use of hands for signing are manual whereas those which include descriptions for shoulder shrugging, head movements, facial expressions or mouth movements are the Non-Manual ones. There

a

```
<sigml>
        <hns_sign gloss="Deaf">
                <hamnosys_nonmanual>
                </hamnosys_nonmanual>
                <hamnosys_manual>
                        <hamfinger23/>
                        <hamextfingerui/>
                        <hampalmu/>
                        <hamear/>
                        <hamtouch/>
                        <hammoveu/>
                </hamnosys_manual>
        </hns_sign>
</sigml>
```

b

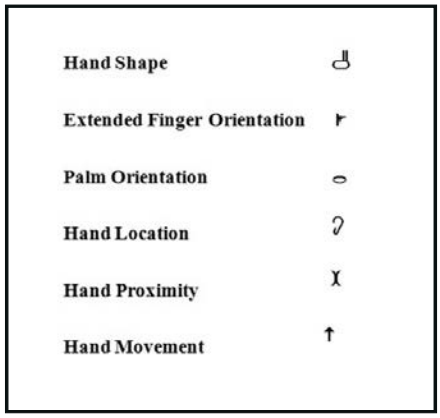


Fig. 5. (a) SiGML for Word "DEAF"; (b) HamNoSys Notation for Word "Deaf".

are various non-manual coding schemes which are defined for facial expressions (eye brows, eye gaze, eye lids and nose), limbs (head, shoulders and body postures) and gestures of mouth, but in ISL mainly the signer uses manual components[1].

1.2 SiGML language

SiGML is Signing Gesture Mark-up Language. It describes HamNoSys symbols into XML tags form. SiGML representation made from HamNoSys notation of sign language is readable by 3D rendering software[3]. SiGML for word "DEAF" is shown in Fig. 5.

2. Existing Work on Sign Language Automation

The automation of sign language is a very popular area of research all over the world where the researchers have been working on it to develop automated systems. These automated systems take text or speech as input and produce animation for it.

2.1 Existing systems for sign language automation

TESSA

Cox *et al.* (2002) had developed TESSA system based on direct translation approach. It is a speech to British Sign Language translation system which provides communication between a deaf person and a post office clerk. TESSA takes English as input text, lookup each word of the English string in the English-to-Sign dictionary, concatenates those signs together, and blends them into an animation. In this system, formulaic grammar approach is used in which a set of predefined phrases are stored for translation and translated by using a phrase lookup table. The post office clerk uses headset microphone and speech recognizer. In speech recognizer, legal phrases from the grammar are stored. When clerk speaks a phrase, speech recognizer matches it with legal stored phrases. Clerk's screen displays topics available corresponding to uttered phrase, for example, "Postage", "Bill Payments" and "Passports". From these phrases clerk select one phrase according to requirement and sign of that phrase is displayed on the screen. Because of use of a small set of sentences as templates TESSA is a very domain specific system. Currently there are around 370 phrases stored in this system[8].

TEAM

Zhao *et al.* (2002) had developed a system TEAM based on machine translation. It is a translation system which converts English text into American Sign Language. In this system the parser analyzes the input text. It involves two major steps. First step includes the translation of input English sentence into intermediate representation. It considers syntactic, grammatical and morphological information. In second step, its interpretation is performed. Its representation is done as motion representation which actually controls the human model and produce ASL signs[9].

Machine translation system from text-to-indian sign language

Dasgupta *et al.* (2008) had developed a system based on machine translation approach. It takes English text as input and generates signs corresponding to the inputted text. Architecture of system has four essential modules which are, input text preprocessor and parser, LFG f-structure representation, Transfer Grammar Rules, ISL Sentence Generation and ISL synthesis. Simple English sentence having only one verb is inputted to the parser. The parser parses the sentence and make dependency tree. LFG functional structure (f-structure) encodes grammatical relation of the input sentence. It also includes the higher syntactic and functional information representation of a sentence. This information is represented as a set of attribute-value pairs. For example, word like "BREAKFAST" in English is replaced by "MORNING FOOD" in ISL. ISL uses Subject-Object-Verb (SOV) word order. The final Indian Sign Language structure is achieved by the addition or deletion of words and restructuring of source representation[10].

