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Sri Lankan Tamil Sign Language Recognition Using Machine Learning and Computer Vision: A Systematic Literature Review

Ealisai Kanesanathan
Department of Electrical and Computer Engineering
The Open University of Sri Lanka,
Nugegoda, Sri Lanka
s92066498@ousl.lk

J. Kirushika
Department of Electrical and Computer Engineering
The Open University of Sri Lanka
Nugegoda, Sri Lanka
jkiru@ou.ac.lk

Abstract*--Sign language recognition has become an important research area in assistive technology, with machine learning and computer vision providing opportunities to support communication between deaf or hard-of-hearing people and the wider community. Existing studies have investigated different approaches for recognizing sign language gestures from images and video, including convolutional neural networks (CNNs), long short-term memory (LSTM) networks, support vector machines (SVMs), wearable devices, depth cameras, and mobile-based systems. However, much of the existing research focuses on widely studied sign languages or Sinhala Sign Language, while research specifically related to Sri Lankan Tamil Sign Language (TSL) remains limited. Therefore, this systematic literature review examines existing machine learning and computer vision approaches for sign language recognition and translation, with particular attention to their relevance to TSL. A total of 18 studies were reviewed based on the sign language considered, type of input data, recognition task, machine learning technique, dataset, translation approach, hardware requirements, and reported limitations. The review shows that CNN-based approaches are commonly used for visual gesture recognition, while LSTM and other sequence-based approaches have been applied to continuous sign recognition. SVM-based methods and specialized hardware such as depth cameras and wearable devices have also been reported. However, the reviewed studies indicate limited availability of TSL-specific datasets and limited research on continuous TSL recognition, Tamil language translation, and low-cost real-time implementation. These findings indicate the need for further TSL-specific research, particularly the development of suitable datasets and the evaluation of computer vision and machine learning approaches using TSL data. The findings of this review provide a basis for future research on practical TSL recognition and translation systems using affordable camera-based devices.

Keywords — *Sri Lankan Tamil Sign Language, Sign Language Recognition, Machine Learning, Deep Learning, Computer Vision, CNN, LSTM, Gesture Recognition, Sign Language Translation*

I. INTRODUCTION

Sign language is an important means of communication for deaf and hard-of-hearing people. In recent years, machine learning and computer vision techniques have been increasingly investigated for automatic sign language recognition and translation. These technologies can recognize hand gestures from images or video and provide text-based or other forms of output to support communication. Existing studies have investigated different approaches, including convolutional neural networks (CNNs), long short-term memory (LSTM) networks, support vector machines (SVMs), wearable devices, depth cameras, and mobile-based systems.

In Sri Lanka, research on automatic sign language recognition has included systems developed for Sinhala Sign Language. For example, EasyTalk investigated machine learning and artificial intelligence for Sri Lankan Sign Language translation [1], while other studies have explored mobile and wearable-based solutions for communication involving Sinhala Sign Language [3], [5]. These studies demonstrate the potential of computational approaches for sign language recognition and translation. However, the available research is not equally distributed across the sign languages used in Sri Lanka.

This study specifically focuses on Sri Lankan Tamil Sign Language (TSL). TSL is considered separately from Sinhala Sign Language and from Tamil sign languages used in other countries. The distinction is

important because sign languages may differ in their vocabulary, gestures, linguistic characteristics, datasets, and recognition requirements. Therefore, methods developed for other sign languages cannot automatically be considered suitable for TSL without further investigation and adaptation.

Recent developments in computer vision and deep learning have improved automatic sign language recognition. CNN-based approaches have been widely investigated for recognizing visual hand gestures, while LSTM and other sequence-based approaches have been used for recognizing sequences of signs and continuous signing [11], [13], [17]. Other studies have investigated SVM-based recognition using depth images and wearable sensing devices [5], [6]. These approaches provide useful technical knowledge for developing sign language recognition systems, but their applicability to TSL depends on the availability of suitable TSL data and the characteristics of the language.

