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Building machine-readable knowledge representations for Turkish sign language generation☆

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ABSTRACT

This article proposes a representation scheme for depicting the Turkish Sign Language (TİD) electronically for use in an automated machine translation system whose basic aim is to translate the Turkish primary school educational materials to TİD. The main contribution of the article is the introduction of a machine-readable knowledge representation for TİD for the first time in the literature. Like many resource-poor languages, TİD lacks electronic language resources usable in computerized systems. The utilization of the proposed scheme for resource creation is also provided in this article by two means: an interactive online dictionary platform for TİD and an ELAN add-on for corpus creation.

1. Introduction

Computer processing of human languages has been a research topic of interest ever since the invention of computers. Sign languages are the native languages of many prelingually deaf people. As it is the case for spoken languages, sign languages spoken in different countries/communities differ substantially from each other (and also from the spoken languages used in these countries) at lexical, morphological and syntactic levels, and systems tailored for a specific sign language are most of the time not directly applicable for another one. Although sign languages are real human languages, the research focused on their computerized processing remains rather limited compared to that for spoken languages. A very important reason behind this phenomenon is the lack of data resources (usable in computerized systems) for most of the understudied sign languages. The unconventionality of written sign language representations naturally makes the collection of such resources even harder; i.e., since sign languages are commonly not written languages, there is no written corpus available that would serve as the data for computational studies.

Several important projects have focused on developing and spreading the sign languages such as Dicta-Sign [1], SignSpeak [2] and SpreadTheSign [3]. Machine translation (MT), which is one of the ultimate aims of natural language processing (NLP) studies, is regarded as an AI-complete problem and becomes even more challenging in the case of sign languages due to the need of translation into/from a newer media (visual) than the conventional ones (spoken, written). Sign language generation from oral language material (i.e., machine translation from spoken/written language into sign language) is an attractive topic paving the way for information access for deaf people. Some important studies are ZARDOZ [4] from English to Japanese, Irish and American (ASL) sign languages, SignSynth [5] from English to ASL, eSIGN [6] for British, German and Dutch Sign Languages, VisiCAST [7] for British Sign Language, TEAM [8] for ASL, [9] for South African Sign Language, [10] and [11] for Spanish Sign Language, [12] from Chinese to Taiwanese Sign Language, MATREX [13] for Irish Sign Language, [14] for British Sign Language.

Written and machine-readable representations of sign discourse are crucial for machine translation systems. SignWriting is a writing system which uses visual symbols to represent the handshapes, movements, and facial expressions of signed languages. It is an "alphabet" - a list of symbols used to write any signed language in the world [15]. HamNoSys was developed by a group of hearing and deaf people as a scientific/research tool and first made publicly available in 1989 [16]. The purpose of HamNoSys, unlike SignWriting, has never been an everyday use to communicate (e.g., in

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letters) in sign language. It was designed to fit a research setting and should be applicable to every sign language in the world. The sign linguist Stokoe, first brought the existence of signed languages to the attention of linguists, with "Sign language structure" [17]. He invented a written notation for ASL, and formed a linguistic structure identical with that of spoken language, using symbols to represent the components parts of ASL. The original notation consisted of 55 symbols in three groups, namely; location, hand shape, and movement. Computer friendly markup languages have been developed in order to use these notations in computer-aided applications. The most well-known examples are, SWML [18] for SignWriting, SigML [19] (signing gesture markup language) for HamNoSys, and STEP notation [20] for HamNoSys written in order to pass to HAnim animation environment.

SignWriting, HamNoSys and Stokoe's sign language notations are graphical representations of the phonetic descriptions. However, with recent technology, it is possible to gather the motion data from human signers via cameras and depth sensors (i.e., Kinect). Similar to phrase based machine translation, if the signs of a block structure are being frequently repeated, they can be stored for use when needed during automated machine translation. Displaying these directly from storage, including necessary modifications, would produce a more natural translation than producing the animation from scratch by combining the motion primitives like phonetic segments. This approach is similar to the speech synthesis directly using phonemes in the old TTS systems. The output speech/accent was interpreted as unnatural and robot/machine-like. The recent approaches tend to concatenate bigger chunks, which leads to more naturally sounding speech. As a result, some recent studies focus on gloss-based notations (HLMSL for Spanish [11,21–23] for ASL) as we do in our proposed scheme.

