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Explainable CamIoT

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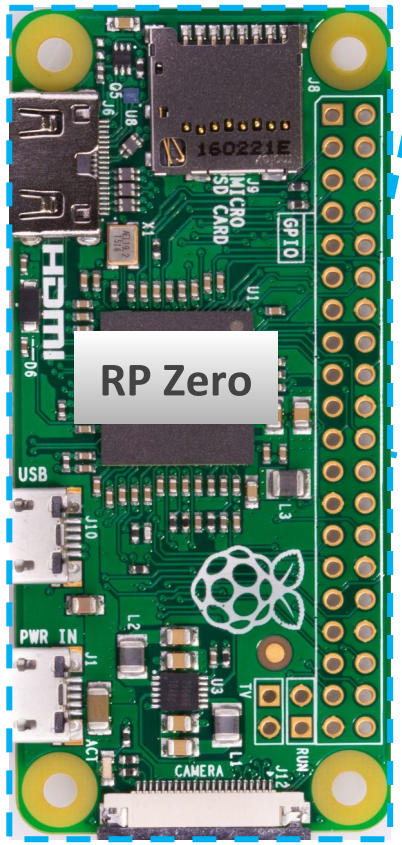
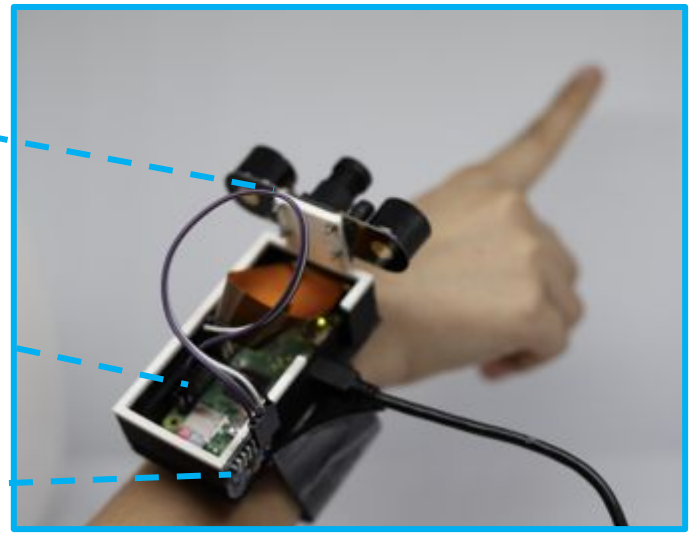
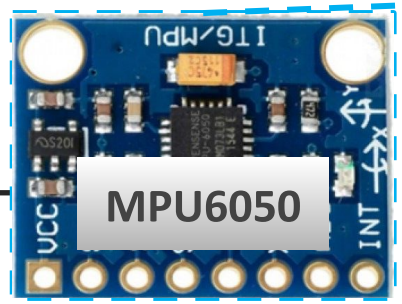
CamIoT: Camera-based IoT device that enables the user to interact with home appliances by simply pointing at the desired object.

