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TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS



AIKO - A Companion Robot

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1] Abstract :

Companion robots is an emerging branch of robotics. These robots are generally developed for providing studying and assisting humans. Most of the companion robot developed/under development are not available Commercially at either unaffordable or not available. In this project we proposed development of an open source, interactive, cost-effective, Social companion robot with multi role capabilities. Current prototype (In-development) focus on principle functionality meting the criteria for companion robot.

2] Introduction :

In the last few years there has been huge interest building in such types of robots which interact in a socially acceptable way with humans. In this they respond to limited users requests such as playing music, weather for. This way voice assistant social became a natural, acceptable and enjoyable conversational partner is likely to be influenced by how it can express itself through explicit behavior while interacting with users. In general social robotics is inspired by the aim to build companion robots to mimic animals, a closer look at human-animal interaction, especially the detailed investigation of the social relationship between. We identify problems in social robotics from an ethological point of view, and will argue that functional considerations in construction of social robots are vital. This view is underlined by the means of an ethological analysis and critical evaluation of present day companion robots. A closer look at human–animal interaction, especially the detailed investigation of the social relationship between humans and dogs, may provide important insights for social robotics [1][2]. Society nowadays is facing mental/psychological issues regardless of age group, gender & race. Especially in our society, mental problems are not addressed as per needs. And lockdown has significantly increased our vulnerability towards loneliness, thus causing psychological issues. We believe that with enough prototyping we would be able to address the needs of society.

3] Related work :

Since the middle of the 20th Century, Various scholars, researchers and institutions have taken great interest in the development of companion robots. Currently, numerous companion/assistant robots have been developed. Researchers have proposed/developed companion robots like for aging people [19], for nursing care assistance (RIBA)[20], for physical assistance (PHAROS) [21], for teaching assistance (ROBOSEM) [22][24], for library's book manipulation[23], for farming assistance [25] and many others. Most of the robots developed specifically for particular tasks. Many companions robots are also available today commercially with features like voice assistance, unique personality and mobility. These products are mostly developed keeping entertainment as the application in mind.

4] Outline :

In this paper, firstly functionalities of AIKO will be discussed in details along with their expected results. Followed by their respective limitation, future prospect and adaptability.

5] Design, Dimensionality & Its Significance

Design & dimensionality aspect of companion robot plays a very important role in determining the acceptability of companion robot. The size of the companion robot should be enough to get hold of and convenient to interact. Authors [3] Hayashi R and Kato S have suggested and proved the effect of pet-look inspired robots have huge positive psychological impacts on users. They have stressed its effectiveness on rehabilitation patients, elderly peoples and person facing autophobia or loneliness. We have taken these characteristics into consideration designing AIKO.

