BosphorusSign: A Turkish Sign Language Recognition Corpus in Health and Finance Domains

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Abstract

There are as many sign languages as there are deaf communities in the world. Linguists have been collecting corpora of different sign languages and annotating them extensively in order to study and understand their properties. On the other hand, the field of computer vision has approached the sign language recognition problem as a grand challenge and research efforts have intensified in the last 20 years. However, corpora collected for studying linguistic properties are often not suitable for sign language recognition as the statistical methods used in the field require large amounts of data. Recently, with the availability of inexpensive depth cameras, groups from the computer vision community have started collecting corpora with large number of repetitions for sign language recognition research. In this paper, we present the BosphorusSign Turkish Sign Language corpus, which consists of 855 sign and phrase samples from the health, finance and everyday life domains. The corpus is collected using the state-of-the-art Microsoft Kinect v2 depth sensor, and will be the first in this sign language research field. Furthermore, there will be annotations rendered by linguists so that the corpus will appeal both to the linguistic and sign language recognition research communities.

Keywords: Turkish Sign Language (TID), Microsoft Kinect v2, Health, Finance, Sign Language Recognition

1. Introduction

Sign Languages (SLs) are the natural means of communication of deaf communities. Each deaf community has its own sign language with specific rules of its own. Although the deaf can communicate with each other via sign language, the communication between the hearing and the Deaf is an issue and often requires interpreters. This issue becomes more crucial when the need to communicate becomes essential for a deaf person to fulfill their daily needs, such as getting services in a hospital or a bank.

Turkish Sign Language (Türk İşaret Dili, TID) is the language used by the deaf community of Turkey. The Turkish Deaf community also has trouble communicating with the hearing, as hearing community members rarely know Turkish Sign Language. Furthermore, literacy rates are low in the Deaf community, which also limits their communication. Recently instated Turkish laws mandate the use of sign language interpreters for public services. However, there is not enough trained personnel to deploy in each office and this absence has necessitated more feasible solutions such as automated translation services.

Sign language linguists have been studying Turkish Sign Language in recent years by collecting large corpora and analyzing the aspects of the language (Özsoy et al., 2013). However, there is no domain-specific corpus for Health and Finance. In this study, we are presenting Turkish Sign Language corpora in Health and Finance domains using a state-of-the-art depth sensor, Microsoft Kinect v2 (Zhang, 2012), that provides depth map, user mask, color image and accurate human pose information of the signers. The corpus consists of signs and phrases from three domains: The first is signs and phrases which would be used in a hospital or at a doctor's appointment; the second contains limited corpus in the finance domain and the third contains commonly used signs in everyday life. We have collected *855* sign and phrase samples from multiple signers: *496* samples belonging to the health domain, *171* samples belonging to the finance domain and the remaining *188* samples comprising commonly used signs in everyday life. When completed, the corpus will have at least six repetitions of each sign performed by 10 signers, giving a wide variance to the data.

In order to streamline the recording procedure, we have developed a recording software which records all the provided modalities of Kinect v2 sensor and allows online sign border annotation. In addition to the sign border annotations, the corpus will include HamNoSys (Hanke, 2004) and gloss annotations rendered by linguists, thus making this corpus a valuable resource for sign language researchers both from the computer science and linguistics community. The developed acquisition software and the collected sign samples are currently available on the BosphorusSign website[1].

Furthermore, a subset of this corpus contains phrases which would be used in interactions during a hospital or a bank visit of a person. As seen in Figure 1, these subsets are used to implement human computer interaction systems for assisting the Deaf in hospitals and banks. The user interaction survey, the graphical user interaction design details of the assistive system and the interaction scheme details can be found in (Süzgün et al., 2015).

The rest of the paper is structured as follows: In Section 2. we go over the currently available corpora used in sign language recognition and analysis. In Section 3. we share the specifications of our corpus collection and annotation procedures. Finally, in Section 4., we conclude the paper by reviewing the contributions BosphorusSign will make both to the Deaf community and to sign language research.

