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VuBot

Multimodal User Interfaces

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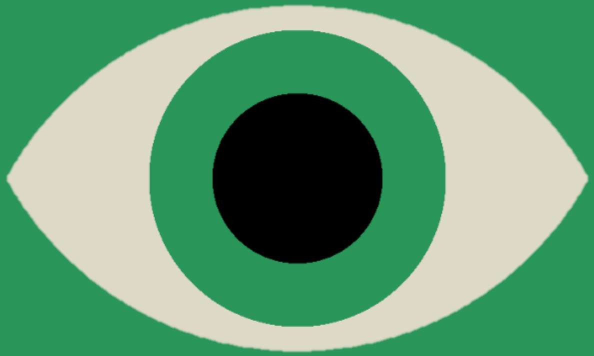


Introduction

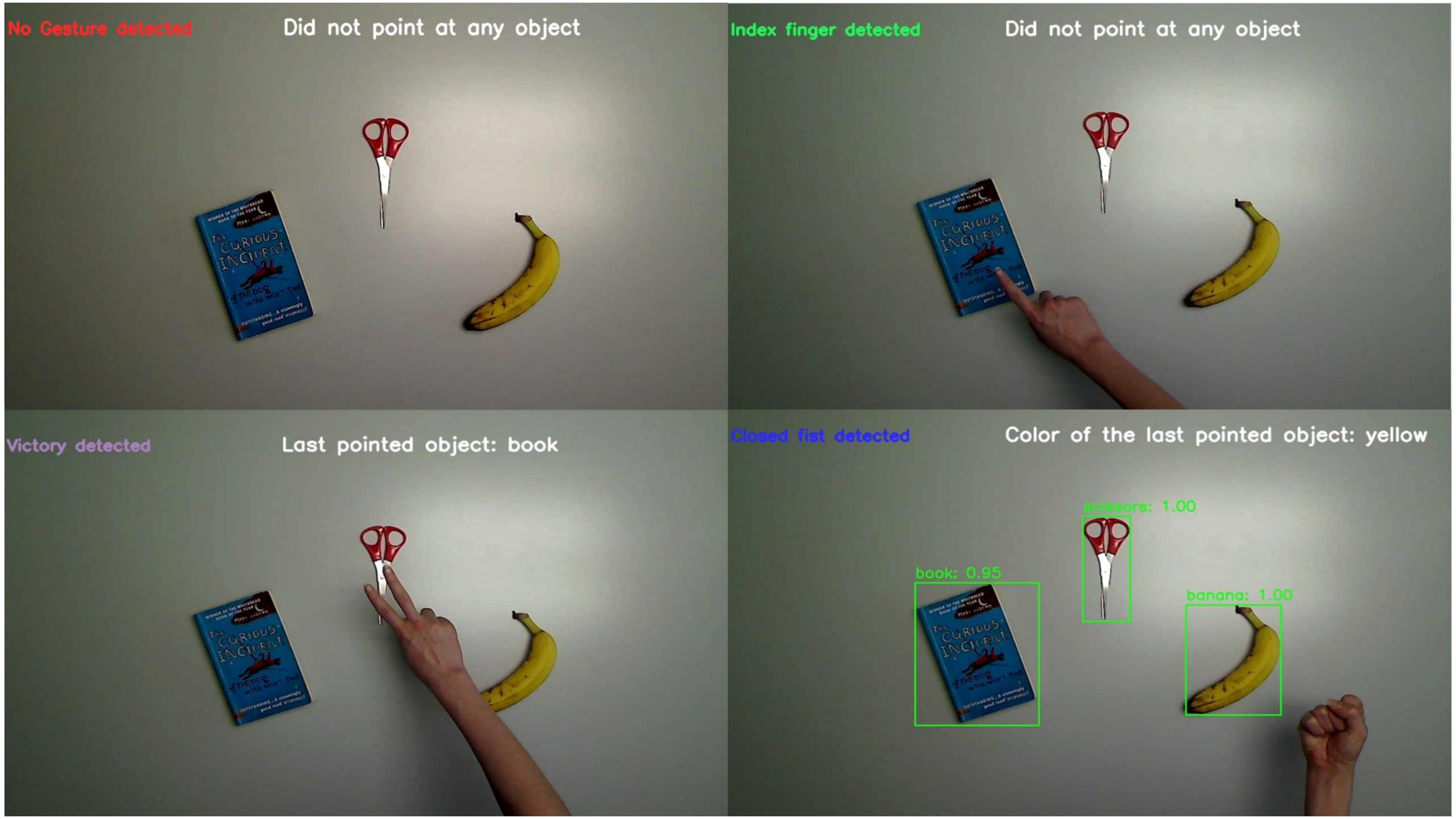
Concept & Aim

- Clinical application
- Associative visual agnosia
  - Intact vision
  - Object recognition deficits
  - Can involve colors

→ Develop visual assistant

Modalities overview

Recognized Gestures


No Gesture detected
Did not point at any object
Index finger detected
Did not point at any object
Victory detected
Last pointed object: book
Closed fist detected
Color of the last pointed object: yellow
scissors: 1.00
book: 0.95
banana: 1.00

