Indoor Navigation System using Optical Mouse Sensor and Smartphone

Department of Computer Science and Engineering,
Indian Institute of Technology, Kanpur - India

Outline

- Background
- Existing Work
- Challenges
- Our Aim
- Our Idea
- Implementation
- Results
- Further Work

Background

- Indoor Navigation Systems:
  - To provide navigational support to users or automated systems in indoor environments based upon the real-time position coordinates
  - Have applications in tracking trolleys in warehouses, finding medical equipment in hospitals, providing navigational support in shopping malls or airports or to the visually impaired people
  - Desired accuracy from the underlying positioning system is very high in indoor environments (unlike outdoor environments where a few meters of accuracy is usually fine)

Background (…cntd)

- Two common approaches for indoor positioning :
  - **"Absolute" Localization**: Finding the current position based upon triangulation techniques usually through an infrastructure setup involving sensors (IR/RF/Optical/Acoustic/EM, etc.) being placed at different points throughout the building
  - **"Displacement-based" Localization:** Finding the current position through computation of displacement from a given starting point in the building, common systems involve wireless kits consisting of sensors (IMU-based/gyro-sensors, etc.)
- Both approaches have their own trade-offs and find application in different problems being handled

Existing Technology

- **Common positioning systems:**
  - **Wi-fi Triangulation based positioning systems**
    - **Pros:** Can be built on top of existing wi-fi infrastructure in some buildings
    - **Cons:** Not all the places have enough access points, also the error incurred is pretty high (of the order of few meters)
  - **Magnetic fingerprint based positioning systems**
    - **Pros:** Usually no extra infrastructure setup is needed
    - **Cons:** The magnetic fingerprints of rooms may be variable, accuracy is not good enough
  - **Other Systems:**
    - Usually have either higher setup costs or lower accuracies

Challenges

- Cost vs. Accuracy Tradeoff:
  - Infrastructure based positioning systems usually provide higher accuracies but have higher setup costs
  - Cheaper navigational-kits based positioning systems usually have lower accuracies
  - Need for a system which is both cheaper and highly accurate
- Portability:
  - Most systems are highly coupled with the infrastructure/building
  - Need for a system which is easy to be ported to different buildings with ease or which does not require special catering in newer environments

Our Aim

- Through our approach, we aim to tackle the problem of providing navigational assistance to individuals through a cost-effective wireless positioning kit and a smartphone

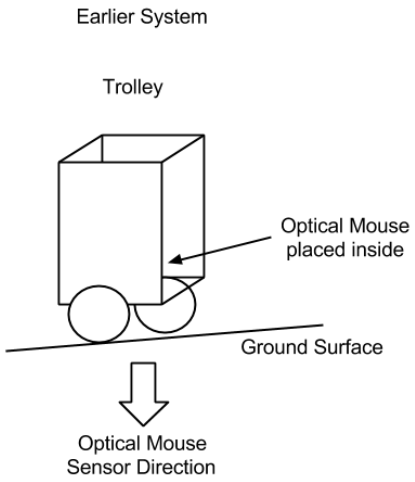
- The positioning kit is intended to be attached to a trolley (in case of shopping malls, airports, hospital equipment, etc.) or to a cane (in case of visually impaired people) for finding the displacement, which is then wirelessly conveyed to the smartphone

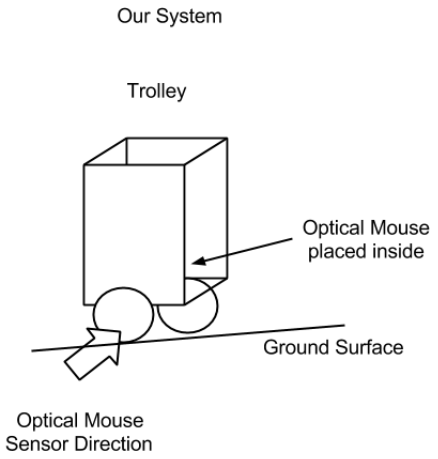
Our Idea

- Optical mouse sensors are known to be highly precise
- In our system, the optical mouse sensors point to the wheels of the navigational kit (which is attached to trolley or cane), and this motion data is then transferred digitally to the smartphone via Bluetooth connection
- The displacement data is then combined with the initially known starting point and used to give relevant navigational instructions based upon current position on the map on smartphone

Our Idea (..cntd)

- Earlier optical sensor based systems have multiple limitations, which we have taken care of, in our prototype:
  - **Surface-type dependence**: In our prototype, the optical sensor points towards the wheels (or a disc which is connected to the wheels), unlike the previous work where it points to towards ground
  - **Speed Limitation:** Optical mouse sensors can work at speeds lower than 1-2 m/s, however, using a system of gears, the motion of the wheels can be transmitted to optical sensor at lower speeds
  - **Fixed distance from the ground surface:** The previous works had to put the optical sensor at a fixed height from the ground with proper illumination, however, in our design, the optical sensor can be placed at higher heights provided the motion of wheels is properly transferred