[1]www.BosphorusSign.com

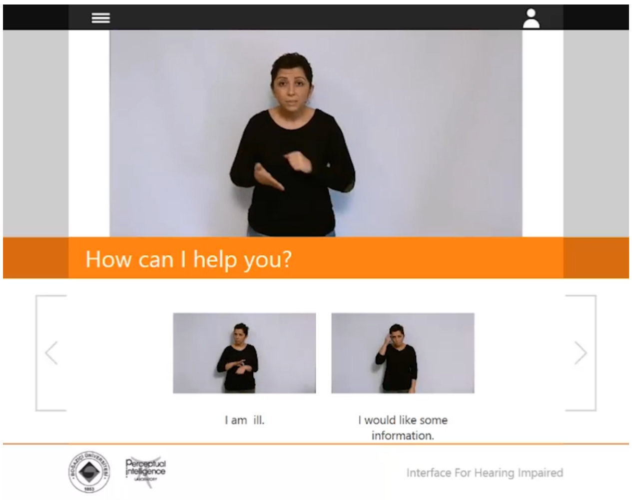

Figure 1: HospiSign: An Interactive Sign Language Platform for Hearing Impaired uses a Subset of the BosphorusSign

2. Related Work

Sign language is an active and challenging topic for linguistics and sign language recognition (SLR) research communities. Linguists pursue analyzing sign languages' properties and rules, whereas computer scientists working on SLR aim to develop systems that can automatically recognize sign language. However, due to several factors such as the lack of high quality capture and annotation technology as well as the absence of common transcription systems, the creation of corpora suitable for sign language recognition and linguistic research only became feasible in the last 20 years (Fenlon et al., 2015).

In sign language research literature, numerous sign language corpora exist with different properties. Known sign language corpora can be grouped according to several criteria such as acquisition method, language, research domain, context of content, size and annotations.

One of the defining bottlenecks for the creation of sign language corpora was the quality of the *acquisition methods*. Especially in the field of SLR, where data was lost in the mapping from 3D world to 2D image space, meaningful capture of signs became achievable with advances in computing, processing, and sensing technologies. First efforts in the field involved instrumented gloves for data capture (Gaolin Fang and Wen Gao, 2002), while later efforts involved RGB coloured (Starner et al., 1998; Dreuw et al., 2008; von Agris and Kraiss, 2010; Forster et al., 2012) and depth based segmentation of signer hands and body (Chai et al., 2015; Escalera et al., 2014; Stefanov and Beskow, 2013).

As can be seen in Table 2., the corpora used by linguistics and SLR communities have their own properties in correlation with respective research interests. Linguistically motivated corpora are often large vocabulary datasets. They usually have higher quality annotations to learn variation in sign performance, but fewer repetitions of signs or clauses due to difficulty of acquisition and annotation. Recent trends in corpora creation include creating datasets with large number of users from different regions / backgrounds to achieve widespread vocabulary coverage (Johnston, 2010; Schembri et al., 2013; Prillwitz et al., 2008).

Contrary to linguistically motivated corpora, machine learning or sign language recognition motivated corpora are created with a smaller vocabulary. SLR consists of a pipeline of subtasks such as human pose extraction, representation and statistical modeling. All of these tasks are open research questions, which makes large vocabulary SLR a challenging problem. Therefore these corpora often contain few users, but a higher number of repetitions per user to improve recognition performance (Cooper et al., 2011). While linguistic corpora contain conversing people (Özsoy et al., 2013), recognition oriented corpora almost always belong to single users performing signs or clauses (Escalera et al., 2014). A large number of these corpora are recorded in constrained recorded environment settings such as dark (Dreuw et al., 2008) or monotone backgrounds (Chai et al., 2015) to allow easier segmentation of human body and hand.

Annotations of SLR oriented corpora are often composed of sign boundary information while annotations of linguistic oriented corpora are more various and detailed. Decades ago Stokoe defined sign language glosses as combinations of movements, hand shapes and location (Stokoe, 1980). However, many studies developed their own gloss based annotations. The creation of sign transcription methods such as HamNoSys (Hanke, 2004) and SignWriting (Sutton, 2000) together with the development and availability of time aligned annotation software such as ELAN (Sloetjes and Wittenburg, 2008) and iLEX (Hanke, 2002) started standardization across sign language corpora, reducing inconsistencies across studies.

3. Compilation of the BosphorusSign Corpus

In this study, we present the BosphorusSign, a Turkish Sign Language corpus that consists of domain specific signs and phrases. The gathered corpus consists of three categories: (1) Signs from the health domain: Signs that a deaf person would use in a hospital, (2) Signs from the finance domain, which are the signs that a deaf person would use in a bank, and (3) Commonly used everyday verbs, nouns and phrases.

In order to create a list of generally used signs and phrases for each category, we have interviewed linguists, members of the Deaf community and domain specialists. The compiled vocabulary list has 855 signs and phrases: 496 signs and phrases that would be used in a hospital visit, 171 signs and phrases which would be used for banking and finance purposes and 188 signs and phrases that people would commonly use. After determining the vocabulary, we have collected samples for each sign and phrase. These samples were then annotated by linguists using ELAN and the HamNoSys. Vocabulary samples and their annotations will be publicly available on the BosphorusSign website for anyone who would like to do linguistic studies or to learn Turkish Sign Language.