A complete preview of the CAD model : <https://a360.co/34CYagc>

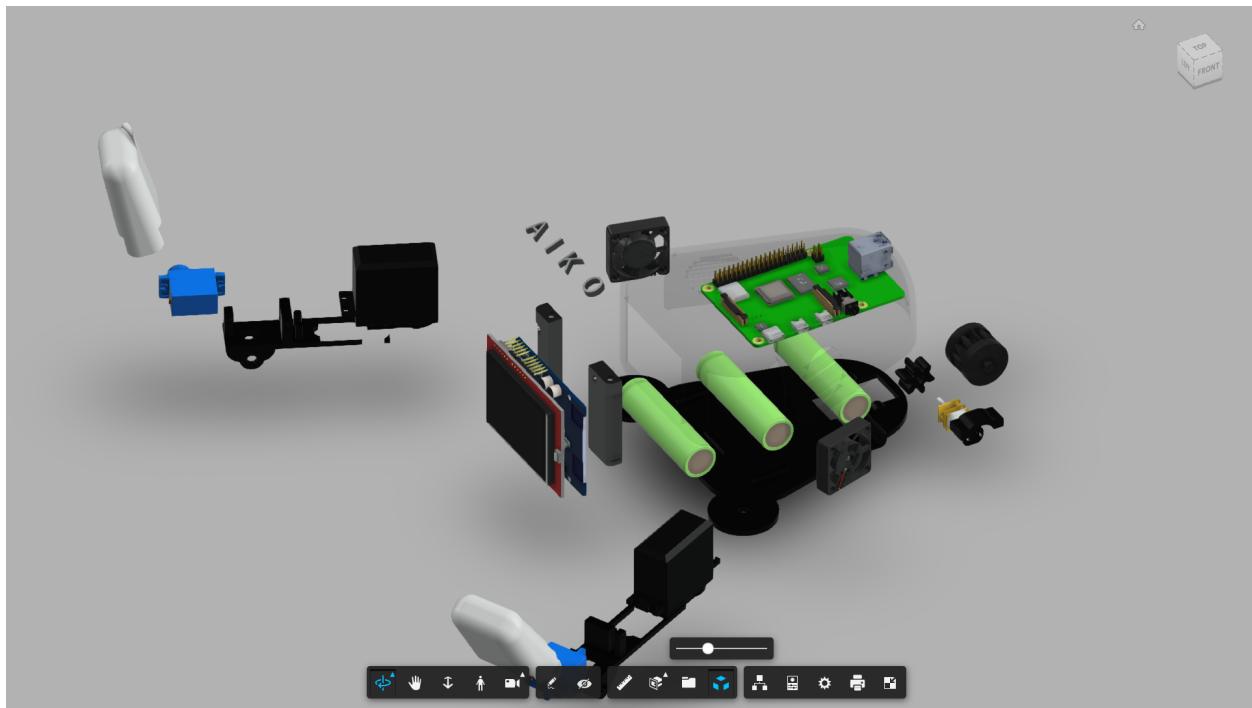


Figure 1] Preview of exploited view of CAD model

Tool / components used :

Hardware :

Computation: Raspberry Pi 3B+

Actuation: MG995, SG90, Polulu geared motor N20

Peripheral : Microphone, 2.4" LFT LCD Shield, Heat skin exhaust fan, Pi cam.

3D printing material : PLA

Software :

Design : Fusion 360

Programming : Pycharm, Ubuntu terminal, python shell.

Features :

- 1] Emotion detection
- 2] Emotion Display & Expression
- 3] Facial Detection
- 4] Locomotion
- 5] Voice assistant
- 6] Sound Localization (Under-development)
- 7] Motion Detection for Security

Note : These features are described in detailed in upcoming pages.

1] Emotion Detection :

Detection of the host's emotion in real-time is very important to interact with them effectively and more naturally. In the first phase we focused on detection of 6 basic form of emotion detection : happy, sad, neutral, angry, disgusted and surprised. The model was trained on CK and CK+ dataset.(Source: <http://www.consortium.ri.cmu.edu/ckagree/>)

For detection of facial landmarks we have used dlib and OpenCV libraries. Accuracy detected in real time ~78%

(Ref:<https://www.pyimagesearch.com/2017/04/03/facial-landmarks-dlib-opencv-python/>)

Facial landmarks :

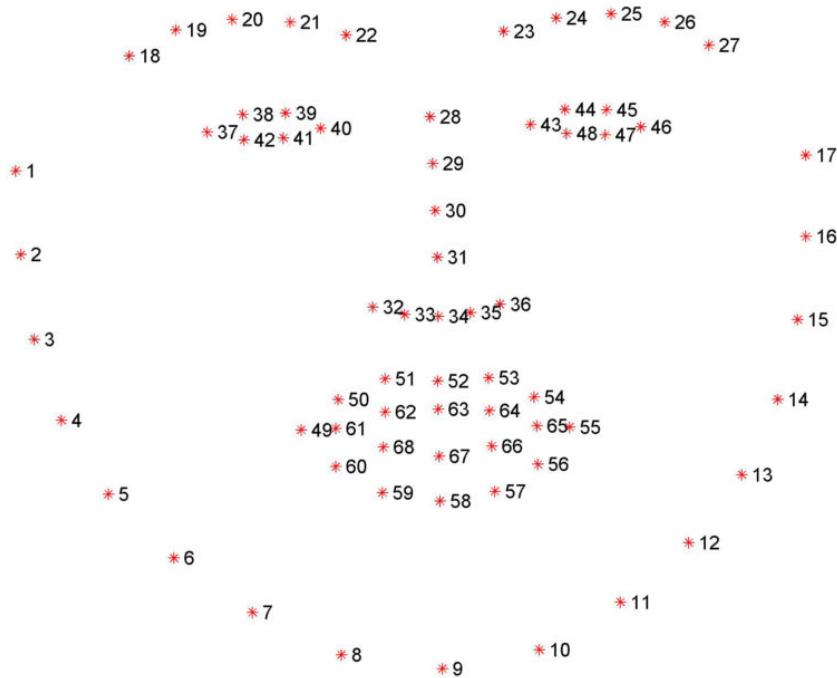


Figure 1: Visualizing the 68 facial landmark coordinates from the iBUG 300-W dataset