The use of knowledge representation for natural language processing applications has been exploited previously in many studies such as sentiment analysis [24,25], handwritten text recognition [26], information retrieval [27], speech recognition [28] and predictive typing [29]. The main purpose of this article is to design and implement a formal TİD representation method to be mainly used in a machine translation system from Turkish to TİD via avatar animations. With the proposed gloss-based representation scheme, we aim to work with the avatar in a "loosely coupled" way so that it produces more natural looking actions and smooth transfers between the actions (each sign motion) via regression, as human beings do; e.g., a human signer would not drop down the hands to the standing position after every sign but would smoothly continue to sign the next sign; the signs in a sentence are continuous by nature in a sign language based conversation. The proposed platform provides this flexibility for the avatar based visual interface.

The main contribution of the article is the introduction of a machine-readable knowledge representation for TİD for the first time in the literature. Like many resource-poor languages, TİD lacks electronic language resources usable in computerized systems. The utilization of the proposed scheme for resource creation is also provided in this article by two means: an interactive online dictionary platform for TİD and an ELAN add-on for corpus creation. The article is structured as follows: Section 2 gives the motivation of the study by providing the detailed architecture of our translation system. Section 3 introduces the knowledge representation for TİD. Section 4 presents the utilization of the proposed representation scheme for resource creation: (Section 4.1) an interactive online dictionary platform for TİD and (Section 4.2) an ELAN add-on for corpus creation. Section 5 gives the conclusion.

2. Motivation

In Turkey, deaf students have great difficulty understanding the written Turkish used in the MEB (Ministry of Education) curriculum and following the course contents. The "Report on the Evaluation of Integrated Education Applications in Primary Schools" [30] presented the problems experienced by these students. These problems are caused by the fact that education in mixed classes (with deaf and hearing students) is not bilingual, that is, teachers of these classes cannot teach using Turkish Sign Language. Deaf students are expected to do something almost impossible, which is to learn how to read and understand a language that they cannot hear or speak. Thus, the ideal educational setting for deaf students would provide at least a bilingual environment with teachers or teaching assistants who can sign in Turkish Sign Language and help the students understand the content of the classes and books. Unfortunately, the scant number of trained teachers and teaching assistants who can teach in TİD makes it impossible to realize these environments in the near future for every school setting. Thus, we believe that a signing avatar-based interface which is especially developed for displaying the automatic translation of education materials would at least make the content of the materials accessible for deaf students. This translation system can by no means be considered as a substitute for a signing teacher but should be seen as a supplementary aid that can be used both in the classroom and at home.

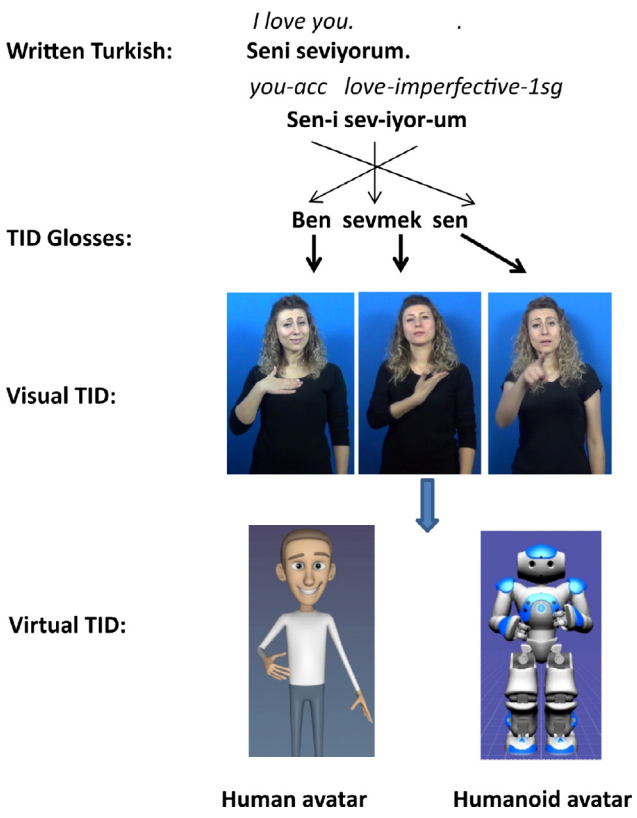

Fig. 1. Main flow of the translation system.

This study is part of an ongoing research project aiming to create a signing avatar for the automatic translation of elementary educational Turkish materials into Turkish Sign Language. It is basically composed of Turkish natural language processing layers, a transfer model from Turkish to TİD and a signing avatar-based interface. This section presents briefly the over-all design of this translation system in order to explain our motivation for the development of the proposed machine-readable knowledge representation for TİD.

The proposed architecture basically consists of two major layers. These are 1) the translation of written Turkish material into a machine-readable TİD representation and 2) the animation of this produced TİD representation. Fig. 1 depicts these layers on