Machine Learning Based Cursor Control Using Eye Movements.

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Abstract

• This research explores using eye movements to control a computer cursor, enhancing accessibility through hands-free interaction. By analyzing gaze direction with CNNs and SVMs, the study converts eye movements into precise cursor actions. It focuses on optimizing camera placement and head movement for efficient human-computer interaction.

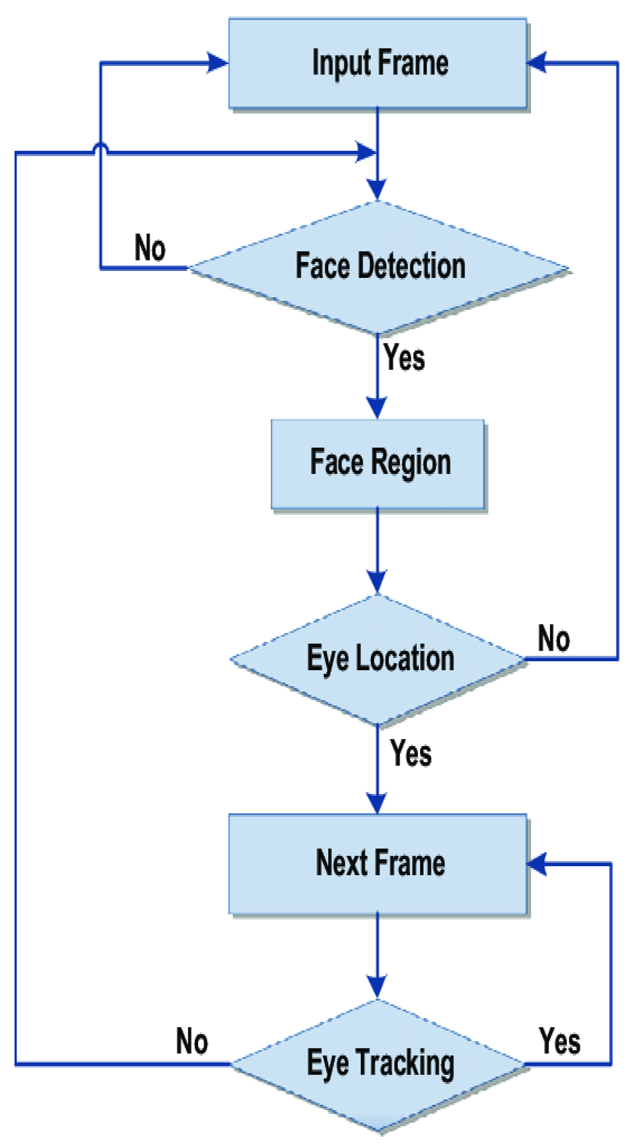
Process

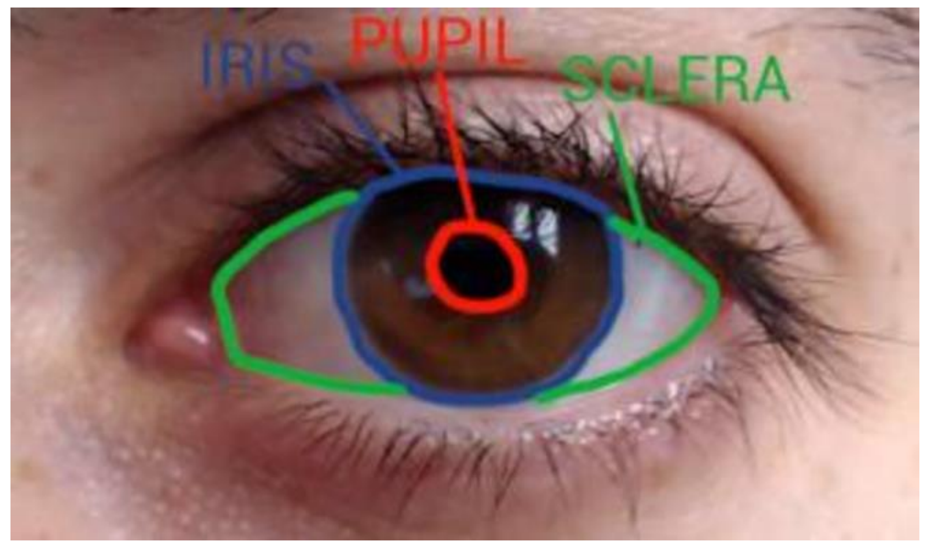
- **Data Collection & Preprocessing:**
  Eye movement data was collected from multiple users, capturing gaze direction and eye images. Preprocessing included cleaning, resizing, normalizing images, and removing noise from blinks or environmental factors.
- **Feature Engineering:**
  Key features like eye position and pupil movement were extracted using techniques such as edge detection. Standardization and data augmentation were applied to prepare the data for model training under varying conditions.
- **Model Selection:**
  CNNs were used to detect gaze direction, while SVMs converted eye movements into cursor actions. Various model architectures were tested to optimize accuracy and responsiveness for real-time interaction.
- **Evaluation:**
  The models were evaluated based on accuracy, latency, and precision in cursor control. Metrics such as F1-score, confusion matrix, and response time were used to measure performance.

Hypothesis

Machine learning algorithms, such as CNNs and SVMs, can effectively convert eye movements into precise cursor actions by analyzing complex patterns in eye images. These models adapt to variations in gaze direction and lighting conditions, improving the accuracy of hands-free computer control and enhancing accessibility for users with physical limitations.

Proposed Architecture





•An overview of the overall proposed solution
•Architecture is based on pupil from eyes.

Methods

<u>Data Preprocessing</u>:
• **Handling Missing Data:** Missing frames due to blinks or environmental noise were removed or interpolated.
• **Noise Reduction:** Preprocessing techniques were applied to filter out noise caused by light changes or head movements.
• **Image Normalization:** Eye images were resized and normalized to ensure consistency across various lighting conditions and user setups.

<u>Algorithms Used</u>:
• **Convolutional Neural Networks (CNNs):** Used for extracting and classifying gaze direction from eye images.
• **Support Vector Machines (SVMs):** Employed to classify gaze movements into specific cursor actions based on learned patterns.
• **Data Augmentation:** Applied to increase data variability, simulating different head and eye positions.

<u>Evaluation Metrics</u>:
• **Accuracy:** Overall success in translating eye movements.
• **Precision:** Correct detection of gaze direction.
• **Latency:** Real-time responsiveness of cursor control.
• **F1-Score:** Balance between precision and recall for system efficiency.

Results:

Best Performing Model:
The Convolutional Neural Network (CNN) excelled in translating eye movements into cursor actions, demonstrating high precision and recall while minimizing false positives and negatives.

Visualization:
A bar graph compares the performance of each model (CNN, SVM) across key metrics (precision, recall, F1-score).

Receiver Operating Characteristic (ROC) Curve:
The ROC curve illustrates the trade-off between true positive and false positive rates for both models, highlighting the CNN's accuracy in cursor movement detection.

Conclusion

In conclusion, eye-tracking technology can significantly enhance accessibility and engagement in AR/VR, gaming, and medical diagnostics through advanced machine learning techniques. This innovation promises to improve user experience and responsiveness to diverse needs. Ultimately, ongoing research will further drive advancements in usability and accessibility, making technology more intuitive and responsive for all users.

References

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