Touri

the Tour Guide Robot

Team 140

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Introduction

Background and Motivation

- The number of **museum visitors** in North America has been on a **downward trend** since 1982.
- Among all age groups, **children and teenagers** (below the age of 24) had the **sharpest decline:** -17% from 2012 to 2017.
- The elderly (above the age of 55) has became the largest population group (at 36%) among all museum visitors in Canada since 2004.
- This phenomenon maybe be caused by the **incompatibility** between the youth's **energetic nature** and the **slow relaxing environment** of the typical museum.
- More and more young people find **non-interactive recreations** like going to a museum **unattractive**.
- The average **attention span** of an average adult is around **40 seconds**, when reading a block of text on the wall.
- We would like to create a **more interactive** medium to convey information for the museums, in order to **attract more/young audiences**.

Project Goal

The goal of this project is to design and build a working model of a tour giving robot that is capable of **self-navigation, object avoidance** as well as providing **voice-over interactions** for museums.

Main Requirements

<u>Primary function:</u>

- **Movement:** must be able to move around following a line on the ground.

<u>Subfunction requirements:</u>

- **Autonomous:** autonomous and be solely powered by onboard battery (9V).
- **Environment Detection:** able to detect the surroundings, and control its movement based on that input such as avoid collision.
- **Audio input/output:** able to output audio containing information about the exhibits it is in front of.

Proposed Design

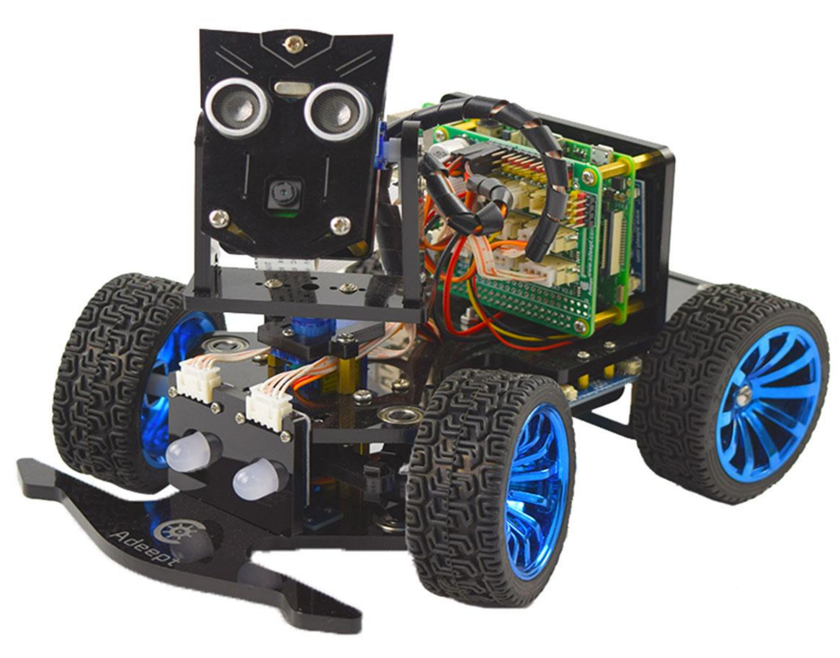
- We would like to design a robot that can **move autonomously in a predetermined path**, leading the user forward.
- The robot will **stop in front of every exhibit along the way**, display a 20~30 second **audio clip** to the user's bluetooth headset.
- The robot needs to be able to detect its distance from the user, so that it can speed up or slow down to **match the user's speed**, or **wait for the user** if needed.
- The robot should be able to **avoid bumping into things** or people.
- The use should have the options to **choose different touring routes**.

Design Challenges

- The main logic controls the robot is written in Python, while other peripheral functions such as audio output, visual recognition, audio recognition will be written in **various** of other **languages**. The implementation of **linkage**, and **data communication** between the different parts will be a challenge.
- The onboard Raspberry Pi 4 has a 1.5GHZ quad-core ARM processor, and 4GB of RAM. It is not powerful enough to run the main control program and visual recognition simultaneously. Therefore, parts of the program needs to be ran on an external computer, and communicate with the Raspberry Pi through a **Client & Server** link.
- The robot's design requires us to draw **vast numbers** of open source **libraries**, which takes time to research, implement, and test.
- Due to the entire onboard program consisting of codes from numerous sources as well as code we write ourselves, the **integration** and **debugging** process is extremely difficult.