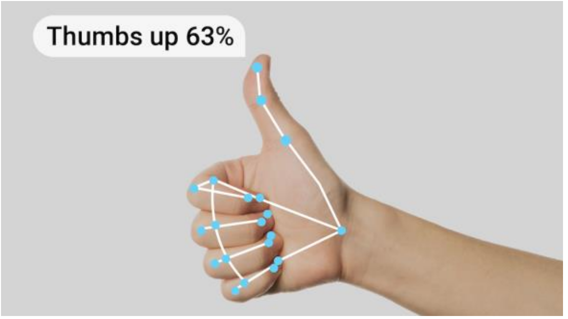
VuBot

Software Architecture

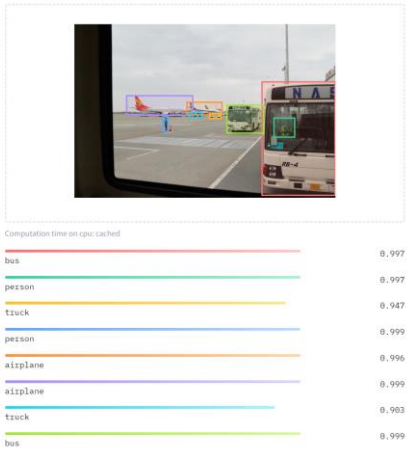
Libraries

OpenCV

MediaPipe



facebook/detr-resnet-50



Computation time on cpu: cached

```
bus        0.997
person     0.997
truck      0.947
person     0.999
airplane   0.996
airplane   0.999
truck      0.903
bus        0.999
```

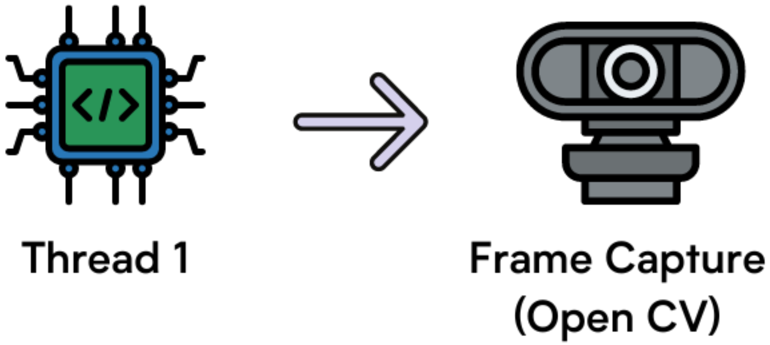
openai/whisper-large-v3

OpenAI

Modality Fusion

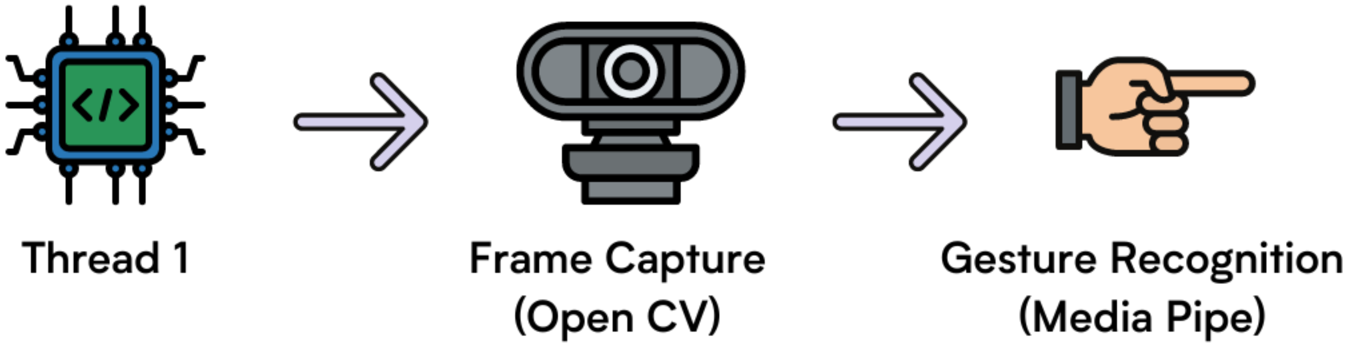
Thread 1

Modality Fusion



Thread 1 → Frame Capture (Open CV)

