Project Proposal: Guide Dog Robot

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October 15, 2020

1 Purpose and Methods

We are trying to design a service robot that can assist people with visual impairment to walk on streets safely. The robot should be able to plan a path from site A to site B based on a given map, recognize traffic signals and make decisions when crossing the streets, and guide the user to walk through the crowds on the street. The project can be roughly divided into two parts: recognition and decision making. For recognition, we will train a network which is capable of recognizing instances in a simulated environment we are going to build which includes sidewalks, pedestrians, traffic, etc.. As for decision making, we will integrate a map and information from the recognition part to enable global and local decision making in order to navigate the user to his/her destination safely.

2 Limitation of Current Approach and Why We will Succeed

Several robot dogs have been developed in the recent years, for instance, a group from the Florida Atlantic University has designed a smart robodog named Astro. However, the current research groups mainly focus on improving dynamic performance and intelligence capabilities of the robodog while paying limited attention to its potential application as a robot guide dog to assist visually impaired people. A handheld guide robot designed by a student from the Loughborough University is able to navigate to the destination but this device can only make use of data from the Internet. A robot guide dog designed by the National Chiao Tung University can handle real-time situation but it is only designed to follow the blind way. None of the above robots is capable of navigating blind people to destination and meanwhile dealing with dynamic real-life situation such as traffic and crowds. Therefore, considering that our novel robot guide dog overcomes several limitations of those existing models, we believe that the accomplishment of this project will be a great success.

3 Resources and Access

Gazebo is a well designed simulator where we can conduct all of our simulations and test our algorithms. We will be specifically using Gazebo-9 together with ROS to build our simulation environment, robots and to deploy sensors for vision and other state measurements. We will mostly build our environment models using existing 3D models downloaded from the open source 3D Warehouse[2] model website. In order to simulate crowds in the environment, we are using a ROS implementation of pedestrian simulator which is able to generate very large crowds moving in real time. This pedestrian simulator implementation is also compatible with Gazebo. As for Computing Resource, a GeForce GTX TITAN Graphic card is available locally for simulation and learning.

4 Risks in Simulation and the Real World

For the simulation, there may exist a risk that the computing power is not high enough due to limited workstation from home. However, we will seek some web service if the current computing power is not sufficient. Some risks in the real world may include that the guide robot leads the user to an unsafe position, such as in the middle of car traffic, or unsuccessfully to avoid the dangerous obstacles. These risks may be caused by hardware failures, sensor errors, algorithm limitations and human-robot interaction failures. Although we only consider the software and simulation parts of the project this semester, the risks and limitations in the real world are also necessary to consider and should not be ignored.

5 Project Impact

According to the Global Data on Visual Impairment 2010 from the World Health Organization, the population with visual impairment is estimated to be 285 million globally and of whom 39 million are blind. If our robot is capable of "seeing" and meanwhile "guiding" in dynamic situations, this will absolutely benefit people who can't see and reduce their inconvenience caused by the vision problems.

6 Planned Schedule, Team Division and Design Metrics

Planned Date	Planning Milestones (Yongxin Guo, Yuchen Guo, Yihang Xu)	Perception Milestones (Yupeng Li, Junfan Pan, Zhuoyu He)
10/21	World model (4 blocks) (Demo: world with traffic lights, crossings, sidewalks, crowds, no car)	Gazebo Sensor and Robot Model (Demo: mobile robot with functioning camera/LiDAR)
11/2	Obstacles labeling, integration of training agent and simulated environment (Demo: interaction b/w agent and environment)	Data collection and NN model construction (Demo: image datasets and neural-network architecture)
11/16	Train agent with perception data and expect improving performance (Demo: less collisions of agent during training)	Train and tune model (Demo: a working system to detect objects and can be used in the planning part
12/02	(Demo: able to plan globally, navigate through crowds while staying on sidewalk and being conscious of traffic signals)	(Demo: able to detect traffic lights, crossings, crowds and achieve desirable AP)
Final Demo	User needs analysis, add human-robot interaction and kinematic models	

Table 1: Planned Schedule Break-down

The milestone of 12/02 is the MDP of our project. We expect to achieve a functional robot model in the simulated world environment assuming precise global position of robot can be given and the interaction between user and robot is ignored. We will manage to add features listed in the final demo row if time allowed.

Design Metrics:

- Obstacles: Recall 100%, mAP 27%
- 0% false positive rate when detecting traffic lights at pedestrian crossing (no tolerance for wrong detection when traffic light is at STOP).
- 80% success rate at local path re-planning for avoiding dynamic and short-term static obstacles.
- 100% success rate at completing global A-to-B tasks.
- 0% rate for walking out of sidewalks all the time, specially at the re-planning time.
- Limited speed under $0.6m/s$[1], which is the efficient and commonly used speed for blind people.
- Small angle of incidence under 25° when local re-planned path merges back to global path for avoiding large radial acceleration that causes discomfort.

Please be noted: All the metrics above which are related to position all consider the robot itself and the user who following behind it as a whole during the entire development process.

References

[1] Swenor B.K., Muñoz B., West S.K. A longitudinal study of the association between visual impairment and mobility performance in older adults: The salisbury eye evaluation study. Am. J. Epidemiol. 2013;179:313–322. doi: 10.1093/aje/kwt257

[2] https://3dwarehouse.sketchup.com