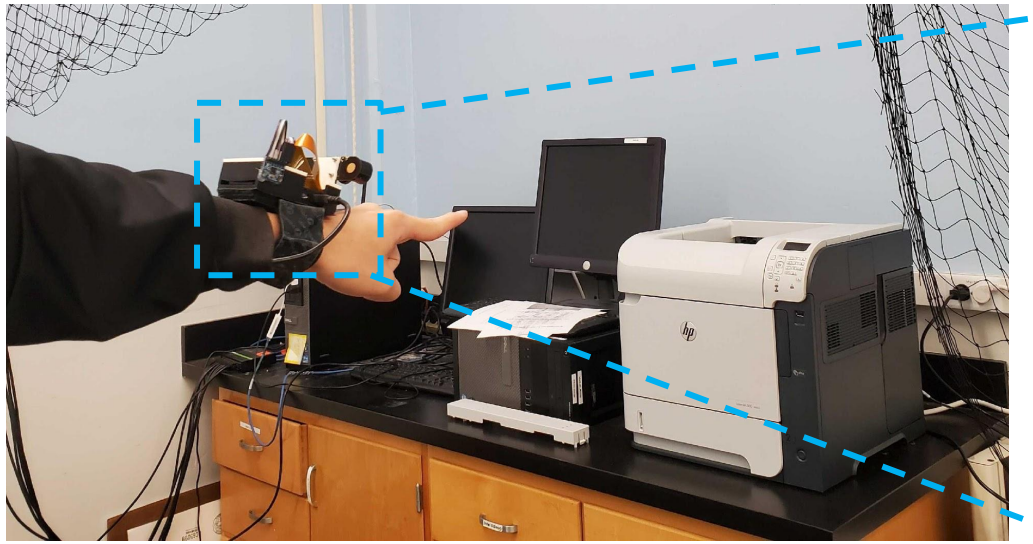


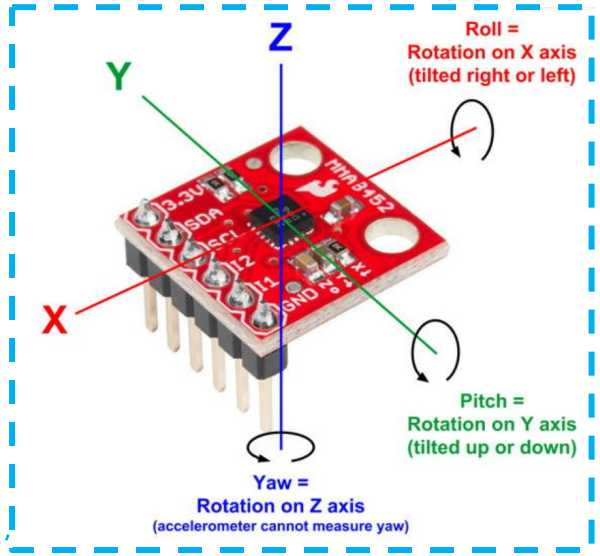


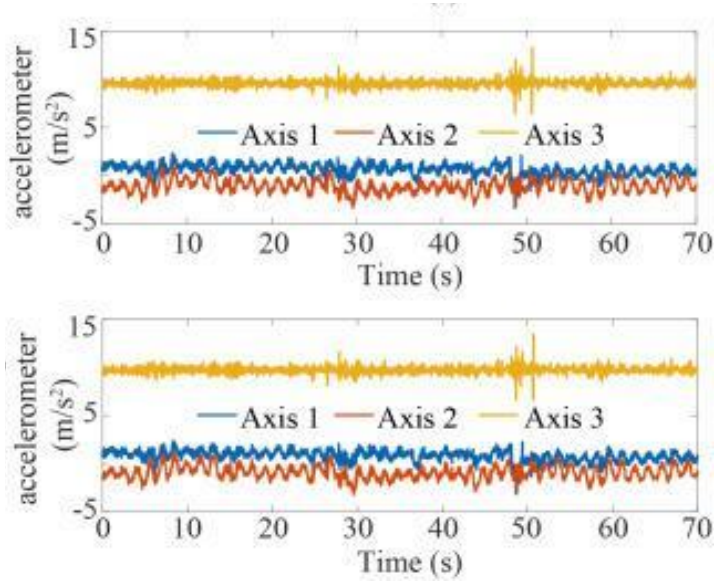


Motion Sensor Implemented at the Core:

- GY MPU6050 Module consists of two 3 axes analog accelerometer and gyro sensors
- Accelerometer data is continuously measured and sent to the server through the Raspberry Pi Zero