Preview of the emotion detection in action :

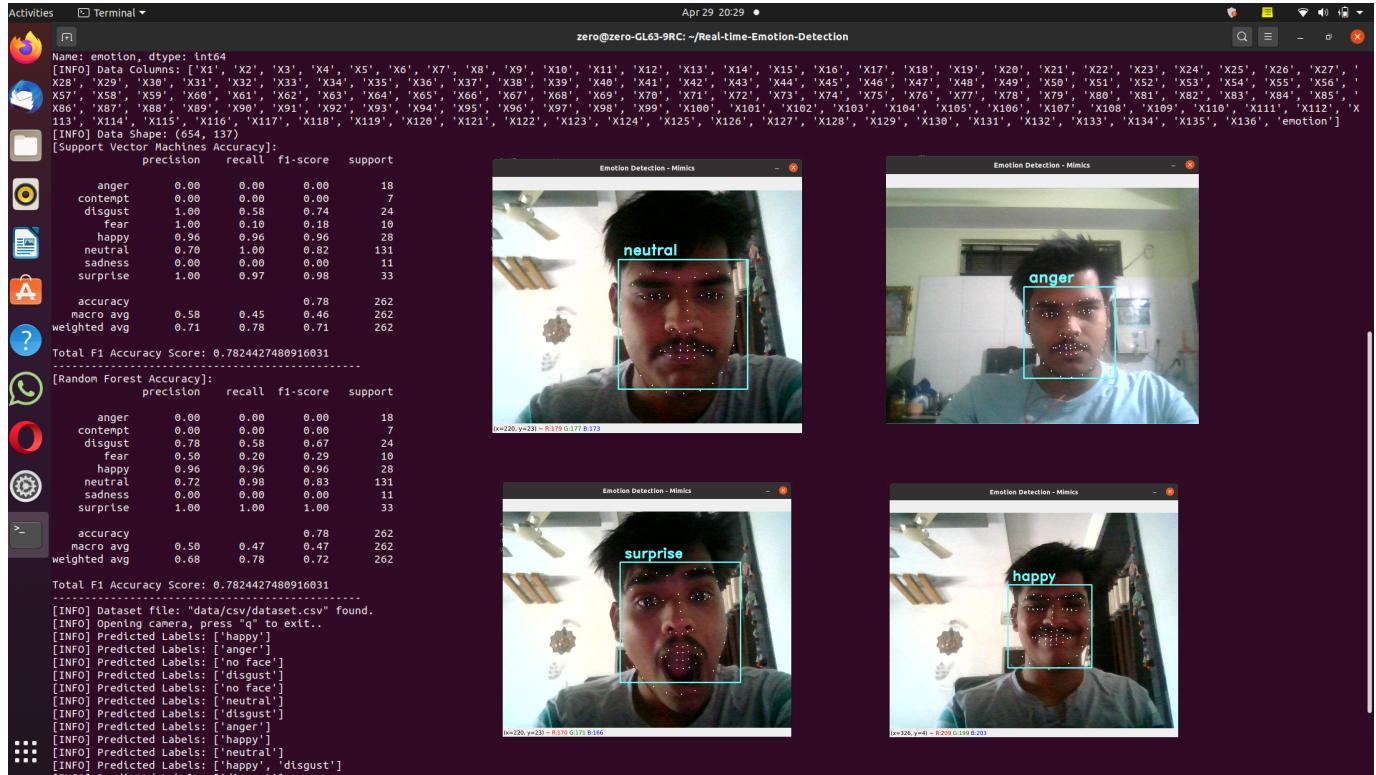


Figure 2: a) top-left - neutral; b) top-right - anger; c) bottom-left - surprise; d) bottom-right - happy

In future, we are planning to employ 3D emotion detection based 3DMM face coefficient from an unconstrained face image without use of landmark detector.