2.2 Existing tools for sign language automation

The system used for automation of signs has many different tools for generating HamNoSys then converting it to SiGML and then playing the signs.

2.2.1 HamNoSys generation tool

The HamNoSys for any word whose sign is known can be entered from HamNoSys Tool by dragging and dropping the required HamNoSys symbols. This can be used for sign language of any region or country unlike eSIGNEditor, which is available only for ASL and BSL.

2.2.2 eSIGN editor: An editor of HamNoSys

An eSIGN Editor is an editor for ASL or BSL which contains HamNoSys and SiGML of various words. It also has the non-manual components such as facial expressions and mouth gestures which can be used during signing.

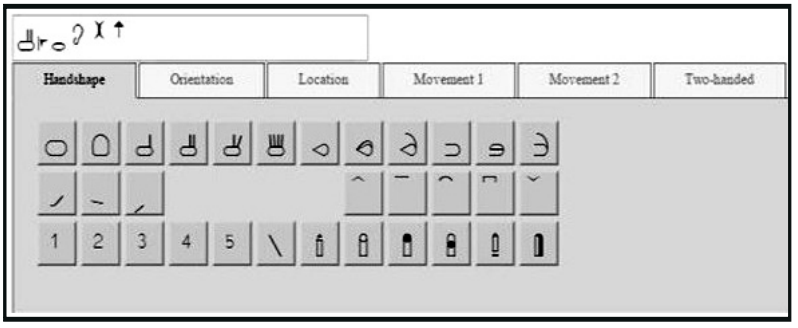


Fig. 6. HamNoSys Generation Tool.

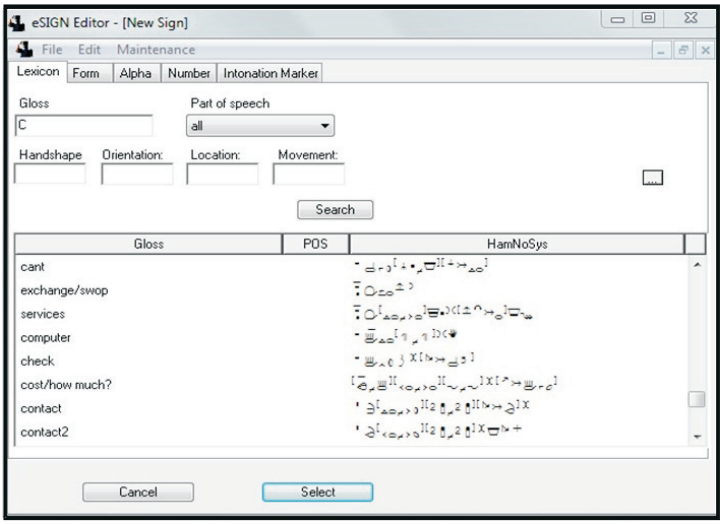


Fig. 7. eSIGNEditor Interface.

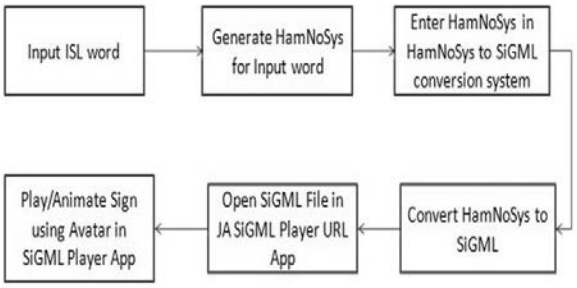


Fig. 8. Steps for ISL Automation.

2.2.3 JA SiGML URL App

The JA SiGML URL App consists of Avatars that are used to play signs. The SiGML file is put in the Player for making the signs corresponding to inputted text[5]. Animation frame definitions are given as input to avatar in a sequence, which also describes the time stamp of avatar, *i.e.*, at what time avatar will be making what type of pose[6].

3. Indian Sign Language (ISL) Automation System

An automation system is designed in which first the HamNoSys is generated for a word whose sign is to be automated .HamNoSys is then modified to produce a SiGML file which contains elements like XML. A virtual human in JA SiGML Player URL APP takes input as SiGML and plays sign corresponding to that ISL word. Thus the system in this way can be used to play the signs automatically to communicate with the deaf people.