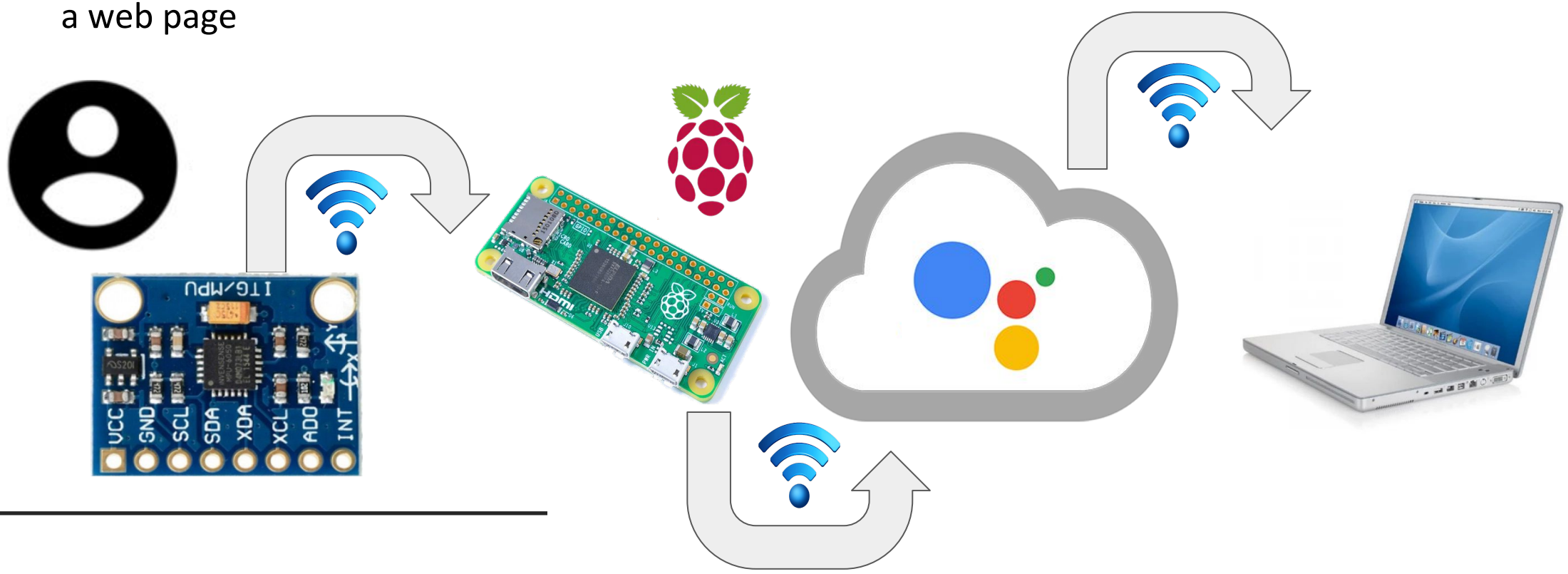






System Communication:

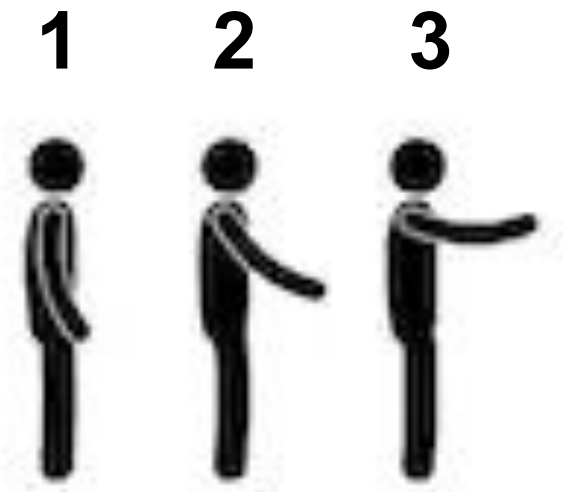
- Accelerometer data is transferred to the server
- Server processes and analyzes the data
- The Google Assistant communicates the needs with the user and let them make some of the decisions
- The data, classification results and AI feedback will be all shown and plotted to the user on a web page

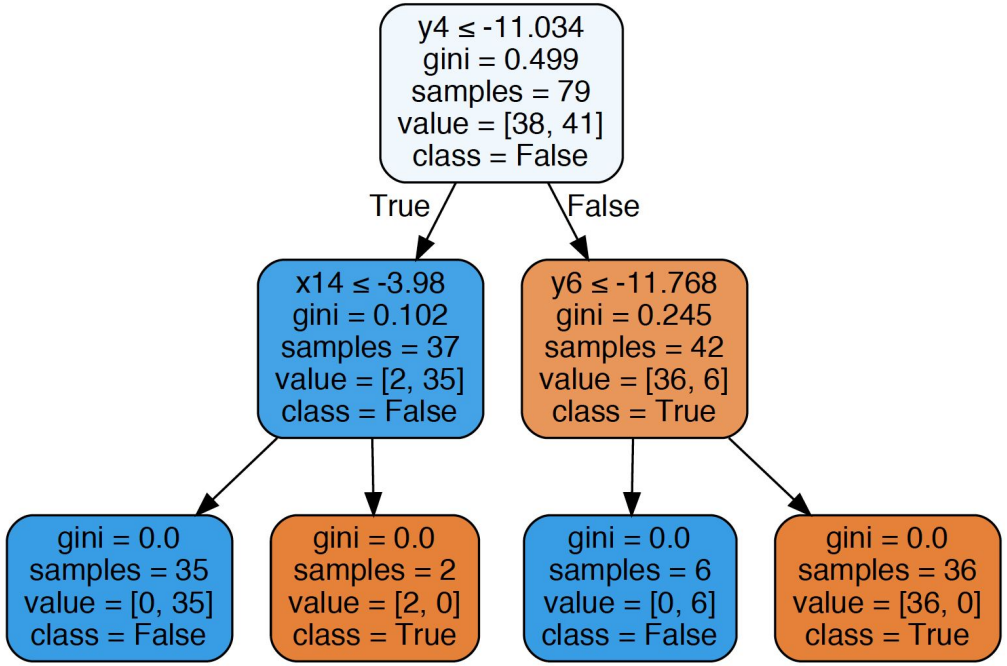


Triggering Mechanism:

