Artificial Guide Dogs

Reinforcement Learning Approach for Training Disabled People Personal Companions

Project Proposal

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1 Problem

Nowadays, there is a lot of effort being put into solving the problem of autonomous driving, not only because of research but also because of the security and comfort that autonomous vehicle may bring to our lives. Despite the fact, this problem being hard, it is made easy because of the environment where the action of driving happens. There are a set of rules about how to drive, and where to drive in order to avoid potential accidents resulting in collisions with other vehicles, persons or objects. In other words, the environment dynamic and risky but, it is less chaotic and more well defined than others, which becomes more suited for the development artificial intelligence approaches for training vehicles to be autonomous.

To our knowledge, there has not been a lot of development of similar techniques for pedestrians, namely the ones that show some form of disability that could put them in danger if not accompanied by some form of personal companion. In fact, the pedestrian environment, unlike the one where vehicles circulate, does not have a set of rules describing the way people should walk nor a place where the action of walking takes place. The pedestrian may be forced to walk in a sidewalk, in a rugged terrain or even in the car lane if no sidewalk exists. Additionally, the objects that a pedestrian needs to avoid obviously increases since a person needs not to worry only about walking itself, but also other obstacles with a more unpredictable moving patterns. Therefore, the environment is often so chaotic that traveling by foot requires assistance and makes the problem less approachable from an artificial intelligence standpoint.

Since the problem of autonomous mobility for disabled pedestrians is not particularly developed, and the only way such mobility can be achieved is with the help of some form of companion, (like for instance a guide dog which requires a lot of training in order to successfully guide people), our idea is to use some form of reinforcement learning technique and train a intelligent agent, therefore reducing the time and costs that would be required in the acquisition and training of a real personal companion.

In short with this project we aim to explore techniques to train the agent to access the hardness the environment and all the obstacles present in order to determine a suitable footpath and guide in some way the person through it. In our research, we intent to start with more accessible environments progressing to more challenging ones as we go along. We will also focus on visually impaired people since they are representative of a group that could benefit a lot from the development of this technology.

2 State of The Art / Literature Review

From our research about the reinforcement learning methodology [SB18] we intend to apply in the training of our intelligent agent we found that a lot of work has been made on this topic both at a theoretical/algorithmic [BS10; Tam19] and practical level. There exist many implementations and approaches that rely on this method for solving problems that involve complex environments where an agent placed in the system must the optimal way to interact with it in order to obtain the reward the maximizes the objectives that the agent is set to solve. For instance, there is a lot of research on the autonomous driving problem that use on reinforcement learning techniques that we plan to build upon in the scope of this project.

In terms of autonomous driving we found a lot of material that ranges from simulators [Duc] that rely on a virtual environment to train an agent that will later be put in the same scenario but in real life, to strategies using known algorithms [VFM21] to detect and classify entities that may appear as obstacles for a vehicle. Although these resources provide us with a lot of tools, unfortunately they do not fit entirely for our goals. As we need not to simulate car lanes and other car traffic signals but sidewalks and pedestrian related signals, and the majority of obstacles will be most certainly people. However, these resources will become a benchmark for the development of our project.

More related with our project proposal we found that some work as already been made not only in the recognition of pedestrians [Dat21] but also using drones as footpath finders [Tan+21], therefore helping the visually impaired people circulation, especially through car lanes. These are the most relevant resources that we found on this topic and that convey the main idea we want to further explore.

3 Materials - Datasets, Frameworks and Algorithms

In terms of data sets we found a few resources online. The following list illustrates ones that are going to potentially be used by us during the development of this project:

- Penn-Fudan Pedestrian Detection and Segmentation: `https://www.cis.upenn.edu/~jshi/ped_html/`
- Flying Guide Dg: `https://drive.google.com/drive/folders/1UFcr-b4Ci5BsA72TZWJ77n-J3aneli6l`
- Pedestrian Datasets: `https://www.cognata.com/pedestrian-datasets/`
- UoL Corridor long-term pedestrian dataset: `https://lcas.lincoln.ac.uk/wp/research/data-sets-software/uol-corridor-long-term-pedestrian-dataset/`

In terms of frameworks we have a few options that we plan to explore:

- DuckieTown: `https://github.com/duckietown`
- Flying-Guide-Dogs: `https://github.com/EckoTan0804/flying-guide-dog`
- Python + ML/RL Libraries: `https://data-flair.training/blogs/pedestrian-detection-python-opencv/`

As for algorithms we are still discussing and reading about the topic and we soon hope to find the ones that will be better for our task.

4 Design of The Experiments

The design of the experiments to be carried out will be based on the detection of entities, namely people, traffic lights, crossings, stairs, etc... . The objective of the agent is to present a behavior appropriate to the environment presented to him. The evaluation of this behavior will be made by successful metrics, to develop, which will serve to inform us about the parameters that we must change, in order to obtain the expected performance, that is, that can navigate a dynamic environment safeguarding the physical integrity of the agent.

In terms of the experimental setup, we thought about how would we implement experiments to train/test our agent in multiple environments, since its really hard to model such complex system using the data available to us. One of the alternatives is to provide the agent with 2D images and through reinforcement learning the agent would select the regions on that image that would provide a viable path avoiding colisions with objects. A more advanced and realistic way would be to design 3D virtual environments and test the agent on those. Both options at the moment show promisse, and perhaps there might be even more possibilities to explore. We are still exploring more on this and we expect reach conclusions anytime soon.

References

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[Tam19] Kaiqing Zhang andZhuoran Tamer Basar. "Multi-Agent Reinforcement Learning: A Selective Overview of Theories and Algorithms". In: *CoRR* abs/1911.10635 (2019). arXiv: `1911.10635`. URL: `http://arxiv.org/abs/1911.10635`.

[Dat21] DataFlair. *Real-time pedestrian detection using Python and OpenCV*. May 2021. URL: `https://data-flair.training/blogs/pedestrian-detection-python-opencv/`.

[Tan+21] Haobin Tan et al. "Flying Guide Dog: Walkable Path Discovery for the Visually Impaired Utilizing Drones and Transformer-based Semantic Segmentation". In: *arXiv preprint arXiv:2108.07007* (2021).

[VFM21] Paulo R. Vieira, Pedro D. Félix, and Luis Macedo. *Open-World Active Learning with Stacking Ensemble for Self-Driving Cars*. 2021. arXiv: `2109.06628 [cs.CV]`.

[Duc] Duckietown. *The Duckietown Library (current version)*. URL: `https://docs.duckietown.org/daffy/`.