Modality Fusion

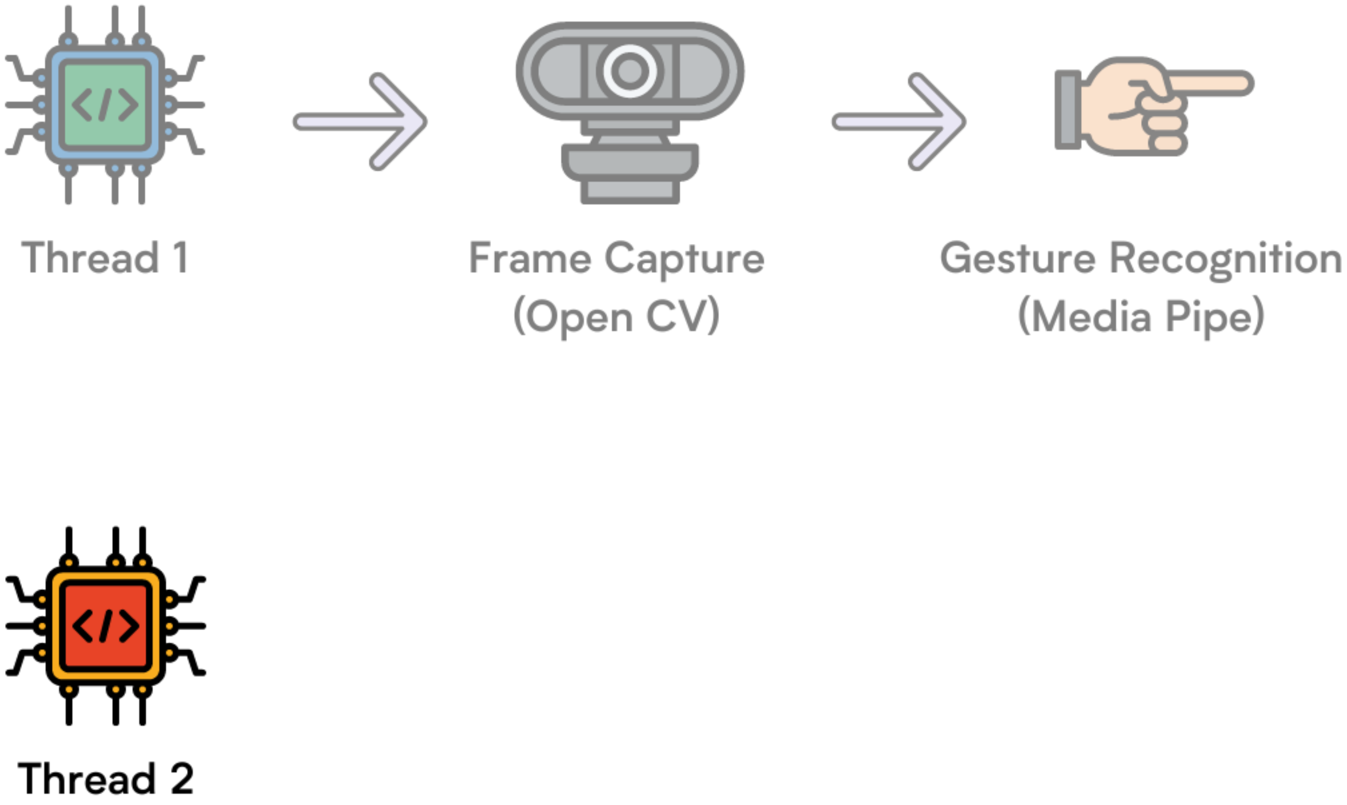


Thread 1

Frame Capture
(Open CV)

Gesture Recognition
(Media Pipe)

Modality Fusion



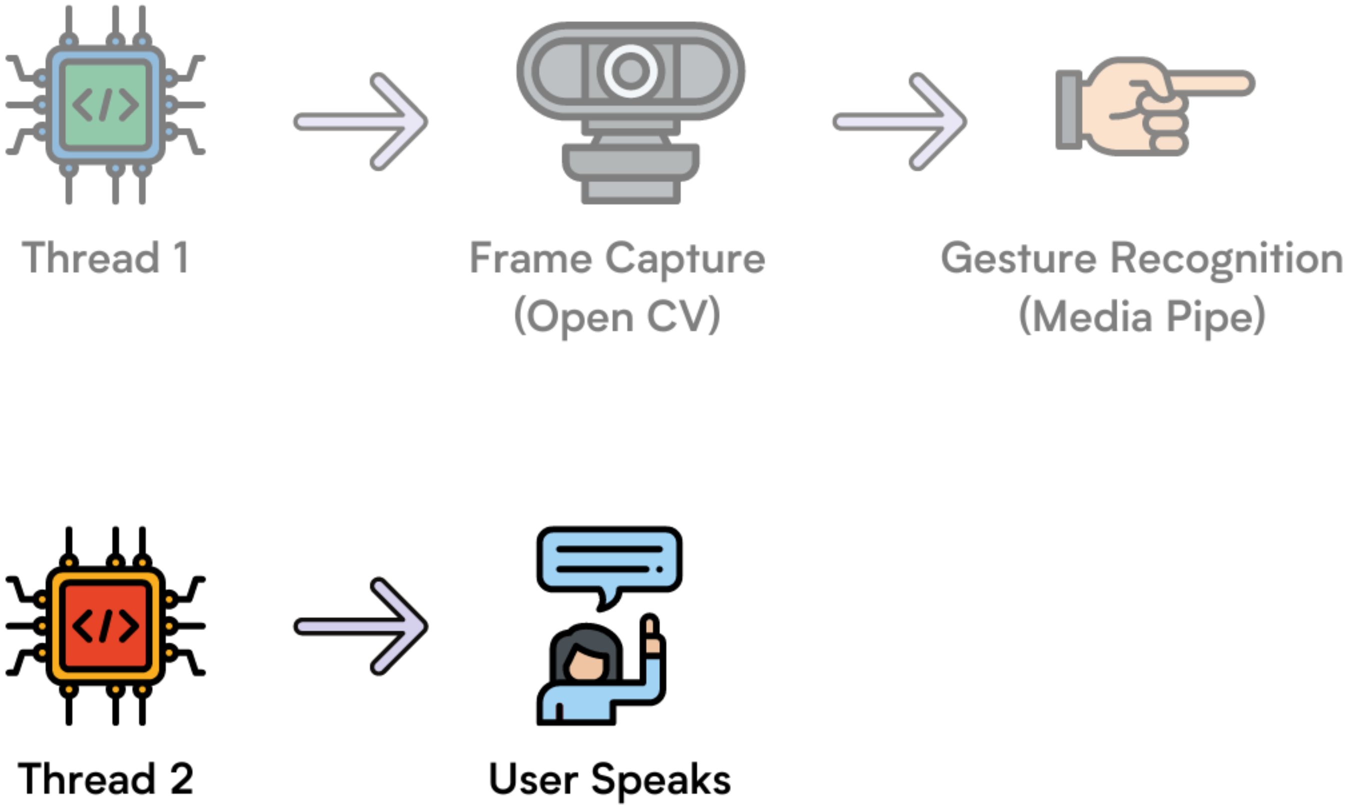
Thread 1

Frame Capture
(Open CV)

Gesture Recognition
(Media Pipe)