Considering the fact that the SLR methods require large amounts of data, the corpora is aimed to have six repetitions

Study	Language	Research Field	Context	VS	Sample Size	NP	Acquisition Tool
(Starner et al., 1998)	American SL	SLR	General	40	478 Sentences	1	Video Camera (VC)
(Gaolin Fang and Wen Gao, 2002)	Chinese SL	SLR	General	208	4368 Samples	7	Data Glove
The NGT Corpus (Crasborn and Zwitserlood, 2008)	SL of the Netherlands	Linguistic	General	N/A	15 Hours	92	Video Camera
ATIS (Bungeroth et al., 2008)	Multilingual	Linguistic	Flight Information	292	595 Sentences	N/A	Video Camera
RWTH-BOSTON (Dreuw et al., 2008)	American SL	Linguistic, SLR	General	483	843 Sentences	4	Video Camera
ASSLVD (Athitsos et al., 2008)	American SL	Linguistic, SLR	General	3000	12000 Samples	4	Video Camera
DGS Corpus (Prillwitz et al., 2008)	German SL	Linguistic	General	N/A	2.25 million Tokens	328	Video Camera
SIGNUM (von Agris and Kraiss, 2010)	German SL	SLR	General	450	33210 Sequences	25	Video Camera
AUSLAN (Johnston, 2010)	Australian SL	Linguistic	General	N/A	1100 Videos	100	Video Camera
CopyCat (Zafrulla et al., 2010)	American SL	SLR	Game	22	420 Phrases	5	Accelerometer & VC
RWTH-PHOENIX-Weather (Forster et al., 2012)	German SL	SLR	Weather	911	1980 Sentences	7	Video Camera
Dicta-Sign (Matthes et al., 2012)	Multilingual	Linguistic, SLR	General	N/A	6-8 Hours (/Participant)	16-18 (/Language)	Video Camera
(Stefanov and Beskow, 2013)	Swedish SL	SLR	Game	51	2550 Samples	10	Kinect v1 Sensor
BSL Corpus (Schembri et al., 2013)	British SL	Linguistic	General	N/A	40000 Lexical Items	249	Video Camera
Montalbano (Escalera et al., 2014)	Italian SL	SLR	Cultural Signs	20	13858 Samples	27	Kinect v1 Sensor
LSE-SIGN (Gutierrez-Sigut et al., 2015)	Spanish SL	Linguistic	General	2400	2400 Samples	2	Video Camera
DEVISIGN (Chai et al., 2015)	Chinese SL	SLR	General	2000	24000 Samples	8	Kinect v1 Sensor

Table 1: Existing Sign Language Corpora. VS: Vocabulary Size, NP: Number of Participants

of each sign and phrase by at least 10 users. To streamline the recording procedure we have developed a recording software for Kinect v2 sensor which guides the signers and allows online sign border annotation during recording sessions. In each session, signers are presented and asked to perform 30-70 signs. These signs are randomly sampled without replacement from the total set of signs. This makes each session unique by randomizing the temporal ordering of signs and reducing the statistical significance of the effects of co-articulation. After each session's end the collected Kinect v2 modalities (color video, depth map, user mask and pose information) and sign border annotations are saved. When the corpus collection is completed, it will be accessible for academic purposes after filling a license agreement form on the BosphorusSign website.

3.1. Recording Software and Setup

All of the recording sessions have been carried out in a controlled environment where all the signers are facing the Microsoft Kinect v2 camera from a distance of 1.5 meters, in front of a green background. Although the Microsoft Kinect v2 sensor provides the user mask, the green background can be used for background subtraction by the researchers who would like to use color videos as their single modality. The recording setup can be seen in Figure 2 from the perspective of the signer and the recording person (user).

We have developed a data acquisition software for Kinect v2 that is user friendly for both the user and the signer and enables streamlined recording. The software was developed using Visual Studio 2013 and C# WPF languages. EMGU CV and FFMPEG external libraries are used for recording the color video and doing compression after each session.

As seen in Figure 3, the recording software consists of two windows, one dedicated to the user while the other dedicated to the signer. At the beginning of each session the user provides a script that contains the sign names and their video samples. During the recording process the signer first sees a sign sample video playing that is surrounded by an orange bordered window (Figure 3). After the sample video finished playing, the user signals the signer to start performing the sign by clicking the *Start Sign* button, turning the borders to green. After the sign is performed by the signer, user clicks the *Stop Sign* button which turns the borders to gray, indicating that the recording of this sample is completed by the signer. Then the user clicks the *Next Sign* button, thus starting the recording procedure for the next sign in the given script. This procedure enables online annotation of the sign borders in the recorded sessions. In case of errors in performing the sign or timing of the online annotation, the sample can be re-recorded using the *Repeat* and *Invalid Sign* buttons, which would invalidate the previously annotated video segment.