- A set of continuous accelerometer data points are used in a trained model looking for a raising hand motion.
- The machine learning algorithm used for detecting the trigger is **Decision Tree**
- CamIoT is activated and the system goes to the next stage for taking picture needed for the next step in classification and interaction purposes

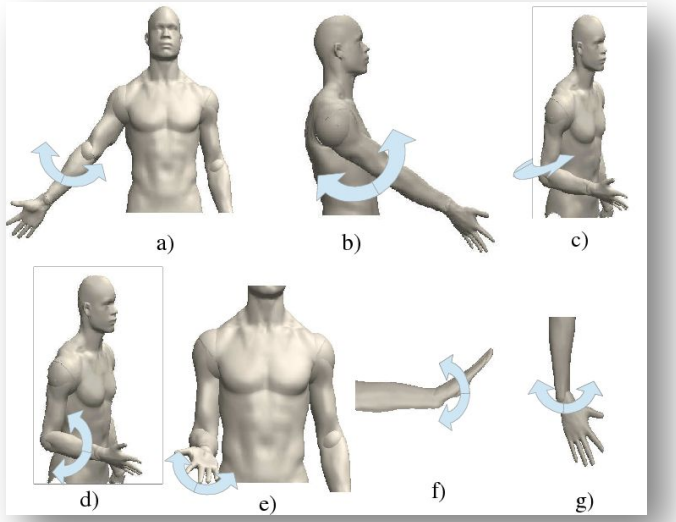
Triggering behavior





Training and AI Communication (step 1):

- At first, the AI provides training for the user by analyzing their speed in triggering motion
- The data is collected from the accelerometer worn by the users with random arm behavior.
- The sensor data is utilized to calculate the average speed of an arm motion
- It is then labeled and classified
- AI will inform the user if their triggering gesture is misclassified in the system and let them adjust adjust the algorithm or correct their speed



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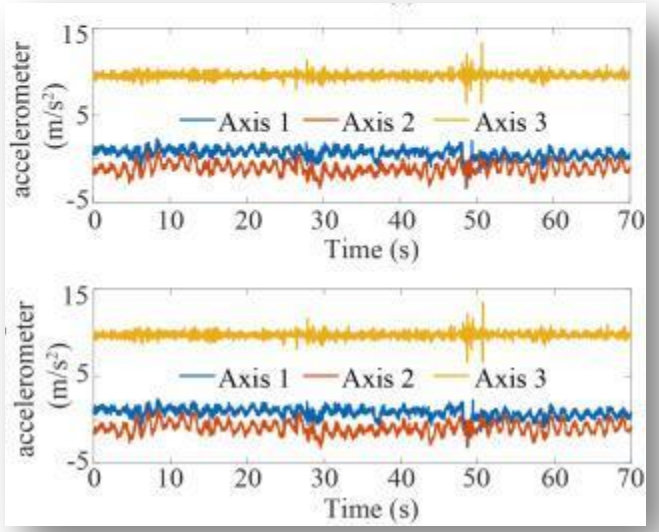
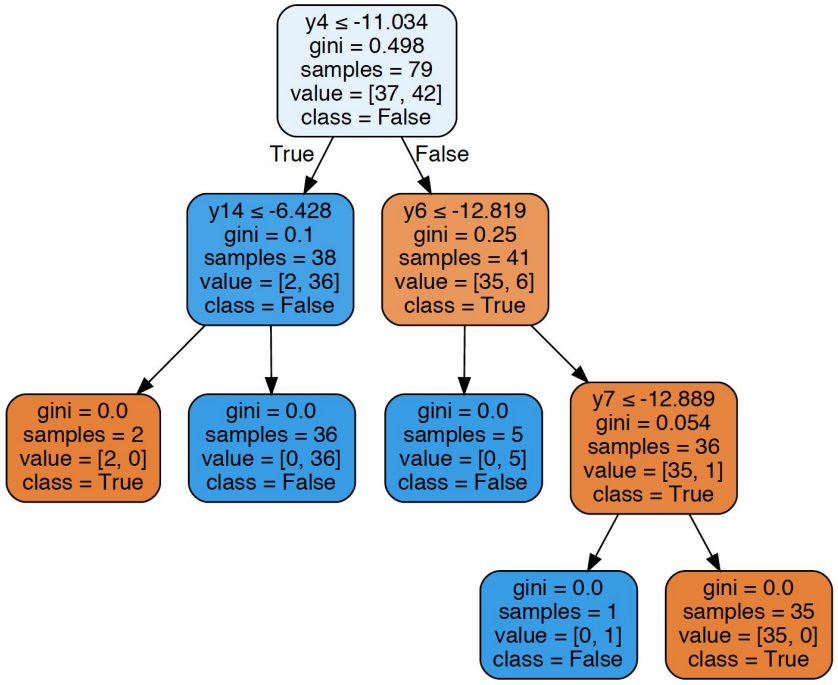