Thread 2

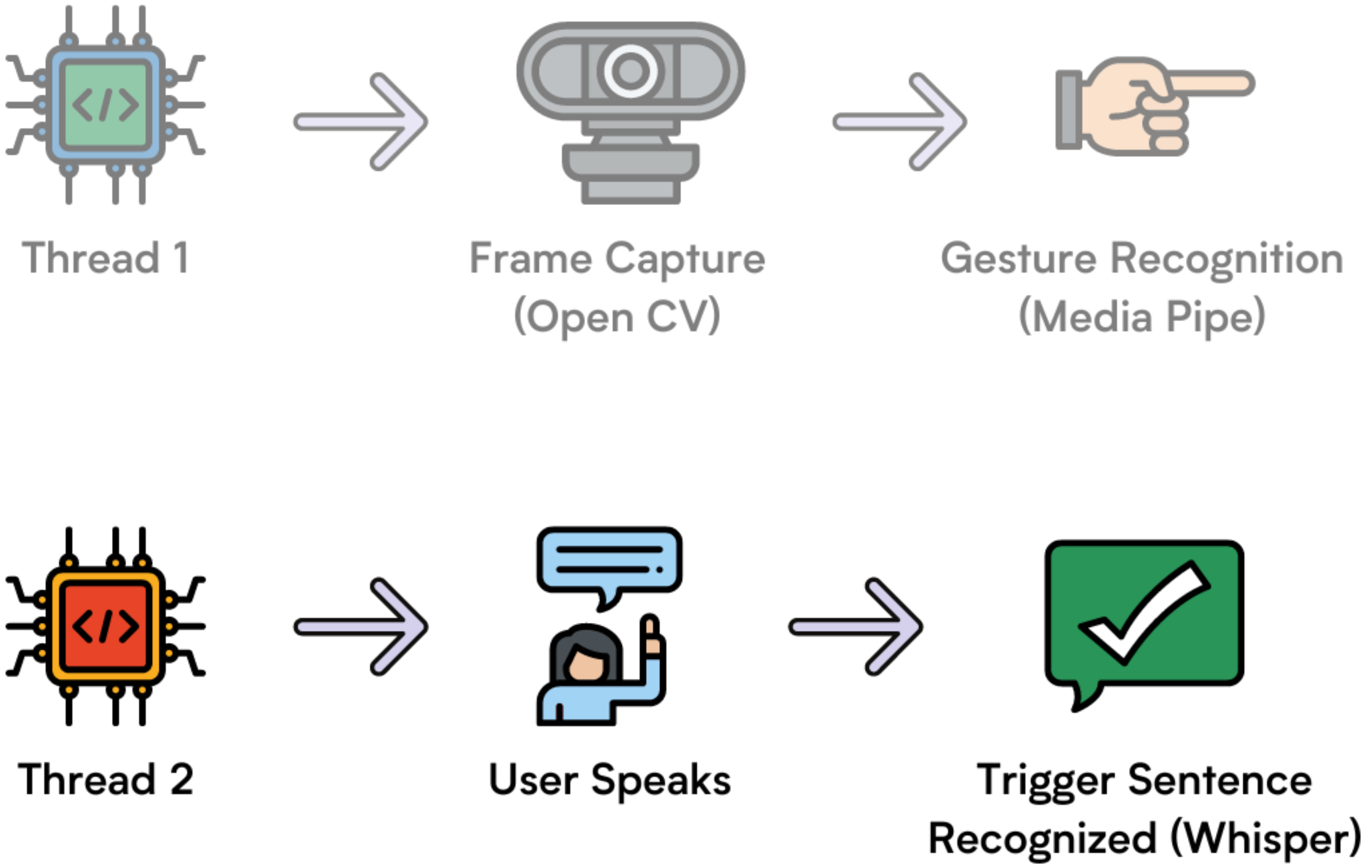
Modality Fusion



Thread 1 → Frame Capture (Open CV) → Gesture Recognition (Media Pipe)