The method is prescribed in the following paper :

F.-J. Chang, A. Tran, T. Hassner, I. Masi, R. Nevatia, G. Medioni, "ExpNet: Landmark-Free, Deep, 3D Facial Expressions", in the 13th IEEE Conference on Automatic Face and Gesture Recognition, 2018 [1].

2| Expression :

We believe while interacting with host expressing at least basic facial expression can greatly improve the quality of the conversation. In current version AIKO can express up to 6 expression in accordance with the input. These expressions are displayed on TFT LCD shield embedded on Arduino UNO (Slave microcontroller).

These are images of various expression displayed :

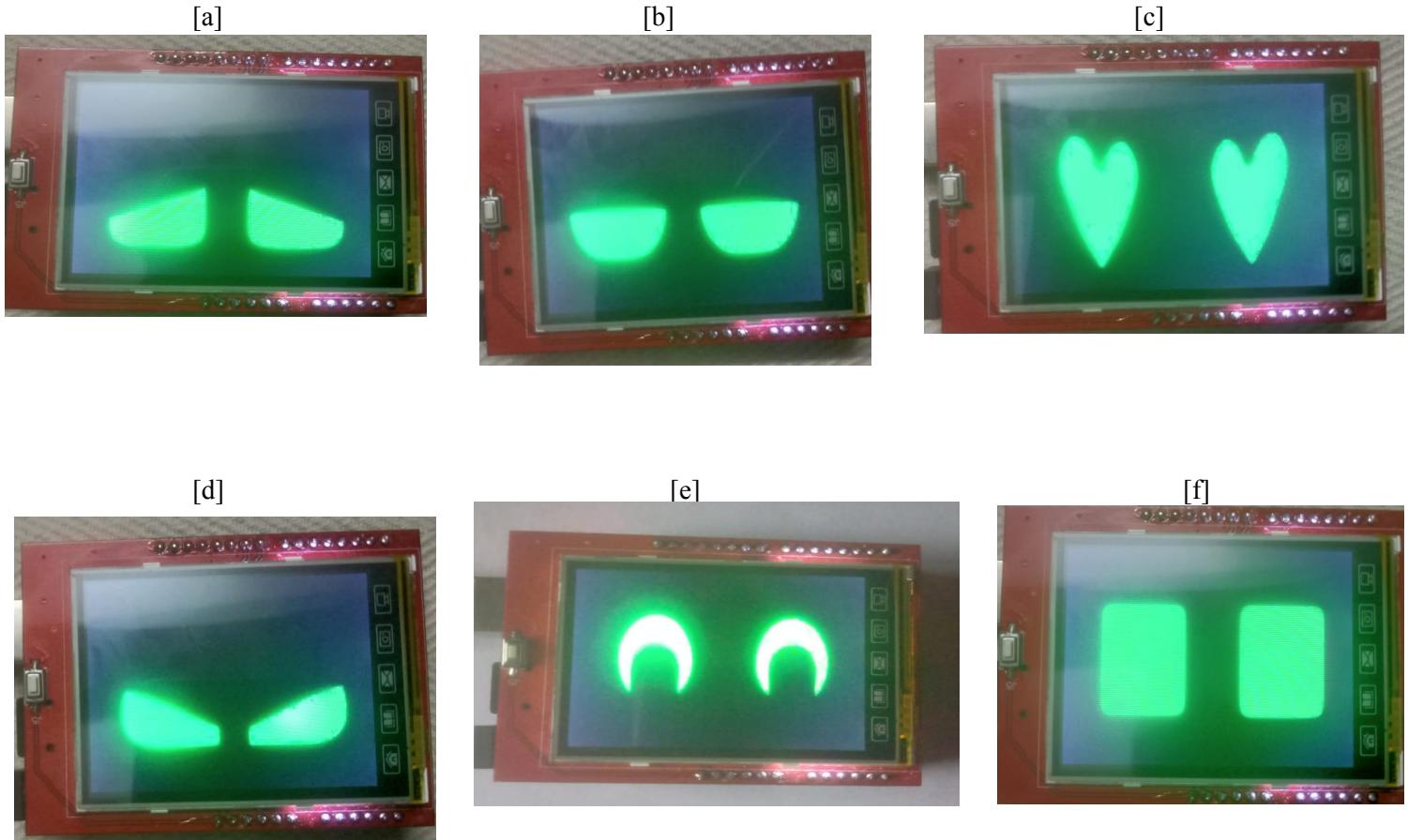


Figure 3] In above given images a) indicates sadness b) indicates annoyed c) indicates affection d) indicates anger e) indicates joy f) indicates neutral state