The software records color video, depth map, user mask, body pose information and sign border annotations in a folder named according to the script used, signer recorded and time of the recording session.

The recording software will be publicly available on the BosphorusSign website.

3.2. Annotation

There will be two types of annotations provided by BosphorusSign: (1) The sign border annotations of each session targeted for SLR researchers and (2) The sign level annotations for each sign sample which will be available online for linguists and sign language enthusiasts. Sign level tagging will include content tagging, glosses, spoken language translations, phonetic description with HamNoSys (Hanke, 2004), parts of speech; such as classifier or buoy, and non-manual marking (Johnston and De Beuzeville, 2011). Briefly, Classifiers are the signs considered as morphemes with a non-specific meaning but representing entities by expressing salient characteristics. Classifiers are represented by a set of iconic handshapes (Zwitserlood, 2012). Buoys which semantically help guide the discourse are produced with the non-dominant hand in a stationary configuration in the discourse while the dominant hand continues signing. They can accompany either a brief part or a significant stretch of the discourse. The dominant hand can also refer to a buoy during signing (Liddell, 2003).

Examples for the glosses of a simple word, compound and phrase are as follows: DEBT is a single handed simple word while ADDICTED consists of two lexical words; BOND and CRAVE. These two lexical words form a new lexical item, a compound BONDˆCRAVE. On the other hand, HOME ADDRESS and SCHOOL ADDRESS are considered as phrases because the words in the phrases can be modified. However, for ADDICTED, the meaning is not preserved when the words are modified. The glosses for

Figure 2: Recording Setup from the perspective of the user (Left) and the signer (Right)

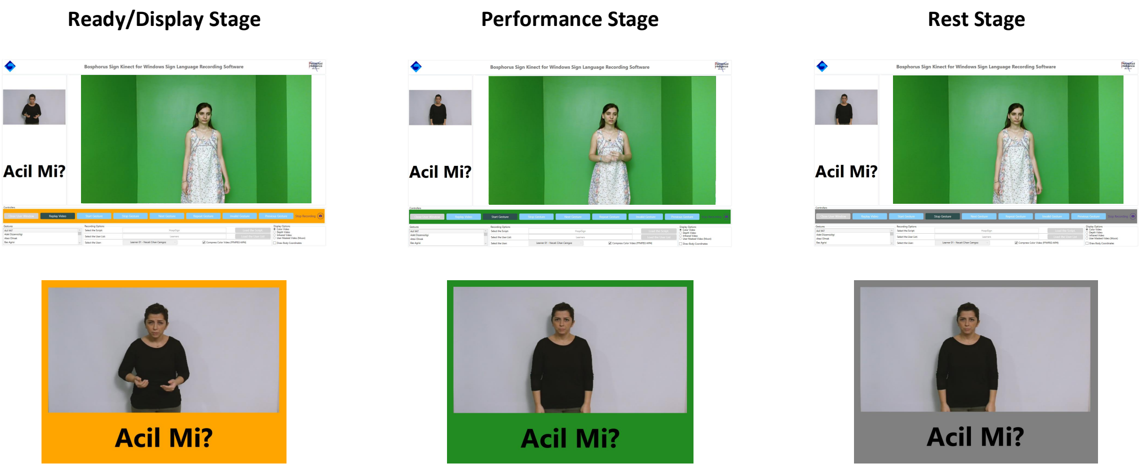

Figure 3: Recording software and its stages of recording a sample. Top Row: User Window, Bottom Row: Signer Window, From Left to Right: Getting Ready/Displaying the Sample Stage, Performance Stage and Rest Stage.

simple words are the same with their meanings while different glosses are provided for each word in the compounds rather than their meaning.

The corpus is annotated using ELAN (See Figure 4), which enables the search among the *.EAF files, according to the mentioned categories. The signs are provided with Turkish and English glosses alongside Turkish and English translations.

The corpus consists not only of words but also compounds and phrases. Due to this, the signs are lemmatized in order to facilitate searches among all the tokens in the corpus. Following these, the signs are phonetically described in HamNoSys to be more consistent for the variations among the signs. In addition to HamNoSys annotation, ELAN files have tiers for mouth movements and other non-manuals. If a sign has mouthing, then the mouthing is annotated. If the sign has a mouth gesture, then the type of the gesture as puffed cheeks or tongue protruding is given in this tier. This piece of information is expected to depict the differences among the signers.