Thread 2 → User Speaks

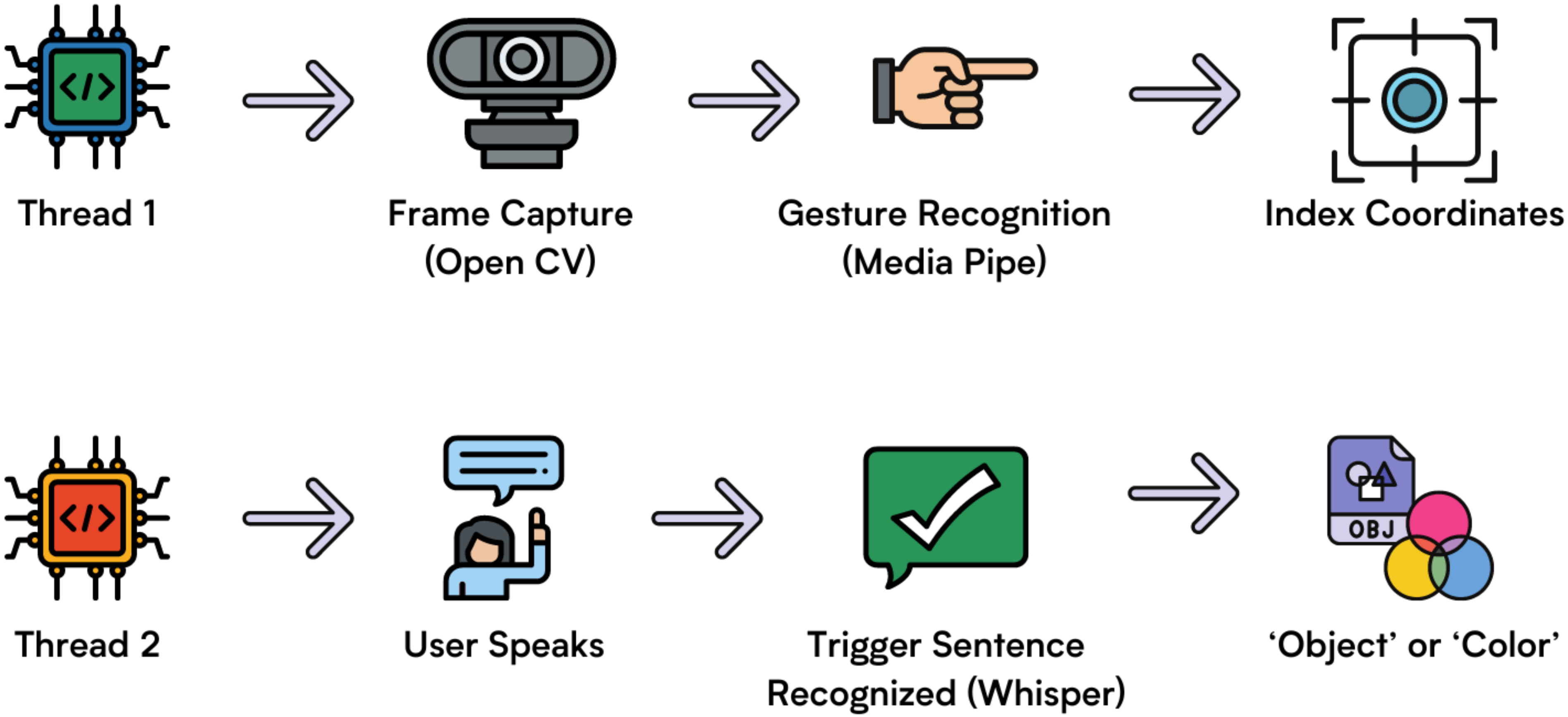
Modality Fusion



Thread 1 → Frame Capture (Open CV) → Gesture Recognition (Media Pipe)

Thread 2 → User Speaks → Trigger Sentence Recognized (Whisper)

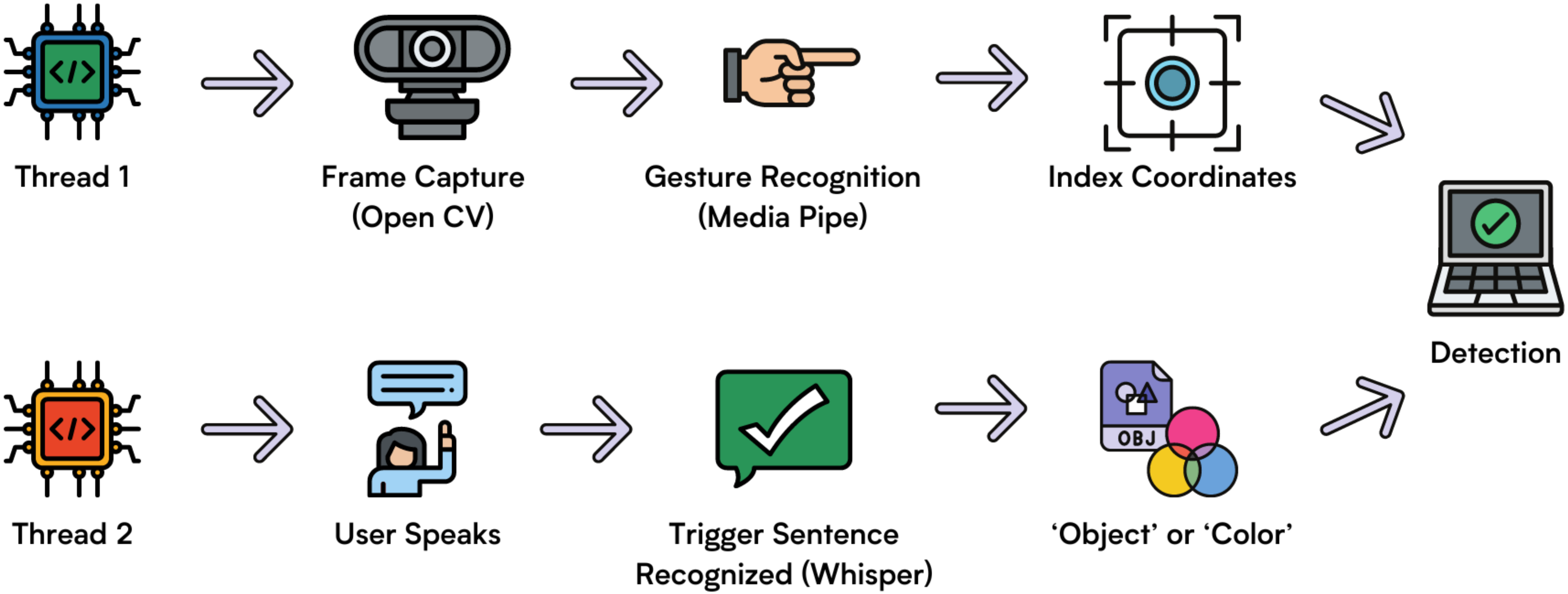
Modality Fusion



Thread 1 → Frame Capture (Open CV) → Gesture Recognition (Media Pipe) → Index Coordinates

Thread 2 → User Speaks → Trigger Sentence Recognized (Whisper) → ‘Object’ or ‘Color’

Modality Fusion



Thread 1

Frame Capture (Open CV)

Gesture Recognition (Media Pipe)

