Sign Language Alphabet Translator Using Transfer Learning with Object Detection

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Abstract

Every country has its own sign language. There is no universal sign language in the world to help dead people communicate with others from other countries. This project focuses on developing a Sign Language Alphabet (SLA) translator that can play an important role by not only its interpretation but also helping deaf people to communicate with each other without learning a new sign language. In this project, the sign language used for training detective models is American sign language, and the detective models were imported from Pre-trained models for Transfer learning in the Keras library. The best six models, VGG16, ResNet50V2, MobileNet, MobileNetV2, DenseNet201, and Xception were selected by comparing the performance of the partial learning for further training of the full training dataset. After the training of the full training dataset, the six models were compared for accuracy and inference time and the result was MobileNet with an inference time as fast as 0.03 seconds and an accuracy of 99.68%. The test dataset was further detected using this MobileNet model and the detected results were mapped to Turkish sign language images for translation.

Index terms should be included as shown below.

Index Terms: sign language alphabet recognition, transfer learnings, object detection

1. Introduction

World Health Organization (WHO) projected that nearly 2.5 billion people in the world have hearing loss by 2050 and emphasized that sign language-related applications are essential tools for deaf people [1].

Instead of oral language using speaking and listening, Sign language is a form of visual communication through gestures, body movements and facial expressions. Sign language can be used for different purposes in different situations, but it is primarily designed for communication with the deaf. As it is more visually accessible to the deaf, sign language is a natural method of communication for the deaf and can express a wide range of meanings in the same way as spoken language; for example, American Sign Language is used by deaf people in the United States and partial provinces of Canada, British Sign Language is used by deaf people in the UK, French Sign Language in France, Japanese Sign Language in Japan and Chinese Sign Language in China.

Although there is no unified international sign language yet, the major sign language systems such as the USA, British, France and China have developed fingerspelling, also called "Sign Language Alphabet (SLA)." SLA represents the 26 common alphabets, A to Z, and local special letters using only hand gestures, mostly in difficult words such as personal names, place names and technical terms, etc. Additionally, it can also be used to facilitate easier communication when encountering issues with sign language dialects.

In the past decade, deep learning has shown excellent performance in image recognition, enabling breakthroughs in sign language recognition technology. Many studies have used neural networks to convert static SLA signs into text or speech, using images of hand gestures as input, and the main approach includes data acquisition technique, static signs, classification with over 90% accuracy of recognition [2]. Moreover, Transfer Learning is one of the major milestones in Deep Learning for Object Detection. With Transfer Learning, pre-trained models have already been trained on a different task, therefore it is a short-cut that re-uses the pre-trained model and shorter the training process. This project aims to utilize pre-trained models from Transfer Learning with Object Detection in Keras and to apply static hand gesture images into different pre-trained model architecture to present a development of an SLA translator, which translates American SLA to Turkish SLA, thereby helping deaf people to communicate with each other without learning a new sign language. The remainder of this paper will include related work in the Sign language recognition research area, the problem statement found in the research, the objective of the project, and the methodology applied in the project. Afterwards, six pre-trained models, VGG16, ResNet50V2, MobileNet, MobileNetV2, DenseNet201, and Xception from Transfer Learning with Object Detection in Keras library are selected and trained as predictive models. The results of relevant inference time and accuracy are evaluated as performance to determine the best model for the use case. In end, the best model predicts ASL images using the test dataset, and the predicted results have a further mapping with Turkish SLA images.

2. Related Work

SLA translator is highly influenced by hand gesture recognition research using various devices for decades. There are two main approaches of sign language recognition: sensor-based or vision-based [3]. The major difference between sensor-based and vision-based approaches is on the data acquisition phase. Sensor-based approaches utilize sensor instruments such as sensory glove to capture sign language, but such equipment was too complex and expensive to be widely actual used. On the other hand, vision-based approaches don't require complex facilities to acquire data, acquiring images or videos of the sign language through camera. For example, D., Cao et al.[4] in 2015 developed sign language recognition by adapting Microsoft Kinect technology and used Random forest to successfully recognized static 24 American SLA with above 90% accuracy. Furthermore, A., Joshi et al.[5] presented a real-time automated American SLA translator that translates American SLA to English text by applying edge detection and cross-correlation methodologies, resulting in 94.23% accuracy for alphabets. In recent years, Convolutional neural network (CNN) has become a common method applied in image recognition and classification. M., Taskiran et al.[6] designed a real-time sign language system with an implementation of feature extraction and classifier based on a CNN structure, resulted in 98.05% accuracy.