3] Facial recognition :

At its core, the facial recognition system uses **Siamese Neural network**. Over the years there have been different architectures published and implemented. The library uses **dlib**'s face recognition model, which is inspired from **ResNet-34** network. The modified ResNet-34 has 29 Convolutional layers. The model achieved 99.38% accuracy on LFW dataset.

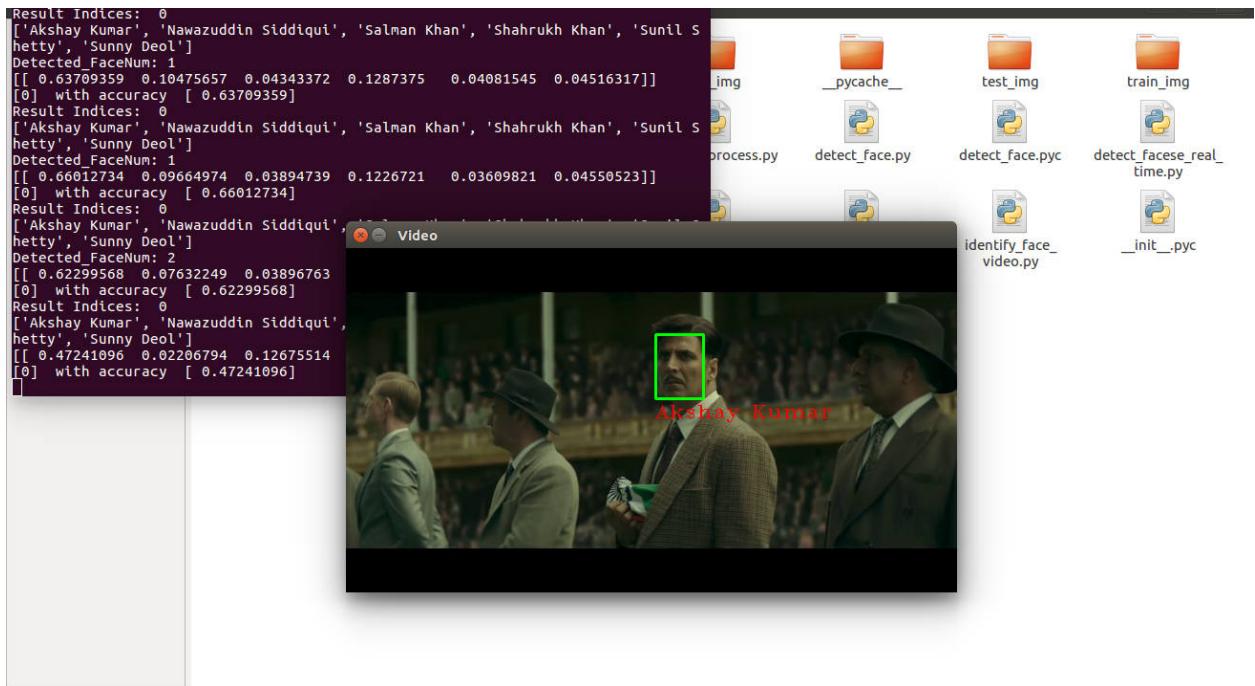


Figure 4] Facial recognition model in action

Face recognition function is important for recognizing the original owner of the companion bot. Further, this function can be used for adding features like calling owner for response. Currently, model is trained based on FACENET. Further work can be done on increasing accuracy and custom facial dataset can be used to train.

4] Locomotion :

Two form of locomotion are available : a) crawling, b) Wheeled drive.