Design Overview

Figure 1: Picture of Touri



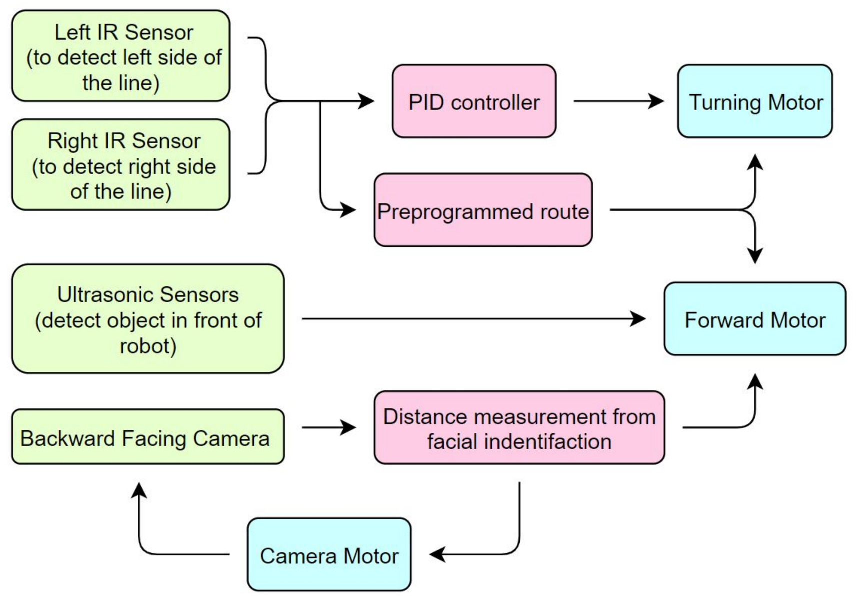
Control-level Overview

<u>Overview of the main algorithms:</u>

- **Line Following:** Touri has 3 IR sensors in the front. They are able to detect the color differences (line) and output 1 for black and 0 for white. The control system uses that input to steer the front wheels.
- **Audio input/output:** Touri's on board Raspberry Pi 4 can be connected to external headset/speaker, and we use Google audio detection to detect specific phrases (such as "start", "wait") from the user's audio input, then translate it into specific commands.
- **User Detection:** our design demand Touri to lead the user forward on a predetermined path, and stay a certain distance (~2m) ahead of the user. This requires Touri to recognize the user's face and be able to calculate the distance between the user and itself. We accomplish this by using OpenCV to detect user's body and face, then approximate distance based on their size ratio in the video feed.

Module-level Overview

Figure 2: Block diagram for the robot's movement logic



<u>Overview of the movement logic:</u>

- **Green box:** these are sensors producing input data, which will feed into the logic processors.
- **Red box:** these are logic processors (algorithms), calculating and producing output to sensory output.
- **Blue box:** these are sensory outputs, which mostly consist of motors and LEDs (not shown).

<u>Logic rundown:</u>

- By default, Touri uses the input of the IR sensors to determine its own position relative to the line, and it controls the turning motor and the forward (main) motor to control the direction and speed. **This is a self-feedback loop, which maintains Touri on the line it is following**.
- Once the frontal ultrasonic sensors detects unknown objects, the forward motor will bring Touri to a stop. **This act as a hard break to avoid frontal collision**.
- Finally the backward facing camera give input to OpenCV to calculate the distance between itself and the user following Touri. **This act as a soft break for Touri to stop and wait for the user if it gets too far ahead.**