The existing literature indicates that Sri Lankan Tamil Sign Language has received comparatively limited attention in machine learning and computer vision research. In particular, there is limited information on TSL-specific datasets, continuous TSL recognition, Tamil language translation, and practical real-time implementation using affordable devices. Therefore, examining existing research on different sign languages is necessary to identify approaches that may be relevant to TSL while also identifying limitations that need to be addressed.

This systematic literature review therefore examines existing machine learning and computer vision approaches for sign language recognition and translation, with particular attention to their relevance to Sri Lankan Tamil Sign Language. The review considers recognition techniques, datasets, input modalities, machine learning and deep learning models, continuous signing, translation approaches, hardware requirements, and reported limitations. Studies involving other sign languages are considered where their approaches provide relevant information for understanding possible methods for TSL. The findings of the review are used to identify the current research gaps and provide a basis for future research on Sri Lankan Tamil Sign Language recognition and translation.

II. SYSTEMATIC LITERATURE REVIEW METHODOLOGY

This systematic literature review was conducted to identify and analyze existing research on machine learning and computer vision techniques for sign language recognition and translation. The review focused on studies involving sign language recognition, gesture recognition, deep learning, computer vision, continuous signing, datasets, and language translation. Since research specifically related to Sri Lankan Tamil Sign Language (TSL) is limited, studies involving other sign languages were also considered where their methods and findings were relevant to the development of a TSL recognition and translation system.

The review process consisted of four main stages: identification, screening, eligibility assessment, and inclusion. The selected studies were then analyzed according to their sign language, dataset, input data, recognition task, computational technique, translation approach, hardware requirements, and reported limitations.

A. Search Strategy

The literature search was conducted using academic sources covering machine learning, deep learning, computer vision, and sign language recognition. The search terms were developed using combinations of keywords related to the research topic. These included “sign language recognition,” “sign language translation,” “gesture recognition,” “machine learning,” “deep learning,” “CNN,” “LSTM,” “SVM,” “computer vision,” “Tamil Sign Language,” “Sri Lankan Tamil Sign Language,” “Sri Lankan Sign Language,” and “Sri Lanka.”

The search strategy was designed to identify both general research on computational sign language recognition and research related to the Sri Lankan context. The inclusion of terms such as “Sri Lankan Tamil Sign Language” and “Tamil Sign Language” was used to identify literature directly related to the main research area, while broader terms were used to identify approaches that may provide relevant technical knowledge for TSL.

The search process identified an initial set of records from the selected academic databases. Duplicate records were removed before the screening process. The remaining studies were screened based on their titles and abstracts, followed by full-text assessment to determine their relevance to the review.

B. Inclusion and Exclusion Criteria

Studies were included when they addressed computational approaches for sign language recognition or translation and provided information about the methods, input data, models, datasets, or system development. Studies involving CNN, LSTM, SVM, other machine learning or deep learning models, computer vision, wearable devices, depth cameras, or real-time recognition were considered.

Studies directly related to Sri Lankan Tamil Sign Language were considered particularly relevant to the review. However, because TSL-specific research is limited, studies involving Sinhala Sign Language and other sign languages were also included when their computational approaches could provide useful information for TSL research.

The selected studies were required to provide sufficient information about their computational approach or system. Studies unrelated to sign language recognition or translation, studies focused only on general gesture recognition without relevance to sign language, and studies that did not provide sufficient information about the proposed computational approach were excluded. Duplicate studies were also removed before the final analysis.

C. Study Selection

The study selection process followed four stages: identification, screening, eligibility, and inclusion.

During the identification stage, records were collected from the selected academic databases using the defined search terms. Duplicate records were then removed. During the screening stage, the titles and abstracts of the remaining records were examined to remove studies that were not relevant to the research topic.

The potentially relevant studies were then assessed through full-text examination. Studies were excluded when they did not satisfy the inclusion criteria or did not provide sufficient information for the review. Finally, the studies that satisfied the eligibility criteria were included in the systematic literature review.