In crawling the fore-arm employs two servos MG945 and SG90. The servo is controlled by PWM and duty cycle generated from Raspberry Pi whereas the power is provided by internal battery pack. (primary locomotion)

In wheeled drive the locomotion is powered with polulu N20 transmitted with hybrid wheel with spur gear engraved. For changing the direction the small wheels are attached on both fore-limb. (secondary locomotion)

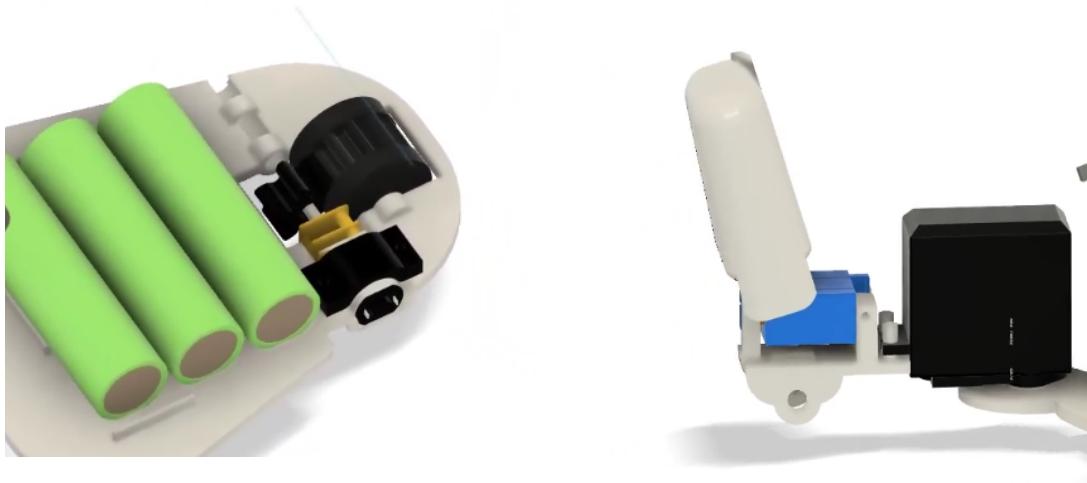
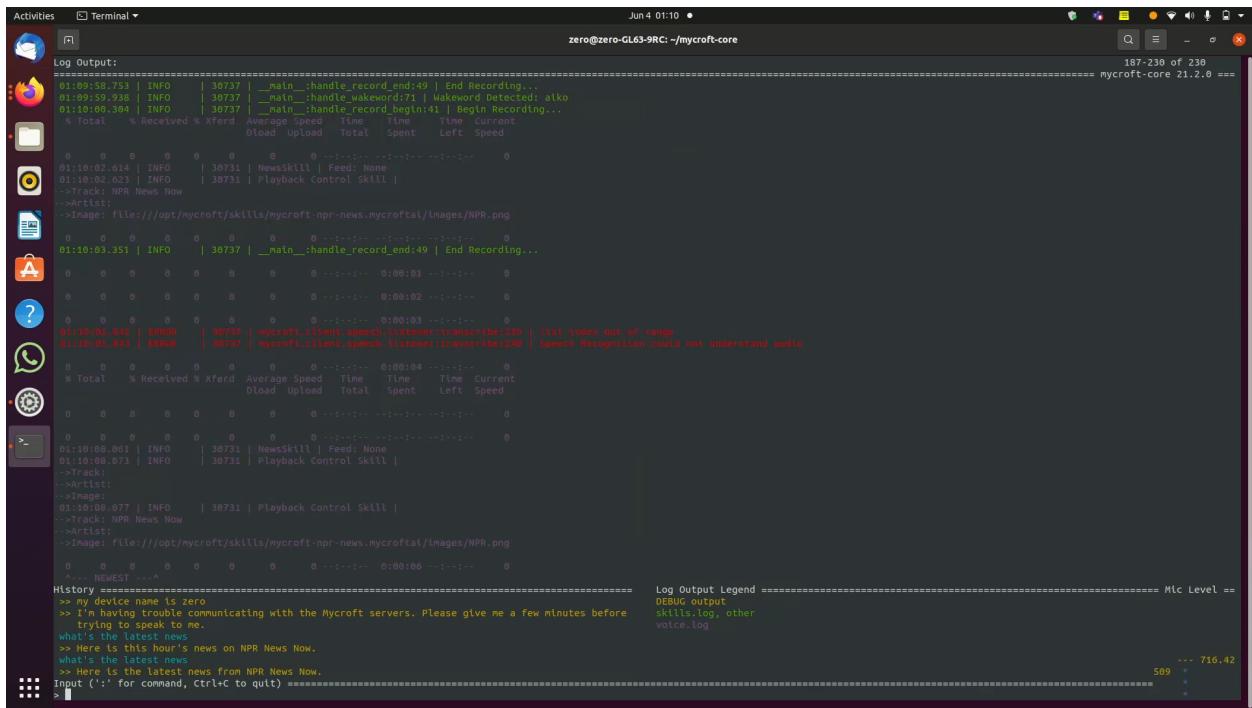