Index Coordinates

Detection

Thread 2

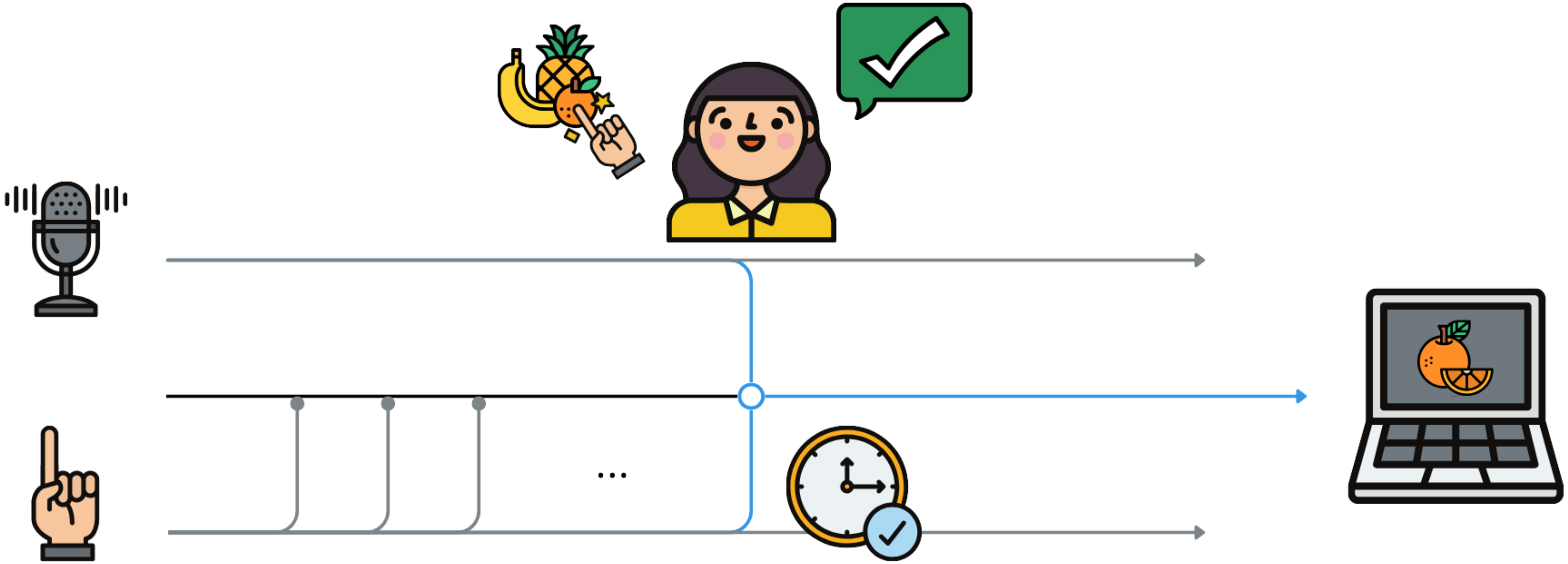
User Speaks

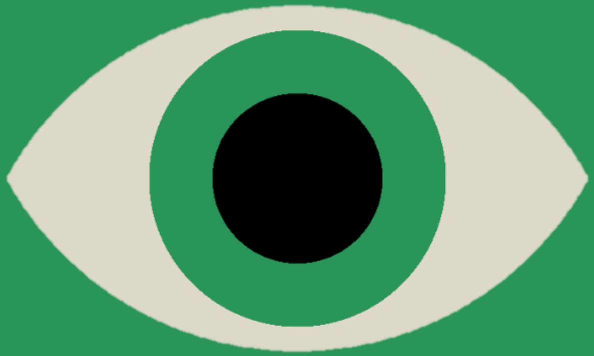
Trigger Sentence Recognized (Whisper)

‘Object’ or ‘Color’

CARE/CASE Models

- CARE: Complimentary
- CASE: Synergistic

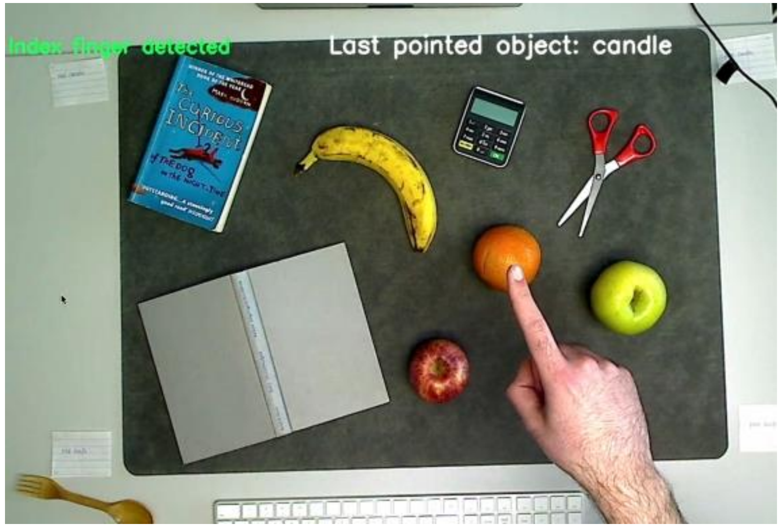




Evaluation

Experiment

- Task: find target objects and colors
  - Vary input modality
    - **Speech** input (original version)
    - **Keyboard** input (alternate version)
- Healthy participants
  - Manipulate labels to simulate recognition deficits

