Object Recognition for Improved User Intent Inference for Robotic Lower-Limb Assistive Devices

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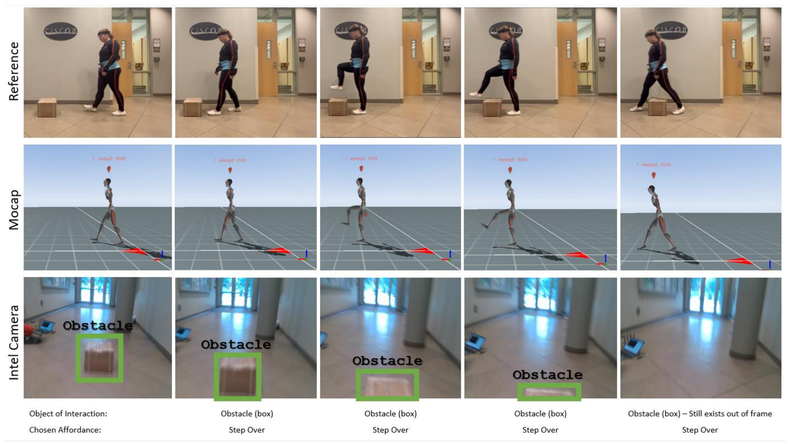
Abstract

To assist the user in achieving their daily objectives, the robotic lower-limb assistive device must be able to determine what action they are attempting to perform. We hypothesize that visual information about the user's environment will be useful in this task. For example, an individual wearing a lower body assistive exoskeleton will be safer if it only predicts a 'sit' action when the user approaches a chair, thus enabling knee joints to bend precisely at the proper moment. To anticipate such an action, we are using a combination of computer vision and human motion capture. Preliminary data was collected using an Intel RealSense Depth Camera and a Xsens Motion Capture Suit as individuals were engaging in their regular daily tasks. Furthermore, analyzing the collected data was done by using a combination of Python and YOLO to detect objects and sort them in a structured list containing the location of each object in the environment. In addition, we are using other developed algorithms, and a technological mapping method (SLAM - simultaneous localization and mapping) to allow the device to build a map and localize itself on that map at the same time. The future of this project aims to implement these technologies and probabilistic inference tools in order to understand how these detected objects and their localization help us predict the user's intent.



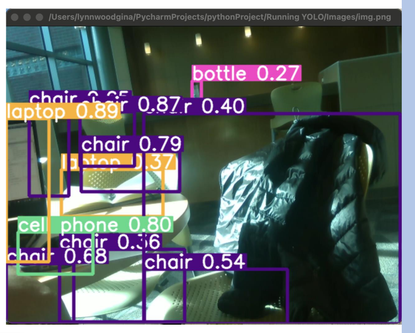
Methods

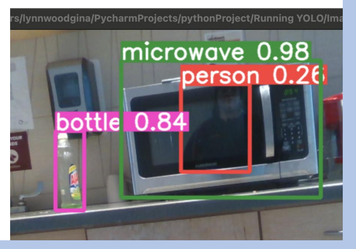
Materials/Softwares:

- Pycharm | Python IDE
- Google Colaboratory | Online IDE

Procedures:

- Install frameworks that provide object-detection pre-trained models
  - ➢ Ultralytics YOLOv8
  - ➢ TensorFlow
  - ➢ PyTorch
  - ➢ OpenCV
- Draft object recognition script in Python
- Qualitatively ensure that code produces desired output
  - First with random images
  - Then with actual human-subject dataset
- Debug code
- Use depth data from Intel RealSense camera to get location of each object detected in image





Results

In the ongoing development of the robotic lower-limb assistive device, partial results have yielded promising outcomes. A robust codebase capable of employing computer vision techniques to discern and classify objects within a user's immediate environment was completed. The code is able to process visual data to identify objects, provide a detailed bounding box for each object, and provide a confidence level for the identification. These critical features play a vital role in enabling the assistive device to anticipate and support user actions with high accuracy, such as bending the knees to sit when near a chair.

Conclusion

Now that objects can be recognized in the user's environment, the next step is to develop algorithms to incorporate this new visual into improved beliefs of the user's intentions. Future work will use Bayesian-based analysis to fuse the visual information with existing motion capture data. Additionally, the algorithm will be adapted such that it can improve over time. The goal is that the more the device is used, the more the intent inference algorithm will become personalized to the user and patterns in their behavior. These advances will lead to robotic lower limb assistive devices that are practical in everyday situations – enabling this innovative technology to significantly improve the lives of people with lower limb disability.

References

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Rodriguez,Maria,et al."Ethical Considerations in User Intent Recognition:A Framework for Robotics." Robotics Ethics Quarterly, vol. 22, no. 3, 2021, pp. 165-180.