Figure 5] Left image shows the arrangement of polulu N20 motor with hybrid wheel attached. Right side image depict the arrangement of the fore-limb with two servos (MG945 & SSG90)

5] Voice assistance :

For providing standalone AI-based voice assistant we have implemented mycroft based assistant. The wake word is set for “AIKO” and system “Zero”. From the observed result, our model is unable to provide reliable and up to mark voice assistance. We are currently working on improving this part further.



The screenshot shows a terminal window titled "Terminal" with the command "zero@zero-GL63-9RC: ~/mycroft-core". The window displays log output from the Mycroft Core application, version 21.2.0. The logs show various system events, skill interactions, and errors related to speech recognition and recording. A scroll bar is visible on the right side of the terminal window.

```
Activities Terminal Jun 4 01:10 ● zero@zero-GL63-9RC: ~/mycroft-core 187-230 of 230
Log Output:
=====
01:09:58.763 | INFO  | 30737 | __main__:_handle_record_end:49 | End Recording...
01:09:59.938 | INFO  | 30737 | __main__:_handle_wakeword:71 | Wakeword Detected: alko
01:10:00.304 | INFO  | 30737 | __main__:_handle_record_begin:41 | Begin Recording...
% Total % Received % Xferd Average Speed Time Time Current
          Dload Upload Total Spent Left Speed
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
01:10:02.614 | INFO  | 30731 | NewsSkill | Feed: None
01:10:02.623 | INFO  | 30731 | playback Control Skill |
-->Track: NPR News Now
-->Artist:
-->Image: file:///opt/mycroft/skills/mycroft-npr-news.mycroftai/images/NPR.png
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
01:10:03.351 | INFO  | 30737 | __main__:_handle_record_end:49 | End Recording...
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
01:10:04.002 | ERROR | 30737 | mycroft.client.speech.listener:transcribe:239 | list index out of range
01:10:04.043 | ERROR | 30737 | mycroft.client.speech.listener:transcribe:240 | Speech Recognition could not understand audio
% Total % Received % Xferd Average Speed Time Time Current
          Dload Upload Total Spent Left Speed
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
01:10:06.001 | INFO  | 30731 | NewsSkill | Feed: None
01:10:06.073 | INFO  | 30731 | playback Control Skill |
-->Track:
-->Artist:
-->Image: file:///opt/mycroft/skills/mycroft-npr-news.mycroftai/images/NPR.png
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
^__ NEWEST __^
History ====== Log Output Legend ====== Mic Level ==
>> my device name is zero
>> I'm having trouble communicating with the Mycroft servers. Please give me a few minutes before
     trying to speak to me.
what's the latest news
>> Here is this hour's news on NPR News Now.
what's the latest news
>> Here is the latest news from NPR News Now.
Input (`:` for command, Ctrl+C to quit) >| 509 716.42
```

Figure 6] Preview of standalone voice assistant in action running on Ubuntu machine.

AI-assistant : <https://youtu.be/47G4-qxK8IE>

6] Motion detection :

By switching to alert mode, AIKO can detect motion in the surveillance area. The input RGB video is converted in grayscale image and shown in left side of the window and original video feed with bounding box indicating the motion detected is shown in right side.