3. Research question

3.1. Problem Statement

The previous works showed great achievements in translating American SLA to texts by capturing images through cameras and using CNN for feature extraction and classification. However, an SLA translator from American SLA to other SLA is still not available today.

3.2. Objective

The goal for this research question aims to develop an SLA translator that use optimal transfer learning for object detection to recognise images of American SLAs and translate them into Turkish SLAs with images. For example, the American alphabet P in sign language is recognised and translated into the Turkish alphabet P in sign language. With sign language recognition, deaf people from different countries can communicate with each other without having to learn a new sign language.

4. Methodology

One of the main benefits of using transfer learning is to make use of previously trained models and save computational cost (CC) for basic tasks like the removal of background. It may also be used when the training data is sparse. For the detection of American SLA we may use (to a degree) any pre-trained model for object detection on our dataset of American SLA signs even if they are limited in count and quality, as they only make the last layer of our final model.

To determine, whether a model may be suitable for our application, we use all of the models and its variants available in Keras[7], as shown in Table 1. The *Avg. Top-5 Accuracy* in the table refers to the average accuracy of all variants combined.

Table 1: *Keras Applications*

Name	Avg. Top-5 Accuracy	Total	Variants (*=Model)
Xception	0.945	1	*
VGG	0.901	2	*16, *19
ResNet	0.931	6	*50, *101, *152, *50V2, *101V2, *152V2
Inception	0.945	2	*V3, *ResNetV2
MobileNet	0.898	2	*, *V2
DenseNet	0.930	3	*121, *169, *201
NASNet	0.940	2	*Mobile, *Large
EfficientNet	-	8	*B0, *B1, *B2, *B3, *B4, *B5, *B6, *B7

In order to determine, which of the above stated models we will futher evaluate and possibly optimize, we train each of the Keras models in an experimental setup. The experimental training is defined by:

1. Training with 5% of the dataset (4.300 images, equally distributed to the 29 targets), with a 80/20 Train-Test-Split
2. 10 Epochs of Training
3. No Early Stopping

The results will focus on two key indicators: accuracy on our dataset and training time.

5. Results

In order to find the most suitable algorithm for translating a live input stream of American SLA to any other suitable SLA (sharing the same alphabet) in a real-world application, the algorithm needs to excel in two main aspects: accuracy and inference time. A third factor that may come into question here is the training time, as computational cost may accumulate when further improving the model in the future.

5.1. Basic layout features

- Proceedings will be printed in DIN A4 format. Authors must submit their papers in DIN A4 format.
- Two columns are used except for the title section and for large figures that may need a full page width.
- Left and right margin are 20 mm each.
- Column width is 80 mm.
- Spacing between columns is 10 mm.
- Top margin is 25 mm (except for the first page which is 30 mm to the title top).
- Bottom margin is 35 mm.
- Text height (without headers and footers) is maximum 235 mm.
- Headers and footers must be left empty.
- Check indentations and spacings by comparing to this example file (in PDF).

5.1.1. Headings

Section headings are centered in boldface with the first word capitalized and the rest of the heading in lower case. Sub- headings appear like major headings, except they start at the left margin in the column. Sub-sub-headings appear like sub-headings, except they are in italics and not boldface. See the examples in this file. No more than 3 levels of headings should be used.

5.2. Text font

Times or Times Roman font is used for the main text. Font size in the main text must be 9 points, and in the References section 8 points. Other font types may be used if needed for special purposes. It is VERY IMPORTANT that while making the final PDF file, you embed all used fonts! To embed the fonts, you may use the following instructions:

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5.3. Figures

All figures must be centered on the column (or page, if the figure spans both columns). Figure captions should follow each figure and have the format given in Figure 1.

Figures should be preferably line drawings. If they contain gray levels or colors, they should be checked to print well on a high-quality non-color laser printer.

Graphics (i. e., illustrations, figures) must not use stipple fill patterns because they will not reproduce properly in Adobe PDF. Please use only SOLID FILL COLORS.

Figures which span 2 columns (i. e., occupy full page width) must be placed at the top or bottom of the page.

5.4. Tables

An example of a table is shown in Table 2. The caption text must be above the table.