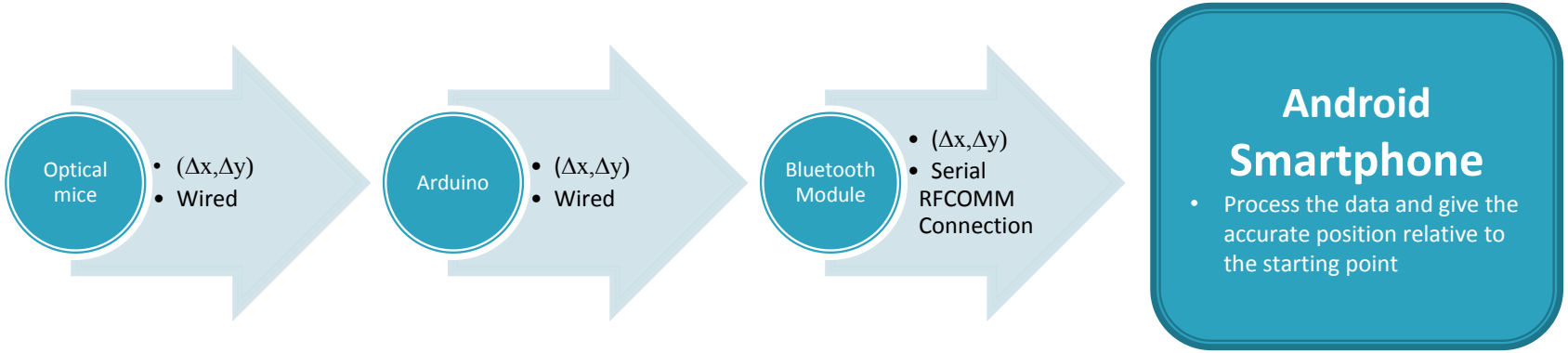




Implementation

- Typical Optical Mouse have a low quality camera which captures images very frequently which are then processed through digital signal processing to give a measure of movement precisely
- We have used Optical Sensor ADNS2610 which transfers data at 38400 baud rate.
- This sensor send the displacement from the starting point to the Arduino UNO which is further connected with a bluetooth module HC-05.
- This data is sent to the smartphone using Arduino and Bluetooth module serially over RFCOMM circuit
- Data is interpreted by an application “ArduBlueMouse” in the smartphone and given a map and a starting point on the phone, it is able to locate the position of the user precisely
- Using A* algorithm, the system determines the path of movement from the current position to selected target position.

Implementation (..cntd)



Application

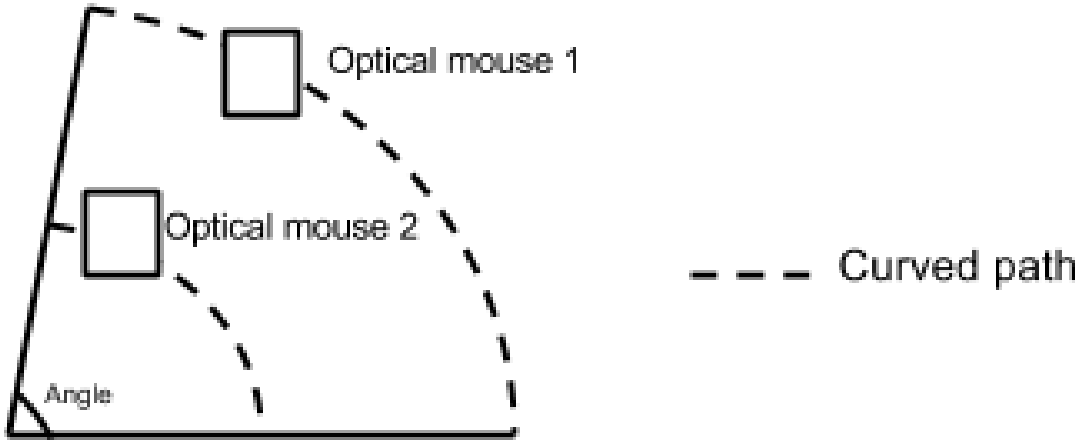
- Tracking trolleys carts inside store, bus and train terminals, public offices, hospitals, educational buildings, and shopping malls.
- Indoor navigational support for visually impaired person
- Helping in indoor movements in shopping malls, museums, airports construction sites
- Analyze user’s behavior. The device can be attached with a shopping cart so as track the places where the customers spend most of the time around a shopping mall. So, the information can be used to improve customer’s experience in a modern shopping mall.

Result

- With our prototype of the system, we were able to get on an average error less than 2% in terms of distance moved.
- The innovative design of our "*Navigational Kit*" makes our system surface-type independent as well as overcome the keeping-in-contact limitation of an optical mouse. (Overcoming the shortcoming of surface-type dependence of an optical sensor).
- Our indoor positioning system is cheaper than most currently available systems and has hardly any setup costs.
- The system is easily deployable thus reducing the installation cost.

Further Work

- The direction determination can be improved by use of two optical mice instead of one



Thank You!