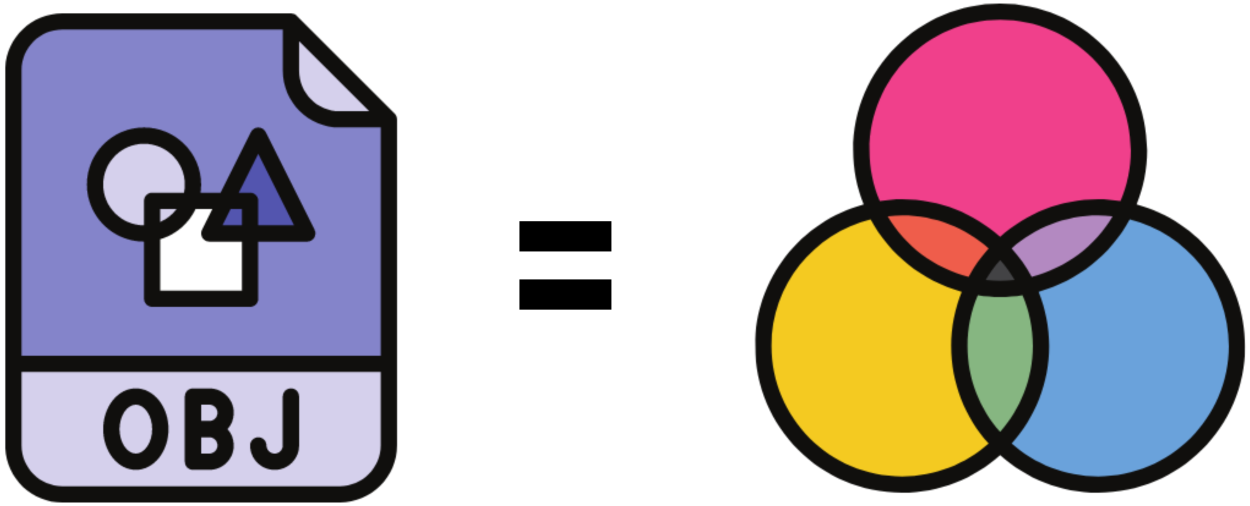


Statistical Analysis

- Time
  - Query time (object vs. color)
  - Task time (keys vs. speech)
- Accuracy
  - Task versions (keys vs. speech)
  - Models

