AUTOMATED NYSTAGMUS DETECTION FOR BPPV USING YOLOV11s SEGMENTATION AND LSTM CLASSIFICATION

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INTRODUCTION

Benign Paroxysmal Positional Vertigo (BPPV) is one of the most common causes of vertigo, characterized by abnormal eye movements (nystagmus) during diagnostic maneuvers. Current diagnosis depends on manual clinical interpretation, which can be subjective and time-consuming. In this study, we evaluate existing machine learning approaches for classifying BPPV using eye movement data.

MATERIALS AND METHODS

2,500 videonystagmography eye movement recordings collected from patients at ISAAC Physiotherapy (Edmonton, Canada). From 2,500 VNG, we extracted frame segments containing visible nystagmus, annotated at the frame level as nystagmus-positive or negative. Eye regions were segmented using YOLOv11s[1] detection to extract position, velocity, and shape features, resulting in a time series data format for 100 steps per time series ID.

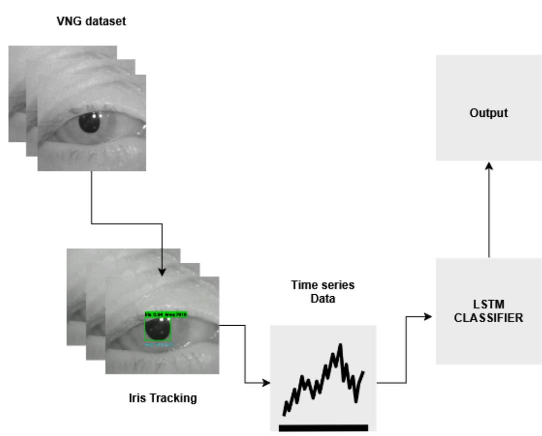

Fig 1 Project Implementation.

Data were input into the existing Long Short-Term Memory (LSTM) machine learning model, because of its ability to process time series data and implement classification[2]. Due to time constraints, we classified nystagmus movement into three different classes: normal eye movement (negative), horizontal nystagmus, and vertical nystagmus. We were implementing common data augmentation (Gaussian Noise Injection, Time Warping, Random Masking, and Axis Flipping) to address class imbalance.

RESULTS AND DISCUSSION

The LSTM model achieved an accuracy of 82% (Table 1). Vertical nystagmus was predicted with higher precision and recall compared to horizontal and negative cases. This may be because vertical eye movements are less common in natural viewing behavior, making abnormal vertical patterns more distinct and easier to separate from noise. In contrast, horizontal nystagmus is more easily confused with regular horizontal eye movements. These findings suggest that future models should incorporate additional noise-reduction strategies and domain-specific augmentation to improve the classification of horizontal and negative cases.

Table 1: Caption for Table 1.

	Precision	Recall	F1-score	Support
Negative Case	0.82	0.76	0.79	253
Horizontal	0.80	0.80	0.80	241
Vertical	0.81	0.89	0.85	225
Accuracy			0.82	719
Macro avg	0.82	0.82	0.82	719
Weighted avg	0.81	0.82	0.81	719

CONCLUSIONS

The LSTM model achieved the highest performance with an accuracy of 82%. These results demonstrate the feasibility of adapting existing machine learning algorithm approaches for automated BPPV classification. While data imbalance and limited sample size remain challenges, the approach shows promise for clinical deployment. Future work will expand to multi-class BPPV variants, integrate domain-specific augmentation, and validate on larger clinical datasets.

REFERENCES

[1] Jocher G, Qiu J. Ultralytics YOLO11, version 11.0.0. 2024. Available from: https://github.com/ultralytics/ultralytics. License: AGPL-3.0.
[2] Karim F, Majumdar S, Darabi H, Chen S. LSTM fully convolutional networks for time series classification. IEEE Access 6: 1662-1669, 201