MONASH University
Engineering

Department of Electrical and
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Automated Video-based Epilepsy Detection and Classification using Deep Learning

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Project Background & Aim

- Epilepsy is a periodical repeated seizure attack usually caused by disordered brain electrical rhythms. This kind of turbulence in bio-electricity signal will result in uncontrolled limbs and facial expressions and even cause absence and fatal consequences. From years of medical studies, it has been recognized that epilepsy is uncorrelated to gender, race, or age. And according to the WHO [1], more than 50 million people suffer from epileptic seizures worldwide; it is one of the most common global diseases.
- In this project, we focused on two types of seizures: 1. The Generalized Tonic-Clonic Seizures (GTCS), and 2. The Psychogenic Nonepileptic Seizures (PNES). As the name suggests, the PNES is not an epileptic symptom; instead, it is a paroxysmal symptom. Even though the patient's outer behavior for the two types of seizures is close, the medical treatments are entirely different. Based on statistical results, about 25 % of PNES patients have been misdiagnosed with GTCS [2]. The traditional way applied in clinical environments relies on EEG, but there are cases where patients cannot tolerate wearable devices.

This project aims to find a way to detect seizures using Deep Learning. There are two types of data modalities have been used to train the networks: optical flow, and joint-semiology.

Overview

Data extraction and storing

During the project, the Alfred Hospital has provided us with video data of seizures; considering privacy issues, all the dataset we generated and collected is privacy-preserved features. The feature extraction is done on Nvidia Jetson Xavier, which is now (and in the future) deployed at Alfred Hospital to generate more data samples.

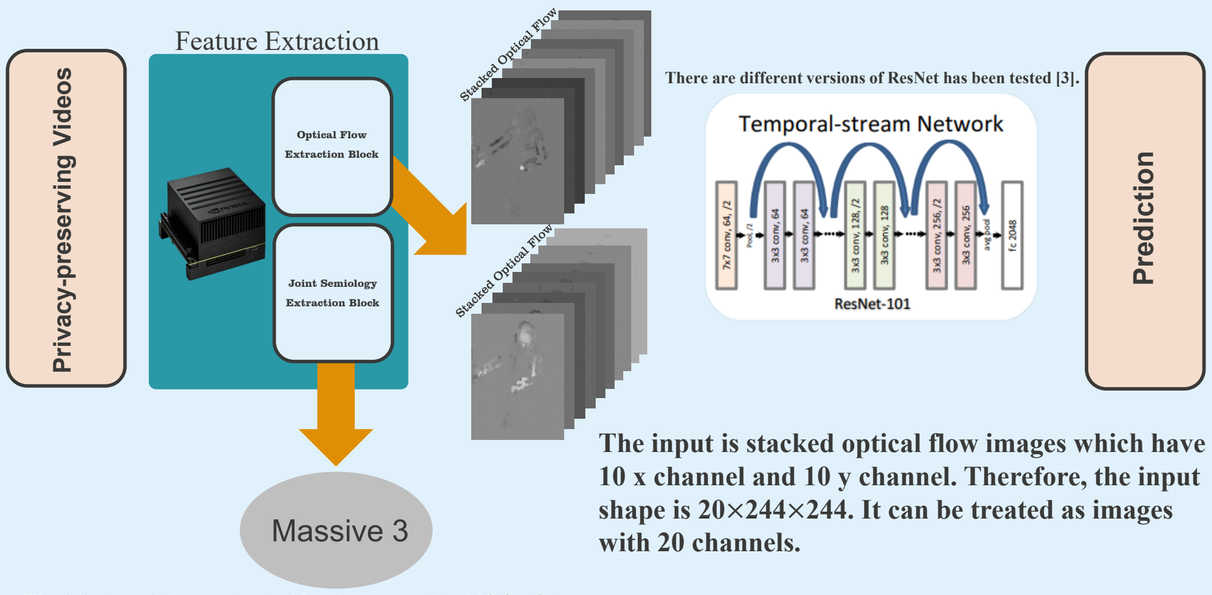
Network Validation

Two models have been implemented to test the performance of the optical-flow-based and joint-semiology-based action recognition and classification, which are 'two-stream-action-recognition' and 'HCN-pytorch'.

Pilot Test

Implemented state-of-the-art techniques for automated detection of epileptic seizures on pilot data from Alfred Hospital.