The tools for HamNoSys generation and for playing the corresponding signs are already available and are universal, *i.e.*,not for the sign language of any particular region or country. But eSIGN Editor, which is used for HamNoSys to SiGML conversion, contains HamNoSys of words for either ASL or BSL. The sign language in India is different from that of ASL and BSL, so a separate system is designed for generating SiGML from HamNoSys so as to reduce the dependency on eSIGN Editor. The steps for sign automation for words given in ISL are shown in Fig. 8.

3.1 Architecture of the proposed system

For generation of sign language from input text, a system has been developed to convert HamNoSys of the given word to its SiGML form, to make it available for animation by the avatar. In this system, the user enters the HamNoSys form of a word and the System converts it into SiGML file automatically by matching the HamNoSys symbols to the corresponding SiGML tags.

3.2 Steps for automation of signs

The sign language automation tools are used to animate or play a sign for any given input word. The steps shown below describe the process of conversion of HamNoSys to SiGML and then automation of the signs by the SiGML Player.

Step 1) Entering HamNoSys

The HamNoSys of the ISL word which is to be converted to SiGML is entered in the system. The System contains a database of approximately 210 HamNoSys Symbols and their corresponding SiGML tags. The System matches the entered HamNoSys symbols with those which are stored in the database file. The HamNoSys for the word "Deaf" in ISL is entered in the system as shown in Fig. 10.

Step 2) SiGML Generation

The SiGML Tags of the entered HamNoSys symbols which are matched with the database file are written in a separate SiGML file. The file is saved automatically in the desired format which is processed by the SiGML URL

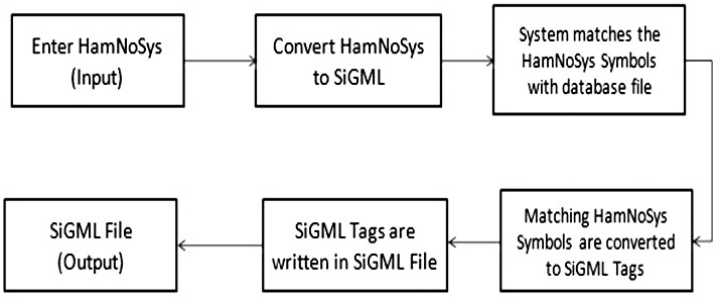


Fig. 9. Architecture of HamNoSys to SiGML Conversion System.

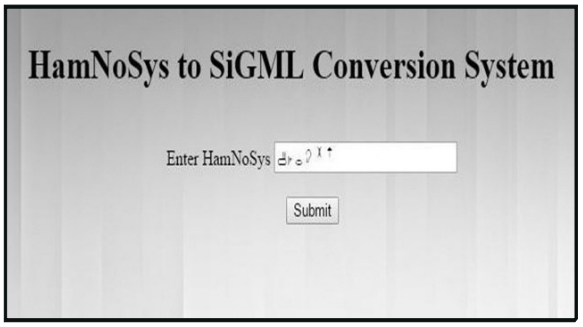


Fig. 10. Entering HamNoSys for Word "Deaf".

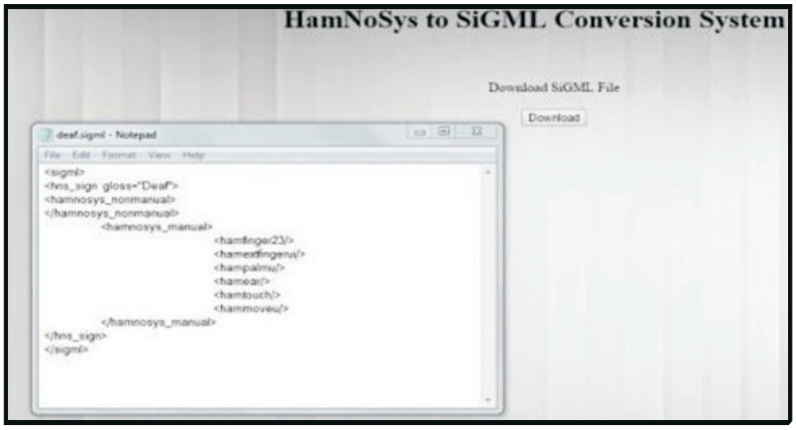


Fig. 11. SiGML Generation for Word "DEAF".

