Applications of Bayesian Analysis on Updating User Intent

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Abstract

To be beneficial, robotic lower-limb assistive robots need to able to infer what the user wants to do, also known as "user intent". Previous intent recognition strategies have used external and onboard sensors to track force resistance and muscle activity to provide signals related to the user's intent. We believe that including information about the user's proximity to objects, the affordances of those objects, and the user's orientation with respect to each object should increase the accuracy of our intent recognition. For this project, we have experimented with various designs of a Bayesian network with which to base our intent recognition algorithm. I am testing each of these designs using a software called Samlam.

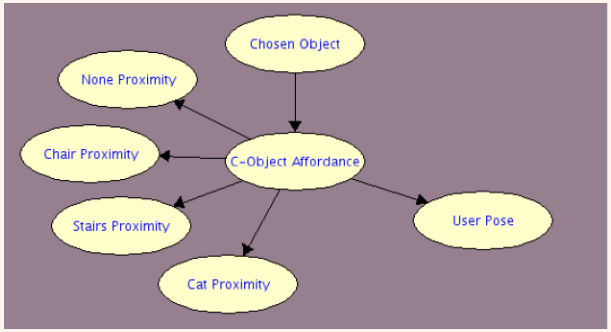
Introduction

When it comes to identifying user intent many existing methods attempt to do so with through onboard sensors on the robotic device or sensors placed on the users' muscles, indicate the likelihood of certain movements.
However, these strategies ignore the information present in the user's environment and often suffer for individuals who have incomplete motor functions in their residual limbs, leading to inconsistencies in readings.[1] We suspect that by using computer vision to recognize objects in the environment, such as chairs, we can better infer the user's movement intent such as a desire to 'sit' in said chair.
Bayesian analysis is a set of mathematical procedures that we suspect will help us to update our belief of the user's intentions based on the various signals we have proposed to measure. We have seen it be used to better estimate the elements based on others effectively, such as Bayesian networks [2].

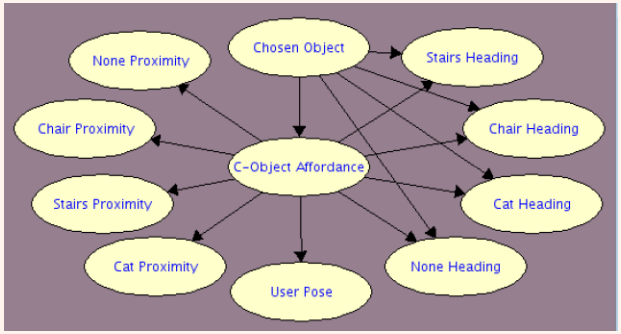
Methods & Resources

- I have relied on three main resources to get started with this project: textbooks, literature, and a Bayesian Network Simulation program called the Samlam .
- I began by learning some background by reading from textbooks MIT Open Courseware and Bayesian Inference and Data Assimilation provided a basis for understanding the fundamentals of Bayesian Analysis and State Estimation, leading into why Bayesian Networks could be best fit for taking in all the project's data.
- Literature on this topic and into how Bayesian State Estimation has been used in previous projects to either take in data or update on one's state was used to further how Bayesian networks could be utilized and developed for this project.
- The Samlam software was pivotal in taking these concepts of Bayesian networks that could update the intent inference and verify it of its capabilities and other variables.

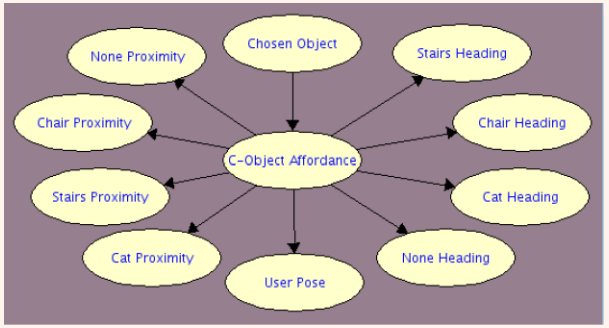
Results



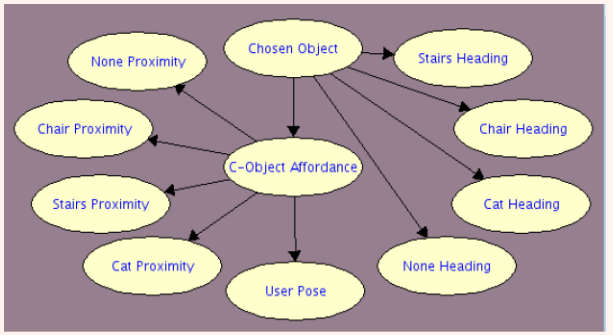
- Results are still preliminary but what it is currently being tested is the implementation of a heading variable within the basis of the Bayesian Network. Above is the given Bayesian Network, where it can determine what the user's chosen object is based on their pose, proximity to other objects and their chosen object's affordance.



- In this version, there is a relationship with both the chosen object and its affordance to the heading. However, due to the many relationships with the variables in this network, the computational process could hinder getting the user's chosen object fast enough.
- As well, to note, the heading variable is given by applying a heading variable for each recognized object. In this case, the heading of the user is considered in being towards a certain object, away from it or neither. Which in turn will affect user's chosen object under a certain intent.



- Above, the heading variable affects the chosen object's affordance.
- Below, the heading variable affects the user's chosen object.



Conclusion & Future Work

The use of Bayesian Networks have proven to be effective in building a way to update the intent inference of the user. As of now, we are looking to test which of these current test networks can best show what is the user's chosen object of interaction, when given a certain route of intent.

References

[1] T. M. Gambon, J. P. Schmiedeler, and P. M. Wensing, "Effects of User Intent Changes on Onboard Sensor Measurements During Exoskeleton-Assisted Walking," IEEE Access, vol. 8, pp. 224071–224082, 2020, doi: https://doi.org/10.1109/access.2020.3044255.
[2] E. Jaramillo-Cabrera, E. F. Morales, and J. Martinez-Carranza, "Enhancing object, action, and effect recognition using probabilistic affordances," Adaptive Behavior, vol. 27, no. 5, pp. 295–306, Apr. 2019, doi: https://doi.org/10.1177/1059712319839057.
University of Notre Dame on Bayesian Inference and Data Assimilation
MIT Open Courseware