

Recognizing Sign Languages Using Pattern Recognition

Abiyyu Avicena Ismunandar
13517083
13517083@std.stei.itb.ac.id

Abstract— Communication is a mean of transferring ideas from one person to another, currently communicating verbally is the most common way. However, some people do not have the ability to communicate like the majority. Some of those people have developed a way to communicate by using Sign Languages. In the age of technology, we had many breakthroughs in technology that made the gap between verbal and nonverbal means of communicating becoming almost undistinguishable. Such breakthroughs have been made possible due to the advances in pattern recognizing algorithms. This paper will discuss the different methods of pattern and gesture recognition that have helped in the advancement of recognizing sign languages in order to bridge the gap of nonverbal and verbal means of communicating.

Keywords—Sign Language, Pattern Recognition Algorithm, Gesture Recognition Algorithm

I. INTRODUCTION

Ideas can be transferred through many means such as from writing or speaking. However, some people are not able to communicate in the way that most people are able to due to physical or mental boundaries. Some nonverbal means of communicating includes Sign Languages or writing explicitly on some kind of medium. These methods have somewhat shortened the gap between verbal and nonverbal communication.

Although, in the past few years there have been numerous advances in the development of bridging verbal and nonverbal means of communication. These advances are able to be reached due to the development of pattern and gesture recognition studies. Both software and hardware that are used for the development of verbal and nonverbal communications have been improved to the point that it may be possible that communication between every means are indistinguishable. These advances can be reached due to the studies done by pattern and gesture recognition experts which will be discussed more thoroughly in this paper.

II. THEORY

A. Pattern Recognition

Before discussing further, pattern recognition as field of study itself has to explained and discussed first. Pattern recognition as a field study is quite an old subject but due to recent advances in technology had hit a “Gold Rush” of

advancements due to developments in technology allowing scientist to reach what was unreachable in the past. Some of the fields that are in pattern recognition includes computer vision, image processing, text and document analysis and neural networks [1]. This field of study can be linked to what was thought in Algorithms Strategies, where the subject of string pattern recognition was used in order to find the right “pattern” in the sea of text. In the study of pattern recognition String matching algorithms are the introduction to the many field of pattern recognition.

For this paper, the branch of study of image processing will be discussed further as it is one of the crucial parts of recognizing sign languages using software and hardware. The branch of study discusses a method of converting an image into digital form so that researcher may extract useful information [3]. From the book made James R. Parker called *Algorithms for Image Processing and Computer Vision* mentions that for basic vision system, the language OpenCV is used [2].

```
void Dilation( int, void* )
{
    int dilation_type = 0;
    if( dilation_elem == 0 ){ dilation_type = MORPH_RECT; }
    else if( dilation_elem == 1 ){ dilation_type = MORPH_CROSS; }
    else if( dilation_elem == 2 ){ dilation_type = MORPH_ELLIPSE; }

    Mat element = getStructuringElement( dilation_type,
                                        Size( 2*dilation_size + 1, 2*dilation_size+1 ),
                                        Point( dilation_size, dilation_size ) );

    dilate( src, dilation_dst, element );
    imshow( "Dilation Demo", dilation_dst );
}
```

An example code using OpenCV to dilate an image used in image morphology

The book also mentions methods that are used in image processing such as edge-detection, digital morphology, and image restoration [2]. Edge detection is a way of recognizing where images boundaries and planes are by extracting a pixel’s intensity variations of gray tones [4]. Digital morphology is a way of abstraction in image processing as the main goal of the field of image morphology is to get the most of the information from an image. And image restoration is a way to “fix” defects from an image [5].

B. Sign Languages

Now that the basic theory for pattern recognition have been briefly introduced, the object that needs to be analyzed has to be introduced. This paper will discuss in the scope of American Sign Language since most of the ongoing research has used American Sign Language in order to develop some sense of information. Most sign language are communicated

through the means of both hand and body gestures. Even the speed of the gestures and the facial expression of the communicator may indicate to different kind of meaning. Sign Language itself did not develop as the English language developed [6]. ASL (American Sign Language) is a language at their own right and is independent from their geographical region's language. Most of the deaf people developing the Sign Language itself are independent from how the local verbal speakers developing their own language. Before, most people thought that the Sign Language was more of a substitute to verbal language.