II. METHODOLOGY

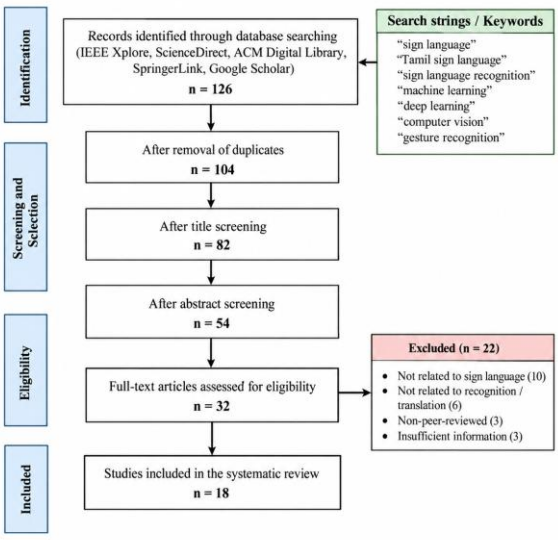


Fig. 1. Methodology of the systematic literature review.

As shown in Fig. 1, the final selection process resulted in 18 studies being included in the systematic literature review.

D. Data Extraction and Analysis

The selected studies were analyzed using a common set of characteristics to allow comparison between different approaches. The extracted information included:

- Sign language studied
- Type of signing, such as isolated or continuous signing
- Dataset or data source
- Input format, such as images or video
- Preprocessing and feature extraction methods
- Machine learning or deep learning model
- Recognition level
- Translation method
- Hardware or sensing requirements
- Reported limitations

Particular attention was given to the differences between studies focusing on Sri Lankan Tamil Sign Language and studies involving other sign languages. This comparison was used to identify which approaches have already been investigated for the Sri Lankan context and which approaches may require further adaptation before they can be applied to TSL.

The studies were also compared according to their use of static images or video sequences and their ability to support real-time recognition. The practical requirements of each approach, including dataset availability, hardware requirements, computational requirements, and suitability for low-resource environments, were also considered.

E. Classification of Studies by Sign Language

To maintain the specific focus of the review, the selected studies were classified according to the sign language investigated. Studies related to Sri Lankan Tamil Sign Language (TSL) were distinguished from studies involving Sinhala Sign Language and other international sign languages.

This classification was important because a recognition method developed for one sign language cannot automatically be assumed to be suitable for another sign language. Differences in sign vocabulary, language characteristics, datasets, recording conditions, and recognition requirements need to be considered when evaluating the possible application of an approach to TSL.

Studies involving other sign languages were therefore not treated as direct evidence of TSL recognition performance. Instead, they were examined to identify machine learning techniques, computer vision methods, dataset approaches, and system architectures that may provide useful directions for future TSL research.

Finally, the findings from the selected studies were compared to identify common computational approaches, limitations, and research areas that remain insufficiently explored for TSL. Particular attention was given to the availability of TSL-specific datasets, TSL recognition research, continuous signing, Tamil language translation, and the possibility of implementing recognition systems using affordable hardware and limited internet connectivity.

III. RESULTS

A total of 18 studies were included in the systematic literature review after the study selection process. The selected studies were examined according to the sign language considered, recognition type, input data, computational techniques, translation approaches, hardware requirements, and reported limitations. The analysis was used to identify the commonly used approaches and the extent to which existing research addresses Sri Lankan Tamil Sign Language (TSL).

A. Overview of the Reviewed Studies

The reviewed studies covered different sign languages and computational approaches. The literature included research related to Sri Lankan sign languages as well as studies from other sign language contexts. This broader selection was necessary because research specifically focusing on TSL is limited.