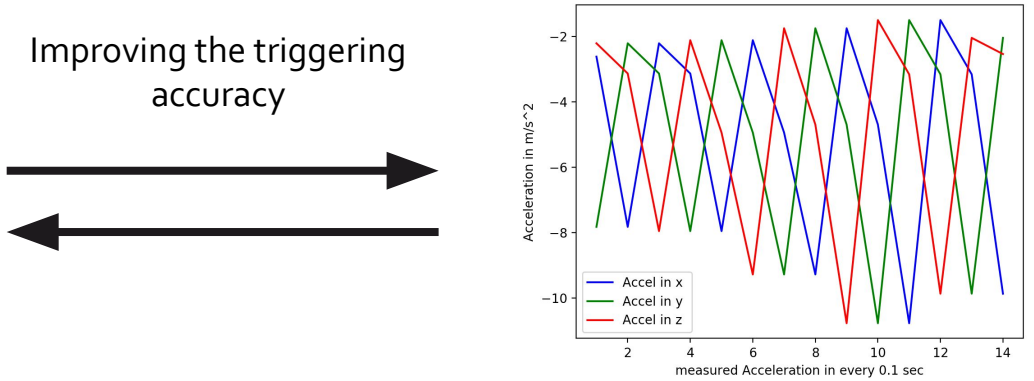
Google Assistant

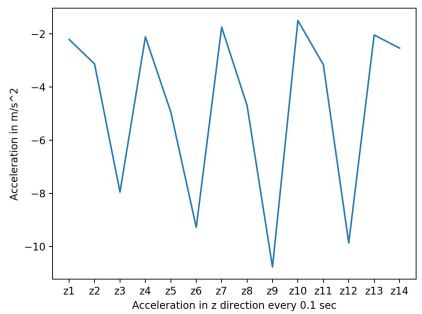
Explainable AI (step 1):

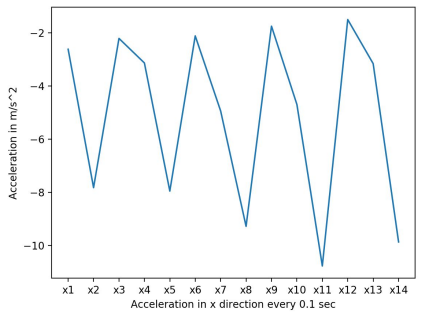
- Our approach is based on **Rule Extraction** :
  - The accelerometer data is analyzed separately from training and test data
  - Comparing the average speed and acceleration of the user motion to the ones from training data, the AI would give simple comments on how the triggering mechanism can be improved