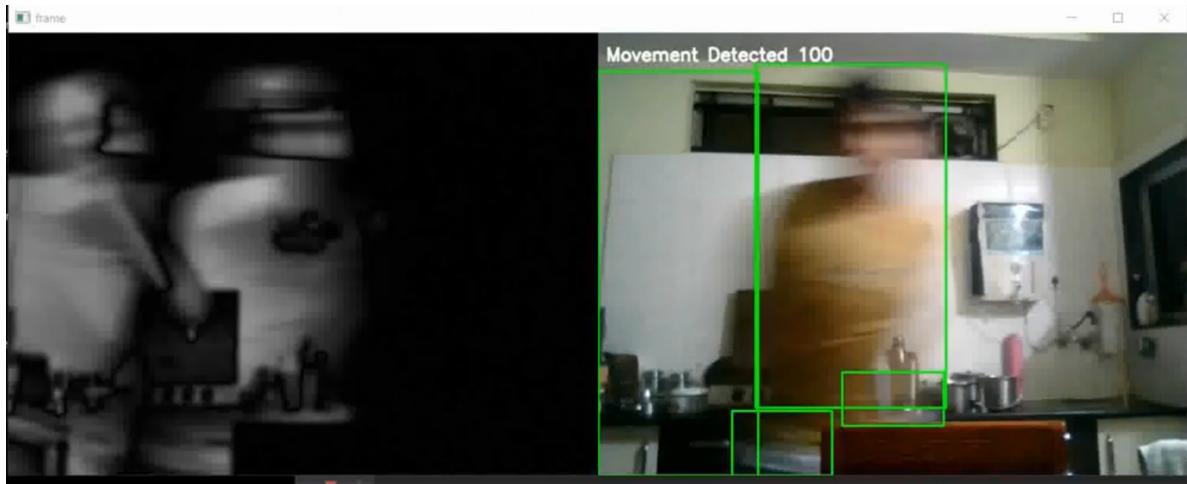


Figure 7] A moving target is detected and indicated with bounding box

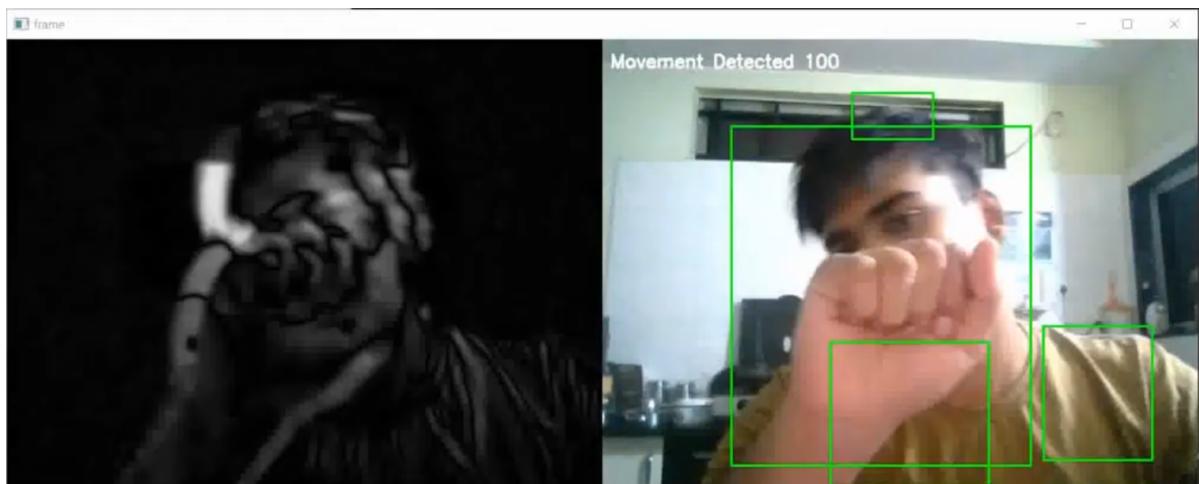


Figure 8] A static target is detected and indicated with bounding box

Preview of Motion detection(dynamic) : <https://youtu.be/sgfpVgC5Sq8>

Preview of Motion detection(static) : <https://youtu.be/6mhk3tDSVF4>

Future application :

Our project has possible applications in following domains :

- 1] **Rehabilitation** : Can be used to train/practise basic communication for Autistic people.
- 2] **Personal Assistance** : Can perform simple tasks like reminders, basic interaction, weather conditions and many other tasks.
- 3] **Education** : Our prototype can be used to teach the prospective students for learning programming language and understanding of robotics.
- 4] **Research** : Data gathered by the Aiko can help us to understand human psychology even better.

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