Research area	Main approaches identified	Key observation
Sri Lankan sign language	ML, AI, mobile and wearable systems [1], [3], [5]	Research mainly focuses on Sinhala Sign Language
International sign languages	CNN, deep learning, SVM, sensor-based methods [6], [8], [9], [15], [17], [18]	More computational approaches and datasets are available
Gesture recognition	SVM, computer vision and depth-based methods [6], [7], [9], [10]	Mainly focused on visual or sensor-based gesture recognition
Continuous recognition	LSTM, CNN-LSTM and other sequence models [2], [13], [14], [17]	Suitable approaches have been investigated for sequential signing
Translation and communication	ML/AI, mobile and assistive systems [1], [3], [5], [11]	Recognition needs to be combined with language/communication processing
TSL-specific research	Limited evidence identified	TSL datasets and TSL-specific recognition remain insufficiently explored

Table 1- SUMMARY OF REVIEW FINDINGS BY RESEARCH AREA

B. Sign Languages and Dataset Availability

The reviewed literature shows that research is concentrated on sign languages for which computational resources and datasets are more readily available. The existing Sri Lankan research identified in the review mainly concerns Sinhala Sign Language, including machine learning, mobile-based, and wearable-based approaches [1], [3], [5]. Research on other sign languages, including ASL and other internationally studied sign languages, also provides a substantial part of the available computational literature [11], [13], [15].

In contrast, research specifically addressing Sri Lankan Tamil Sign Language is limited. The reviewed literature indicates limited availability of TSL-specific datasets for training and evaluating machine learning models. This limitation is important because recognition performance depends strongly on the availability and characteristics of the training and testing data.

Therefore, approaches reported for other sign languages provide useful technical directions but cannot be directly considered validated approaches for TSL.

C. Recognition Approaches

The reviewed studies demonstrate the use of both traditional machine learning and deep learning approaches for sign language and gesture recognition. Earlier research included methods such as SVM together with depth images and wearable sensing [5], [6]. More recent studies have increasingly investigated deep learning approaches for visual sign recognition.

CNN-based methods are commonly used for recognizing hand gestures from images because they can learn visual features directly from image data. The reviewed literature also includes approaches using CNN and LSTM together, particularly for real-time or sequential sign recognition [17].

The results therefore indicate a distinction between isolated sign recognition and continuous sign recognition. Isolated recognition generally deals with individual gestures, letters, or words, whereas continuous recognition requires the system to process a sequence of signs and determine their meaning.

D. Continuous Sign Recognition and Translation

The reviewed studies show that continuous sign recognition presents additional challenges compared with isolated gesture recognition. Continuous recognition requires the system to process a sequence of movements and identify the meaning of the complete sequence. Research on sentence-level continuous signing has investigated this problem using computational and language-processing approaches [2].

The review also indicates that sign language translation involves more than recognizing individual hand gestures. After recognition, the output needs to be represented as meaningful language. Existing work such as EasyTalk has investigated machine learning and artificial intelligence for sign language translation [1], while other Sri Lankan systems have explored communication support for Sinhala Sign Language [3].

However, the reviewed literature provides limited evidence of a complete recognition and translation pipeline specifically designed for Sri Lankan Tamil Sign Language.

E. Hardware and Real-Time Implementation

Different hardware configurations have been used in the reviewed studies. Some systems use ordinary cameras, while other approaches use specialized hardware such as depth cameras and wearable devices [5], [6]. Wearable and depth-sensing approaches can provide additional information about hand or body movement, but they may also increase system complexity and hardware requirements.

Recent research has increasingly investigated real-time recognition using machine learning and deep learning approaches [11], [17]. These developments indicate the possibility of developing practical camera-based recognition systems. However, the requirements of the target language and available dataset must be considered before applying these approaches to TSL.

For the Sri Lankan context, affordability and accessibility are important considerations. A system based on commonly available cameras or mobile devices could reduce the need for specialized hardware and make future TSL applications more practical.

F. Research Gaps Identified from the Results

The analysis of the reviewed studies identifies several areas that remain insufficiently explored for Sri Lankan Tamil Sign Language.

First, TSL-specific datasets are limited compared with the datasets available for more widely studied sign languages. This creates a difficulty for training and evaluating recognition models specifically for TSL.