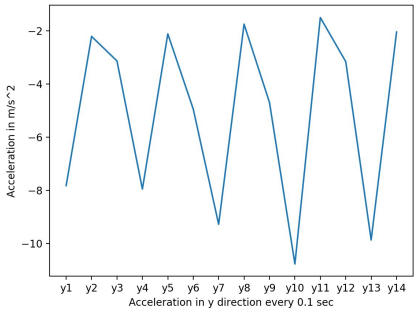


Improving the triggering accuracy



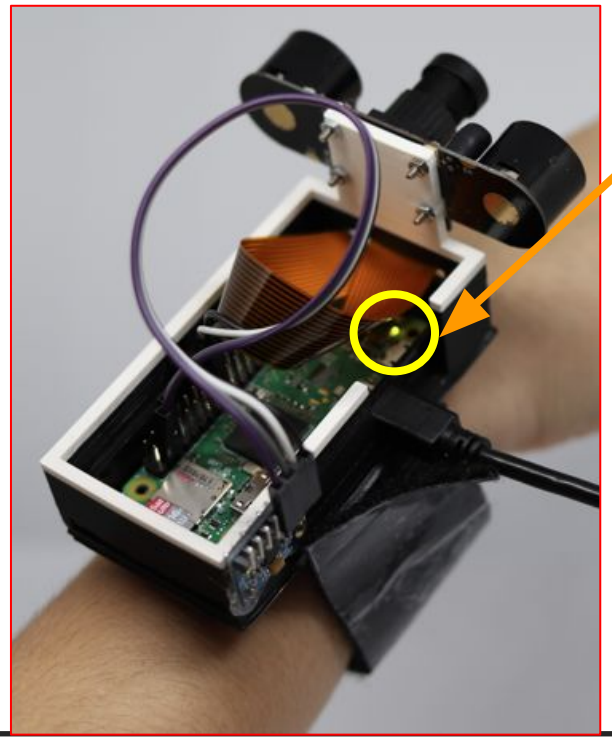




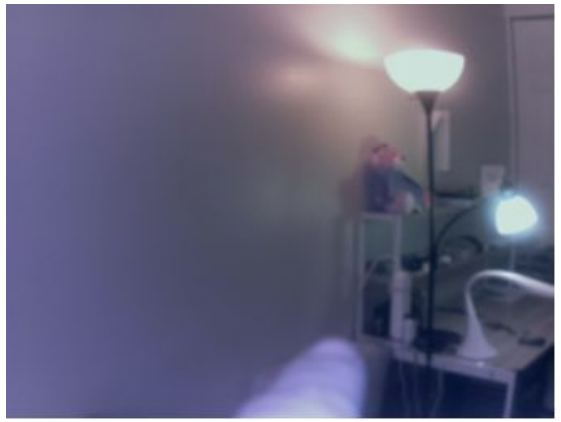


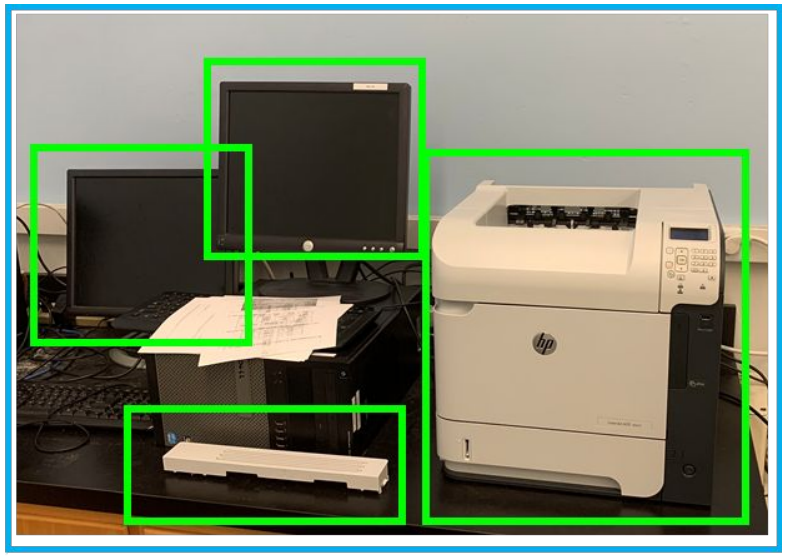
Explainable AI (step 2):

- In case multiple objects are detected (decided based on threshold value):
  - Provide the image taken and correct the label and add it to the training set for the next round
  - comment on finger occlusion and position :
    - Either showing a blinking LED or accepting voice command



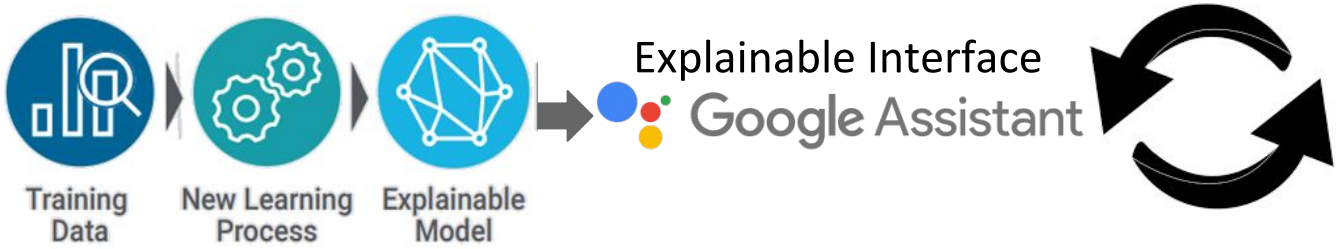
Can we provide feedback on how the user should correct his pointing direction?