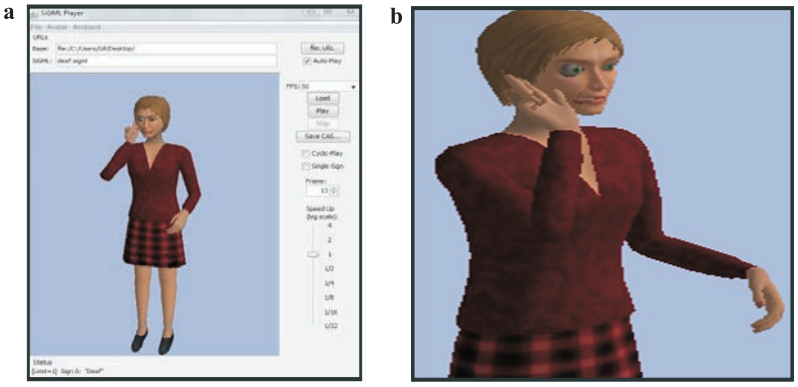


Fig. 12. (a) Avatar Showing Sign for the Word "DEAF"; (b) Side View of Avatar Showing Sign for Word "Deaf".

player. The HamNoSys for word "Deaf" is converted to its SiGML format by the system. The SiGML file for the word "Deaf" is shown in Fig. 11.

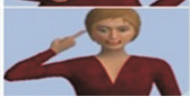
Step 3) Playing Sign

The JA SiGML URL App is used to play the sign from the SiGML File which is generated from the system. The SiGML file "Deaf.sigml" is given as input to Avatar Player which then plays the sign for word "Deaf".

4. Results

HamNoSys to SiGML conversion system has been tested for simple words which make use of manual components, *i.e.*, words which require hands only for signing and not other body parts. The system has been tested on 250 words which include basic hand-shapes, commonly used words in daily day-to-day communication such as names of birds and animals, body parts, colours and shapes, dishes and spices and also the words used in school items and in basic behaviour norms. The signs for all these words have been taken from the books on Indian Sign Language, which are published by an organization for hearing impaired persons. The signs after automation have been evaluated by the sign language experts of the same organization, the results are really very encouraging and are worth to be used for easy communication with deaf people. The system can be used for automating the entire Indian Sign Language content

Table 1. Example Words used for Testing HamNoSys to SiGML Conversion System.

Sr. No.	ISL Word	HamNoSys	Signing Avatar
1.	मैं (Me)		
2.	बच्चा (Child)		
3.	दांत (Teeth)		
4.	ताकत (Power)		
5.	घड़ा (Pot)		
6.	तीन (Three)		
7.	सोचना (Think)		

and also for learning sign language in a very easy and economical way. Some of the example words along with their HamNoSys and their corresponding signs are illustrated in Table 1.

The system has also been evaluated by another organization for deaf, dumb and blind children. The sign language experts at the organization provided us with the natural signs (signed by human user) for “Thirsty Crow” Story. The system is then used for the automation of “Thirsty crow” story for the purpose of learning for deaf children. It can be used in various educational institutions for deaf children to make them learn Indian Sign Language easily. The video URL for Thirsty Crow Story in ISL is provided below.

https://youtu.be/wKFoGV-FWzs

5. Conclusions and Future Scope

Deaf people or people who take birth in deaf families learn sign language as their first language. These people prefer to access information in form of sign language only. The ideal method for sign language creation is by transcription of HamNoSys and then automation of the signs. In this method, HamNoSys is generated corresponding to the ISL words and is further converted into XML form known as SiGML. The HamNoSys to SiGML Conversion System reduces the dependency on eSIGNEditor tool which is for ASL or BSL as signs in American or British Sign Language are different from that of Indian Sign Language. Virtual human player in JA SiGML URL APP takes input as SiGML and plays corresponding signs.

Sign language generation system works only for manual components and makes use of different tools. A system can be developed for ISL by combining all these tools together and also with a database of words which are commonly used in our daily day-to-day life. The HamNoSys generation system includes basic hand movements. It can further be extended to generate all the possible hand movements and non-manual expressions and a system can be developed to automatically convert text or image to its SiGML form as for generating HamNoSys of any given word, HamNoSys expert is required.

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