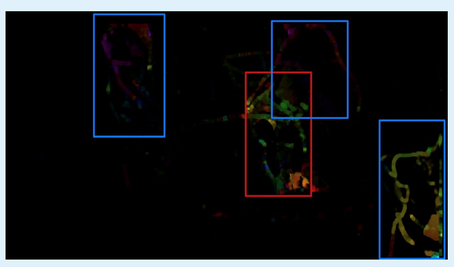
Methods



The input is stacked optical flow images which have 10 x channel and 10 y channel. Therefore, the input shape is 20×244×244. It can be treated as images with 20 channels.

The joint-semiology extracted has been saved to M3 for future use.

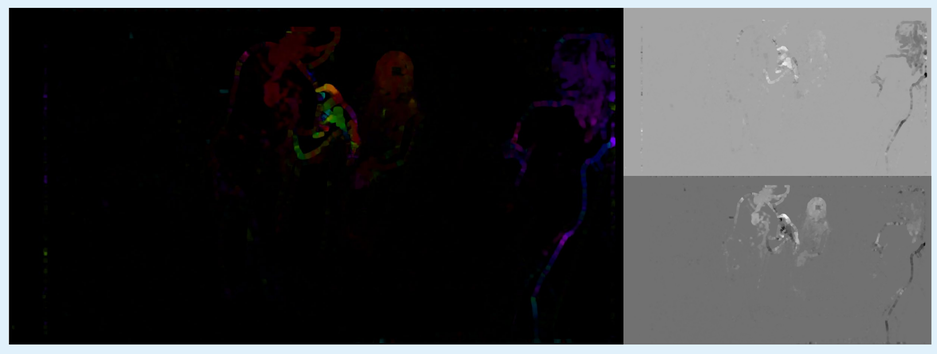
Challenges



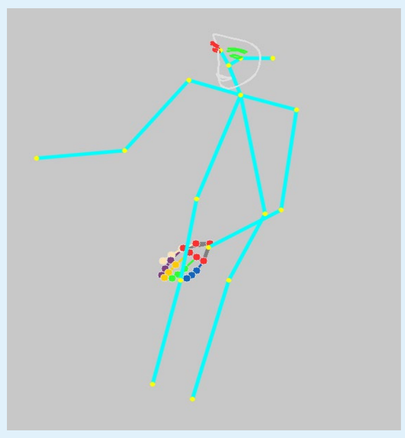
- One common issue for optical-flow-based and joint-semiology-based epilepsy recognition is that the medical staff would block the patient frequently. As shown in the figure, the red box is the patient's location, and the blue box is the medical staff's location. (ROI mechanism has been used to improve this issue.)
- Another difficulty is that many videos were recorded during the night using infrared cameras, making the feature extraction becomes unstable.

Results & Future Improvements

- The figure below shows the extracted optical-flow features of patients. The image in Grayscale is the u and v channel separated from the RGB channel.



- The outcome of integrated human-joint semiology is shown below. The semiology for the body is based on the 'light-weight-human-pose-estimation' method, and the facial and hand semiology is based on 'MediaPipe'.



- The training accuracy for optical-flow-based epilepsy recognition is 74.74%, and the testing accuracy is 65.52%.

Conditions	Training Accuracy	Testing Accuracy	With ROI	With Further Split
Res18-Stack Size 10	73.199%	63.727	Y	Y
Res18-Stack Size 20	73.346%	64.826%	Y	Y
Res18-Stack Size 50	69.778%	58.874%	Y	Y
Res34-Stack Size 10	73.170%	62.003%	Y	Y
Res34-Stack Size 20	74.741%	65.512%	Y	Y
Res34-Stack Size 50	67.455%	55.509%	Y	Y
Res101-Stack Size 10	71.829%	61.201%	Y	Y
Res101-Stack Size 20	70.532%	62.650%	Y	Y
Res101-Stack Size 50	68.114%	55.780%	Y	Y

- At the current stage, dataset insufficiency (only 9 GTCS videos have been provided) is the primary constraint for gaining a high prediction accuracy. The feature extraction process will keep operating in the Alfred Hospital to generate more data.

[1] "Epilepsy", *Who.int*, 2022. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/epilepsy.

[2] "The Truth about Psychogenic Nonepileptic Seizures," Epilepsy Foundation. [Online]. Available: https://www.epilepsy.com/stories/truth-about-psychogenic-nonepileptic-seizures

[3] Yi Huang, Rajat Shrivastava "two-stream-action-recognition: Using two stream architecture to implement a classic action recognition method on UCF101 dataset", *GitHub*, 2022. [Online]. Available: https://github.com/jeffreyyihuang/two-stream-action-recognition.