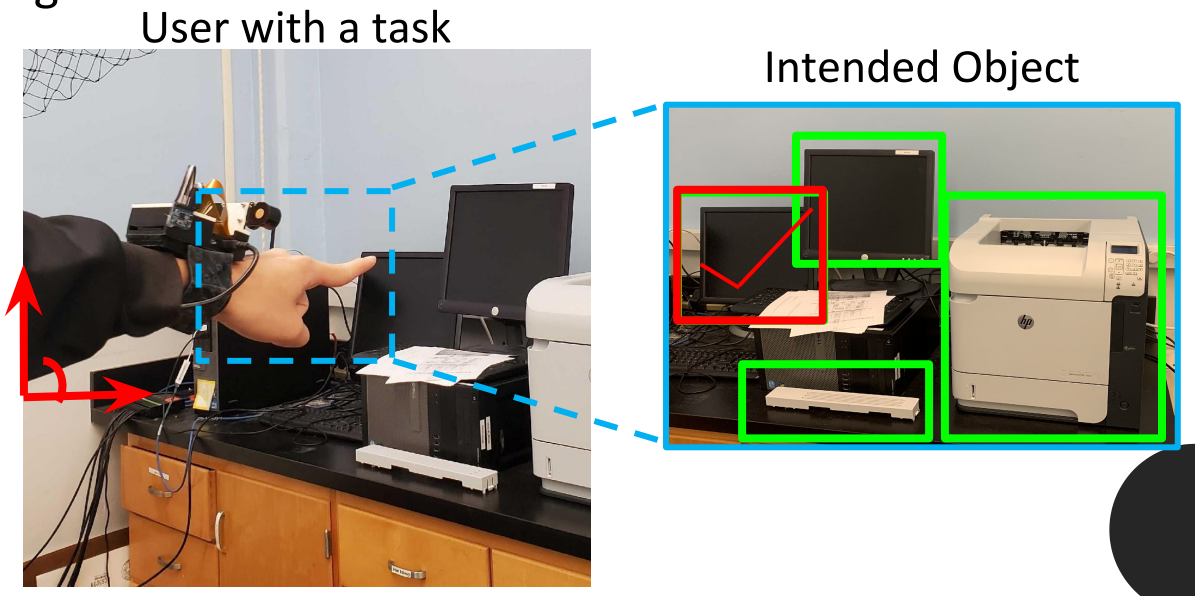




Explanation Metrics -

- Triggering Mechanism
  - The user will have the choice to add a new triggering motion (speed) to the system to improve the decision tree classification
- Image Disambiguation
  - Add user feedback to the classification system
  - This can further be improved by coupling the image processing algorithm with some of the gyro and accelerometer data to look for view angle





Evaluation Metrics

1. Design user Study to see how helpful explaining our AI can be:

Misclassified rate measured  **Misclassified rate measured**

Explainable
CamIoT
feedbacks

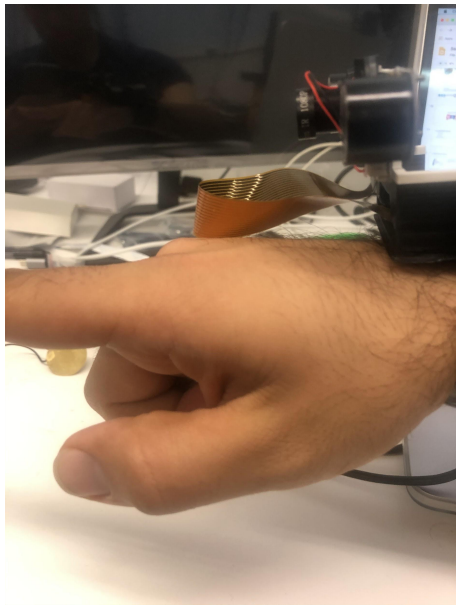
e.g go faster/slower, hold your hand still for 1 sec, …
lower your finger, raise your finger slightly, point more to left