Assessment of Final Design

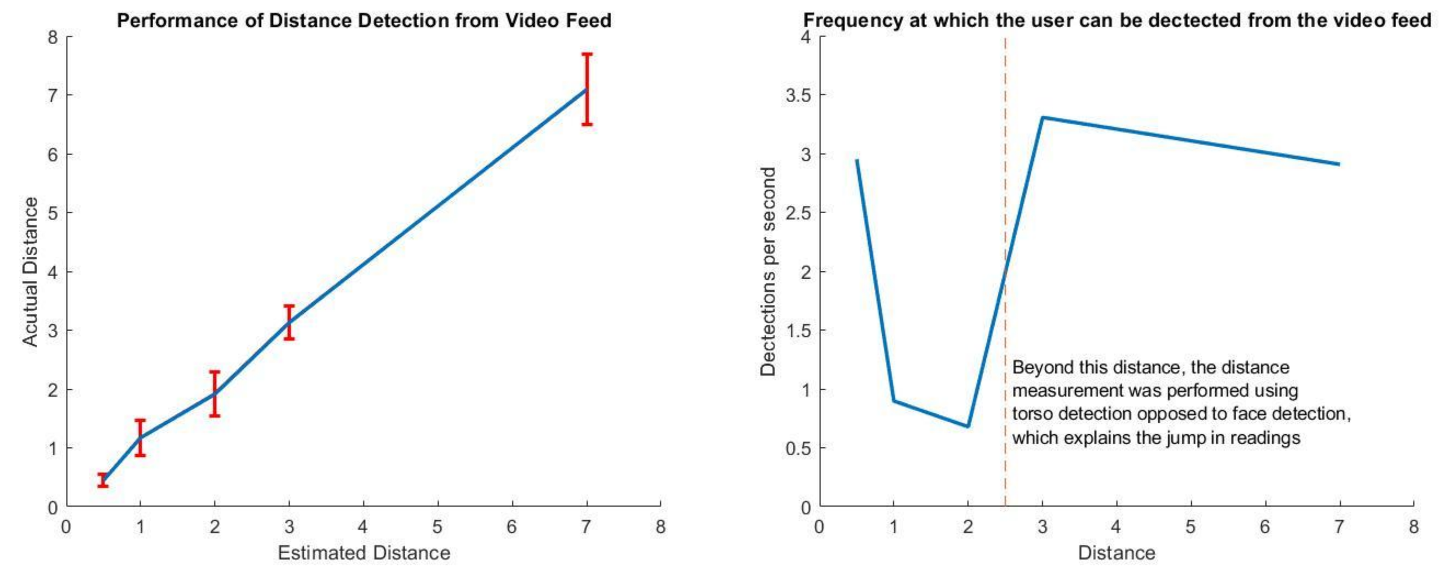
Functional Test Result

<u>Touri passes all the functional test criteria below:</u>

- **Movement: Touri is** able to follow a curved line for 10 m.
- **Autonomous: Touri** is solely powered by the onboard battery and can run without manual control.
- **Runtime Limit:** Touri is able to run autonomously for 25 mins for every new set of 9V batteries.
- **Environment Detection: Touri is** able to detect the line it is following, objects in the path, as well as the user following the robot.
- **Audio input:** Touri is able to connect with external headset via bluetooth 3.0, and receive voice commands and make movements based on the command (such as "start", "stop", and "wait").
- **Exhibit Detection:** Touri is able to detect dots on the line (indicating an exhibit nearby), it is able to make a stop, display audio clip, and move on to the next dot.
- **Audio output:** when Touri stops at an exhibit, it displays the correct audio file to bluetooth. This is hard coded in the logic, because audio files needs to be manually downloaded.
- **Budget:** the total cost of the project in $234 CAD (under budget).

User Detection Test Result

Figure 3: User detection test result



We also did specific tests for the hard to verify criterias, such as user distance detection in OpenCV.

In the this test, we had 3 main focuses:

- Ability to accurately measure distance between user and Touri.
- Frequency which a user can be detected in the video feed.
- Ability to frequently detect the user in an image, while minimizing false positives.

After testing for 400 images, the algorithm successfully detected the user 278 times, or a 69.5% detection rate, with 2.5% false negative rate. This means with 10 image per second, Touri can detect the user with less than 40 people pass close by. We deemed this test passed based on Touri's design requirement.

Summary

- Our project came about from a basic idea: we wanted to make museums to be more accessible and enjoyable for the general public.
- We laid out the goals and requirements for the project in our proposal. Now, having a look at the progress we have made, considering the circumstances, I would say that we have met the majority of our goals and requirements.
- Overall, all of us have enjoyed the experience of working on the project. We have learned many new skills - both technical and non-technical. There were hiccups along the way, but we did our best to work around them and still try to meet the requirements.
- However, work is not finished yet. Touri, with its current functionality, can be used as a proof of concept. In the future, Touri could have better navigation functionality.

Acknowledgements

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