Table 2: *This is an example of a table*

Ratio	Decibels
$1/10$	-20
$1/1$	0
$2/1$	≈ 6
$3.16/1$	10
$10/1$	20
$100/1$	40
$1000/1$	60

5.5. Equations

Equations should be placed on separate lines and numbered. Examples of equations are given below. Particularly,

$$x(t) = s(f_\omega(t)) \tag{1}$$

where $f_\omega(t)$ is a special warping function

$$f_\omega(t) = \frac{1}{2\pi j} \oint_C \frac{\nu^{-1k}\mathrm{d}\nu}{(1-\beta\nu^{-1})(\nu^{-1}-\beta)} \tag{2}$$

A residue theorem states that

$$\oint_C F(z)\,\mathrm{d}z = 2\pi j \sum_k \mathrm{Res}[F(z), p_k] \tag{3}$$

Applying (3) to (1), it is straightforward to see that

$$1 + 1 = \pi \tag{4}$$

Finally we have proven the secret theorem of all speech sciences. No more math is needed to show how useful the result is!

5.6. Information for Word users only

For ease of formatting, please use the styles listed in Table 2. The styles are defined in this template file and are shown in the order in which they would be used when writing a paper. When the heading styles in Table 2 are used, section numbers are no longer required to be typed in because they will be automatically numbered by Word. Similarly, reference items will be automatically numbered by Word when the "Reference" style is used.

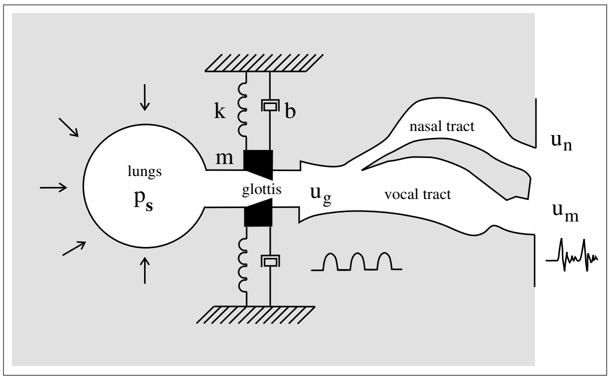

Figure 1: *Schematic diagram of speech production.*

Table 3: *Main predefined styles in Word*

Style Name	Entities in a Paper
Title	Title
Author	Author name
Affiliation	Author affiliation
Email	Email address
AbstractHeading	Abstract section heading
Body Text	First paragraph in abstract
Body Text Next	Following paragraphs in abstract
Index	Index terms
1. Heading 1	1st level section heading
1.1 Heading 2	2nd level section heading
1.1.1 Heading 3	3rd level section heading
Body Text	First paragraph in section
Body Text Next	Following paragraphs in section
Figure Caption	Figure caption
Table Caption	Table caption
Equation	Equations
• List Bullet	Bulleted lists
[1] Reference	References

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The INTERSPEECH organizing committee offers the possibility to submit multimedia files. These files are meant for audiovisual illustrations that cannot be conveyed in text, tables and graphs. Just like you would when including graphics, make sure that you have sufficient author rights to the multimedia materials that you submit for publication. The proceedings media will NOT contain readers or players, so be sure to use widely accepted file formats, such as MPEG, Windows WAVE PCM

(.wav) or Windows Media Video (.wmv) using standard codecs.

Your multimedia files must be submitted in a single ZIP file for each separate paper. Within the ZIP file you can use folders and filenames to help organize the multimedia files. In the ZIP file you should include a TEXT or HTML index file which describes the purpose and significance of each multimedia file. From within the manuscript, refer to a multimedia illustration by its filename. Use short file names without blanks for clarity.

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5.9. Page numbering

Final page numbers will be added later to the document electronically. *Do not make any footers or headers!*

5.10. References

The reference format [8] is the standard IEEE one. References should be numbered in order of appearance, for example [9], [10], [11, pp. 417–422], and [12].

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The total length of the abstract is limited to 200 words. The abstract included in your paper and the one you enter during web-based submission must be identical. Avoid non-ASCII characters or symbols as they may not display correctly in the abstract book.

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Please list country names as part of the affiliation for each country.

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The maximum number of authors in the author list is twenty. If the number of contributing authors is more than twenty, they should be listed in a footnote or in acknowledgement section, as appropriate.

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6. Discussion

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7. Conclusions

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9. References

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