In addition to the mouth tier, another non-manual tier is also given even though this information can also be stated in HamNoSys. The motivation behind it is that a researcher may want to look through the tokens consisting of a specific non-manual marker in the corpus. As a further step, the same motivation leads us to state the parts of speech information because the signs in the corpus contain classifiers or buoys, which can be crucial for future morphology research projects. The annotations also mark the types of classifiers (Kubuş, 2008) or buoys (Liddell, 2003) such as SASS (size and shape) or fragment buoy, respectively based on the studies in the literature.

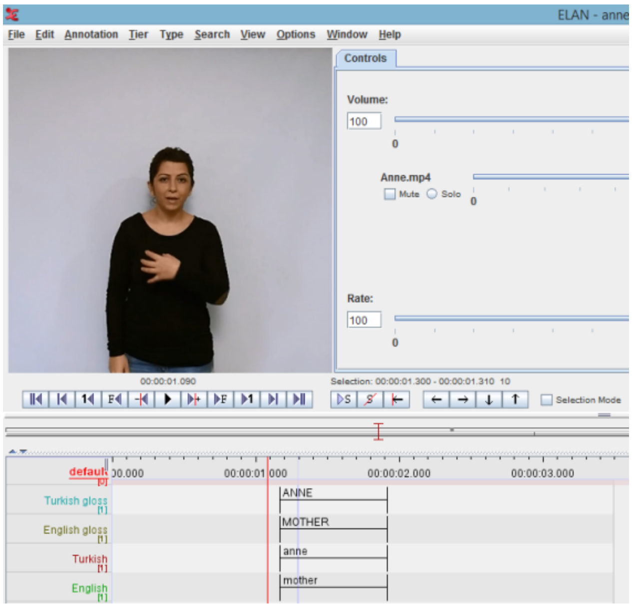

Figure 4: ELAN annotation sample of the word ANNE (MOTHER in English)

3.3. Distribution

The collected corpus will be available to download for academic purposes upon filling a license agreement available from the BosphorusSign website. The provided data will include Kinect v2 modalities (1080p color video, depth map, pose information and user mask) and their sign border annotations.
In order to distribute the corpus we had to solve the file size issue. The Microsoft Kinect v2 sensor provides high definition color videos, which occupy large disk spaces. For example, an unprocessed one-minute long video has an approximate size of 12 GBs. The recording software we have developed does lossless compression at the end of each session, thus shrinking the video's size. Nonetheless, these compressed videos are still not feasible for distribution as their sizes are approximately 5 GB/minute. In order to solve this issue, while preserving the video quality, we have conducted experiments using x264 compression algorithm and its parameters to lower the video size.
In the light of our experiments, we have chosen the lossy x264 parameters to be 23 for the Constant Rate Factor parameter and VerySlow for the preset parameter, which dropped the video size from 5 GB/minute to 14 MB/minute, making the video feasible to distribute while persevering the video quality (Mean pixel error rate of 2.7).
The provided data for each recording session, their formats and their mean sizes can be seen in Table 3.3..

4. Conclusion

The availability of carefully collected and annotated sign language samples is essential for research in both sign language recognition and sign linguistics. In this study we present the BosphorusSign, a Turkish Sign Language (TID) corpus which will serve both of these research communities as research material. The corpus contains 855 signs, 496 from the health domain, 171 from the finance domain and 188 from everyday life. The corpus will have six repetitions from 10 participants.
BosphorusSign has two main targets. The first target group is the sign language recognition researchers. SLR community will be provided with recording sessions and their sign border annotations upon filling a license agreement available from BosphorusSign website. The second target group is the sign language linguists, who will be able to study our publicly available samples and annotations. The corpus will also serve as a lexicon to people who would like to learn Turkish Sign Language, as our previous lexical database did[2].
Furthermore, we share the recording software developed for acquisition with Kinect v2 with researchers who would like to record their own data.

5. Acknowledgements

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[2]www.cmpe.boun.edu.tr/tid/

Modality	File Type	Resolution	Content	Mean Size
Color Video	.MP4 Video File	1920*1080 Pixels	24bpp Image Sequence	14 MB/minute
Depth Map	.RAR Binary File	512*424 Pixels	16bpp Image Sequence	255 MB/minute
User Mask	.RAR Binary File	512*424 Pixels	8bpp Binary Image Sequence	2 MB/minute
Pose Information	.CSV File	25 Joints	Joint Coordinates and Angles	5 MB/minute
Border Annotations	.CSV File	30-70 Signs	Sign Border Frames with Labels	5 KB/session

Table 2: Contents of the BosphorusSign Corpus

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