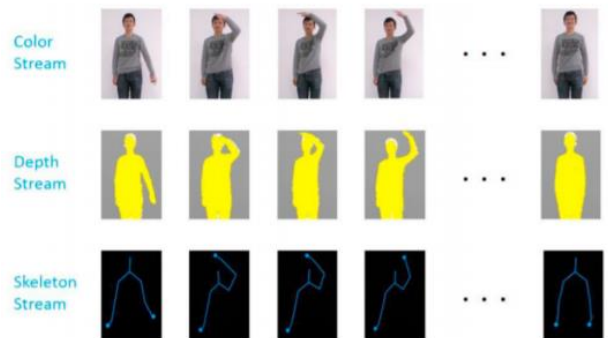
The alphabet in Sign Language

To further the claim that most Sign Languages is an entirely different language with the regional's own language lies in the grammar used in sign languages. For example, in the American Sign Language's grammar there is a certain word order that is entirely different with how the English language is structured, that there is no indication of a state of being in American Sign Language and when expressing a sentence that contains an indication of time ASL follows this order "Time-Subject-Verb-Object" so that means a person who uses ASL needs to mention the time of occurrence first [7]. These distinctions that are unique for a Sign Language distinguish their presence as a language themselves.

C. Methods of Gathering Data

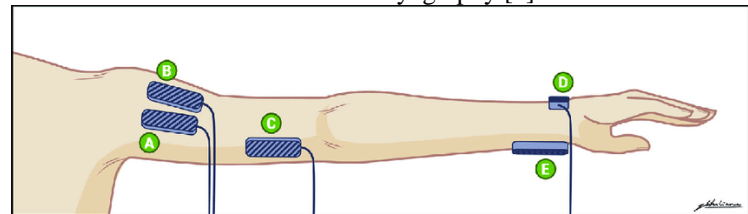
In order to analyze Sign Language using pattern recognition, scientist has to first receive the pattern of sign gestures to analyze. The method of gathering images varies from image processing using cameras to using active sensor devices. There are benefits and also costs in doing one or the other's method.

The main device used by many scientists in processing Sign Language Recognition is the camera [8]. In order to capture high quality data, scientist use higher resolution cameras to avoid blurriness and use cameras that can capture 30 frames per second videos which can be used to analyze gestures. There is also the choice of using a device called the Microsoft Kinect. The device provides color and depth video stream simultaneously.



Example of Microsoft Kinect Image Results

Another method of Sign Language recognition uses accelerometer and sensory gloves. These devices can easily distinguish hand orientations and movements with different trajectories [8]. However, it is not quite practical to be used in a day-to-day basis since the equipment used are quite expensive and may be tedious to be used. Some of the example sensory gloves and accelerometer are 3-axis accelerometer and flex sensors, 5-dimensional tracker, and Accelerometer and surface electromyography [8].



Example of Accelerometer and surface electromyography

D. Methods of Processing Data

In the processing Sign Language Recognition, the Hidden Markov Model is used in temporal pattern recognition such as gesture recognition. A Hidden Markov Model is a statistical Markov Model that has hidden states and is assumed to be in the Markov process [9]. Moreover, scientists also use other algorithm in pair with the Markov Model. Such algorithms include fuzzy K-means algorithm. The algorithm is used for classifying hand shapes, the hands of the Sign Language gesturer will be classified to eight clusters for the right hand and seven clusters for left hand [8]. After classifying the hand into clusters the Hidden Markov Model will then be used to distinguish different movement the Sign Language gesturer did.

As mentioned above Sign Language Recognition also uses the neural network some of the methods used are 3D Convolutional Neural Network [8]. This neural network method is a deep learning algorithm that finds significance from various aspects in the object and is able to differentiate from them [10]. At the 3D CNN layer, the data that has been created distinguishes each movement and analyze the significance of different kind of movements.