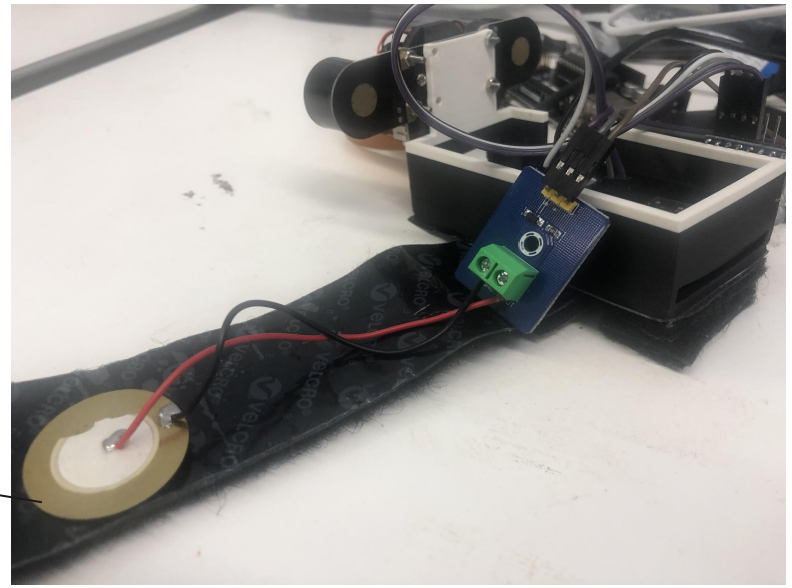
2. Focus feature highlighted in decision tree and try to explain the model behavior using **acceleration and velocity**
3. Add user's data to training set and re-train and compare the results

Thank you for listening

Haptic Feedback

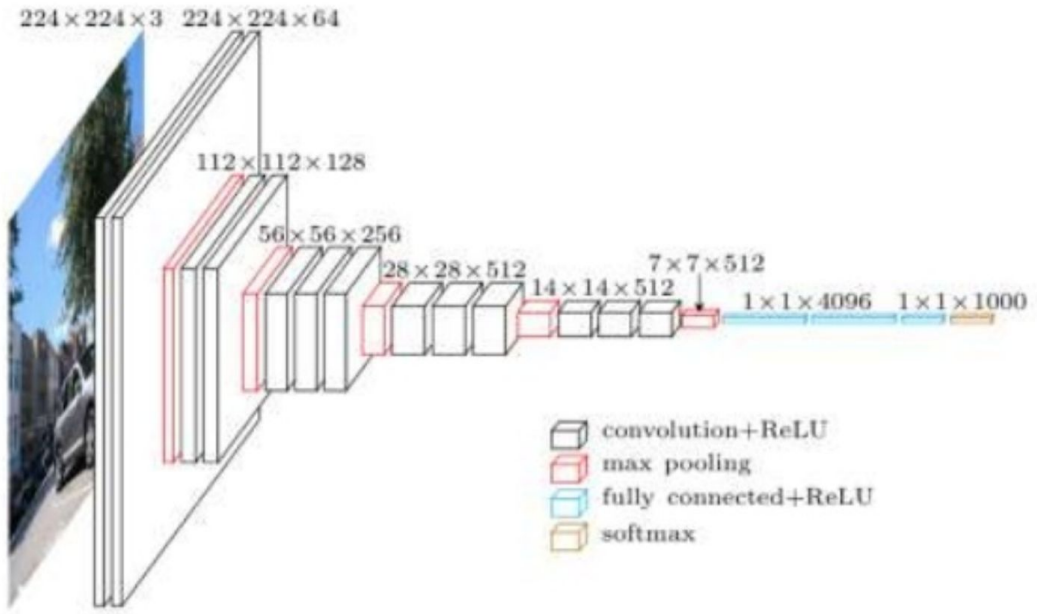
Piezoelectric Vibration Sensor





Our Object Detection algorithm:

VGG16 Pre-Trained Model



The model achieves 92.7% top-5 test accuracy in ImageNet, which is a dataset of over 14 million images belonging to 1000 classes.

1. Diagram source : https://arxiv.org/pdf/1409.1556.pdf

Some supplementary materials:

- Good explanations allow you to answer questions[1]:
  - Why did you do that?
  - Why not something else?
  - **When do you succeed?**
  - When do you fail?
  - When can I trust you?
  - **How do I correct an error?**
- Good explanations help even if the AI you explain isn't very good
- Not all explanations look like explanations

1. CMU Human AI interaction course by Jeffrey Bigham