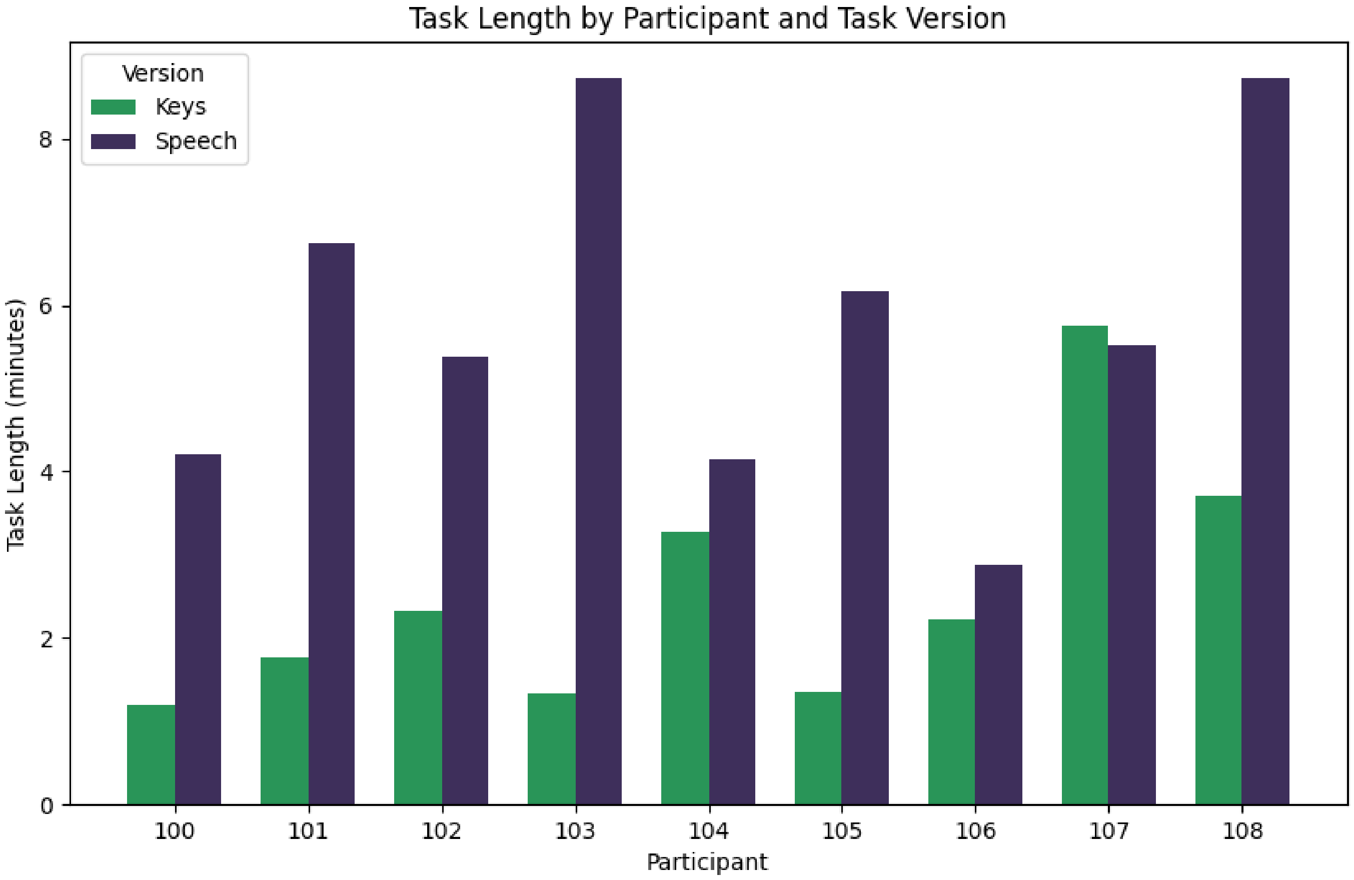
Query Runtimes

- Object and color queries take the same amount of time to compute



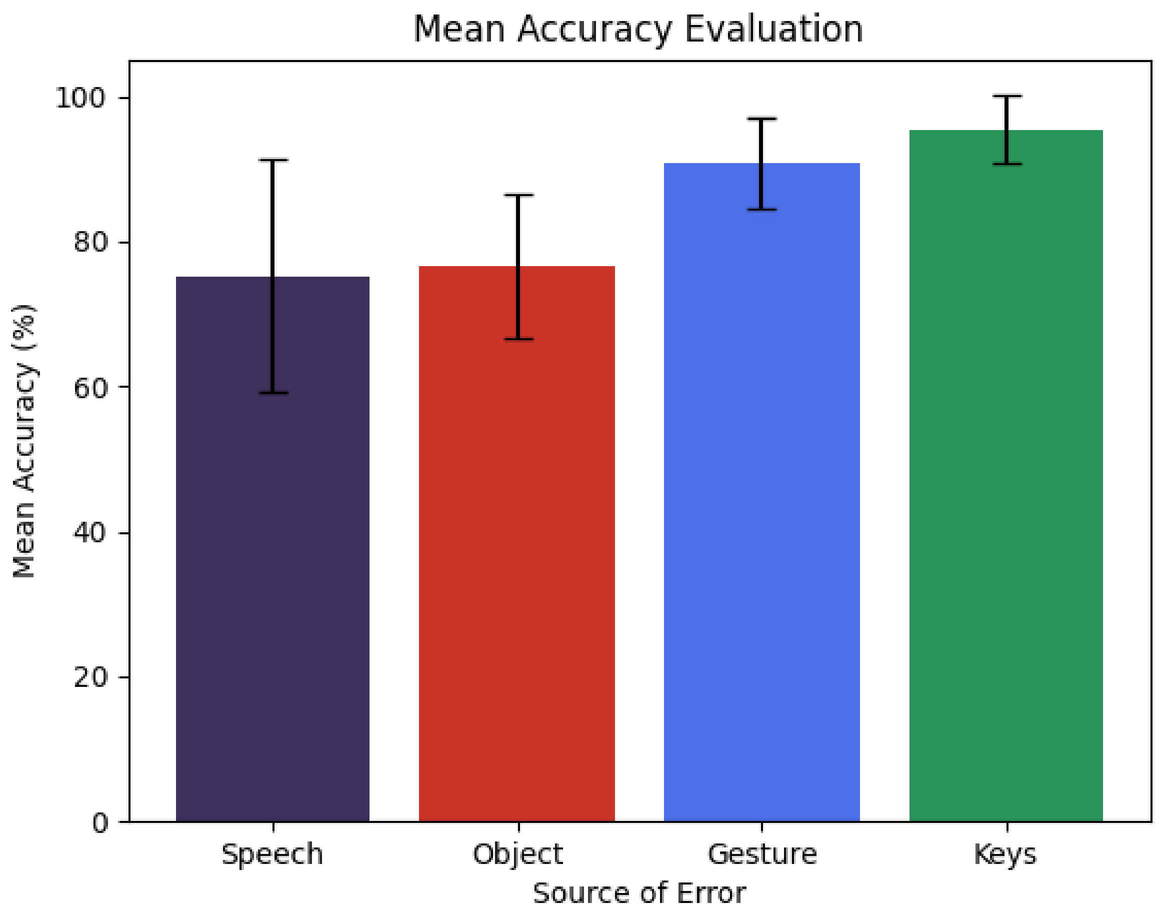
Runtime Performance

- Task is shorter when querying with keys than with speech
- *M_keys = 2.55min*
- *M_speech = 5.83min*



Accuracy

- Tracking of errors via screen recordings
- More speech errors than key errors
- Generally high accuracy across recognition models (80%)



Interpretation of Results

- Keys outperformed speech
- Speech remains the best modality for the future development of VuBot
  - Natural
  - Hands-free
  - Simpler scalability

Limitations and Future Work

Limitations

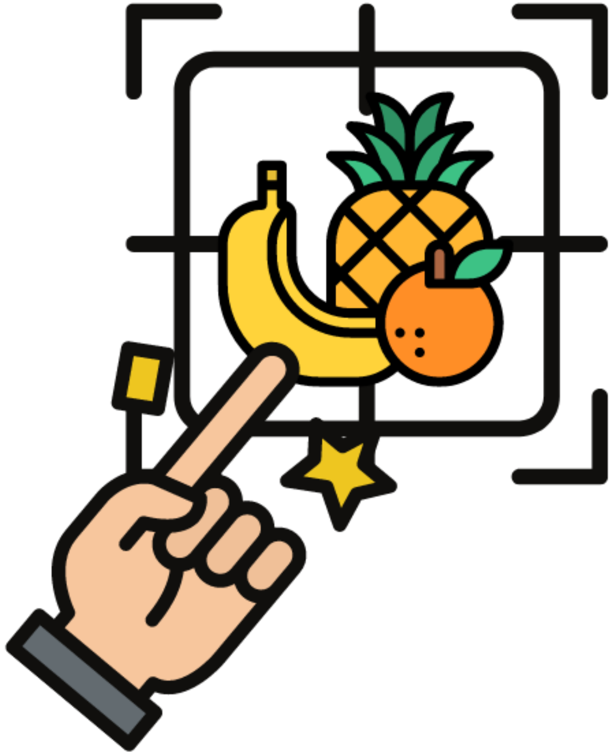
- General Recognition Errors:
  - Mistakes due to lighting or camera angles
- Color Recognition
  - Background and hand influence
- Speech Recognition:
  - Not meant for live transcription
  - Prononciation of trigger words

Future Works

- Mobile Version
- Large Language Model (LLM) Integration

Conclusion

Conclusion



- VuBot is a visual assistant
- Complementary and synergistic fusion
- Recognizes objects and colors
- Many limitations
- This combination of modalities is best for future development
- Potential to empower individuals to have more independence

Thanks for listening

VuBot

References

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