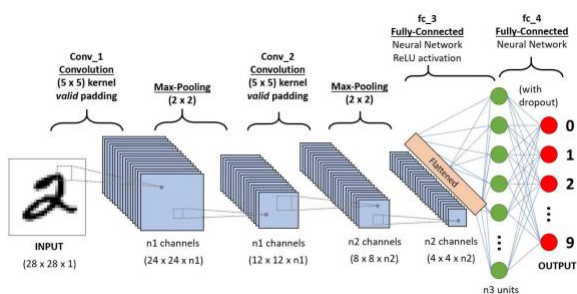
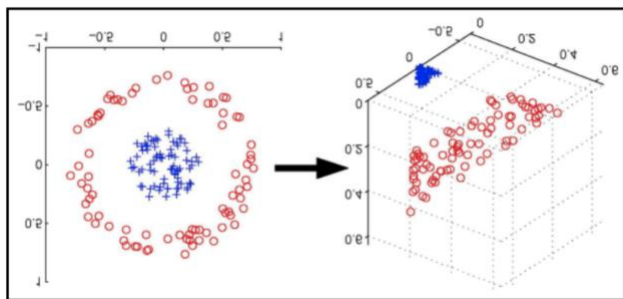


Illustration of 3D CNN

Another method of Sign Language Recognition is by using simple ANN. ANN or Artificial Neural Networks are loosely modelled the biological brain networks. They are used to illustrate how the brain solves problems with large clusters [11]. These systems will try to learn by itself and solve problem in the future by using what it has learned from the past. This method will be useful in recognition of Sign Language as it sees more and more examples of Sign Languages.

Another method is called Support Vector Machine, called SimpSVM or simple Support Vector Machine. To explain briefly it is used to approximate the normal vector and reduce the set expansion. By reducing the set expansion, the smallest number and corresponding reduced methods result in loss that is acceptable.



Support Vector Machine

III. ANALYSIS

In this paper, sign languages are recognized and analyzed by using a combination of vision, image processing and neural networks to distinguish the gestures and shapes of sign languages that are used. There have been mentions of methods to process images in order to retrieve information about the shape or form of the image in question. The challenges in recognizing sign languages using pattern recognition lies in the costs of doing such high-end analysis. Since, using more high precision equipment means the cost of using it will be higher. Therefore, this paper will list some of the methods that were used and analyze the result and success of such methods.

A. Usage of HMM in SLR

HMM is applied in SLR in pair with some other algorithms. When paired with fuzzy K-means algorithm the fuzzy K-means will first classify the hands' shape. The HMM will then distinguish different gestures and put meaning onto them.

Another type of HMM is the light HMM where the key frames through low-rank approximation and adaptively determine the hidden states. By doing so the frames will be linearly independent of each other.

There is also the method quite similar to CHMM (Continuous HMM) called TD-HMM. This method reduces the amount computation since similar Gaussian mixture components are mixed together.

From the methods mentioned above the Light HMM method has an accuracy of 83,6% and Tied-Density HMM results in 91,3% accuracy.

Even though, HMM is an ancient method—though popular. Most of the scientist that develop in the HMM method has continued on to develop the accuracy of SLR by using HMM. Scientist in the field have modified HMM for furthering researches.

B. Usage of Neural Network in SLR

In neural network, application of SLR by using Neural Network is in the image recognition. The use of 3D-CNN in research for SLR is to extract hand and upper gesture. The 3D-CNN has the accuracy of 94,2%.

ANN is another Neural Network method that learns from examples by constructing input and output mapping. This method also has a high accuracy rate of 91,5%.

The most accurate method of SLR is by using the Neural Network Method. It may be caused by how it uses deep learning algorithm that it becomes more and more accurate as a method. Most scientists in the field of SLR adopts the Neural Network method as the common way to research in Neural Network Method.

IV. CONCLUSION

The Sign Language has become more and more recognizable since the development in SLR methods have allowed scientist to know more about how the Sign Language itself works. In hope, this paper will inspire readers to the possibility of bridging yet closer the gap between verbal and nonverbal communicators.

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Abiyyu Avicena Ismunandar dan 13517083

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