Second, there is limited research on continuous TSL recognition. Existing studies provide evidence that continuous signing requires different processing approaches from isolated gesture recognition, but this area has not been sufficiently investigated for TSL.

Third, Tamil language translation remains an important research area. Recognizing a sign or gesture is only one stage of a complete communication system. Further processing is required to convert recognized signs into meaningful Tamil text or other language output.

Finally, there is a need to investigate low-cost and real-time implementation for the Sri Lankan context. Some existing approaches depend on specialized hardware, while future TSL systems could investigate affordable camera-based approaches.

Overall, the results demonstrate that although a range of machine learning and computer vision approaches has been developed for sign language recognition, there remains a clear need for research specifically focused on Sri Lankan Tamil Sign Language.

IV. Discussion

The findings of the review indicate that machine learning and computer vision provide several possible approaches for automatic sign language recognition. However, the suitability of these approaches for Sri Lankan Tamil Sign Language (TSL) depends on the availability of appropriate TSL data and the characteristics of the language.

A. Recognition Approaches and Their Relevance to TSL

The reviewed studies show the use of both traditional machine learning and deep learning techniques. SVM-based approaches have been used with depth images and wearable sensing, while CNN-based approaches have been widely investigated for visual gesture recognition [5], [6]. More recent studies have also combined CNN and LSTM models for real-time and sequential sign recognition [13], [17].

These approaches provide useful directions for TSL research, but their reported results were generally obtained using datasets from other sign languages or gesture-recognition contexts. Therefore, the performance of these models cannot be directly assumed for TSL without evaluation using TSL-specific data.

B. Dataset Availability

A major issue identified from the review is the limited availability of datasets specifically related to Sri Lankan Tamil Sign Language. Several reviewed studies use established datasets or data collected for other sign languages. In comparison, the availability of suitable TSL data for training and evaluating machine learning models is limited.

This creates an important challenge because the recognition model needs representative TSL samples covering different signs and users. Therefore, developing a structured TSL dataset is an important requirement for future research.

C. Continuous Recognition and Translation

The review also highlights a difference between isolated sign recognition and continuous sign recognition. CNN-based approaches are commonly associated with visual gesture recognition, whereas LSTM and other sequence-based approaches can be used to process sequences of movements [13], [14], [17].

For TSL, recognizing individual signs is only one part of the communication process. A practical system would also need to convert recognized signs into meaningful Tamil language output. Existing studies demonstrate the possibility of combining recognition with translation or communication functions [1], [3], [5], but this area remains insufficiently investigated for TSL.

D. Practical Implementation

The reviewed studies include systems using cameras, depth cameras, wearable devices, and mobile platforms. Specialized hardware can provide additional sensing information but may increase system cost and implementation complexity [5], [6]. Camera-based approaches therefore provide a possible direction for developing more accessible TSL recognition systems.

For the Sri Lankan context, future systems should also consider computational requirements and the availability of affordable devices. These considerations are particularly relevant when designing a system intended for practical use rather than only controlled experimental environments.

V. CONCLUSION

This systematic literature review examined 18 studies related to machine learning and computer vision-based sign language recognition and translation. The review considered different sign languages, datasets, input types, recognition approaches, machine learning and deep learning models, translation methods, and hardware requirements.

The findings show that CNN-based approaches are widely used for visual gesture recognition, while LSTM and related sequence-based approaches have been investigated for continuous sign recognition. SVM-based methods and specialized devices such as depth cameras and wearable systems have also been used in sign language and gesture recognition research. However, much of the available research focuses on sign languages other than Sri Lankan Tamil Sign Language.

The review identified limited availability of TSL-specific datasets and limited research on continuous TSL recognition and Tamil language translation. The findings also indicate the importance of considering affordable hardware and practical real-time implementation when developing a TSL recognition system.

Therefore, future research should focus on developing suitable TSL datasets and evaluating computer vision and machine learning approaches using TSL-specific data. Such research can provide a foundation for developing a practical system capable of recognizing selected TSL signs and producing meaningful Tamil language output.

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