Smart Robot Walker : Key features

Social Relevance

- Help people with cognitive impairments and walking disabilities live an independent life and guide them to their destination.

What does it do?

- Front following robot to help crossing roads(Outdoor), navigate in shopping malls(indoor), help identify restrooms and warn potential hazards.
- It should be able to move autonomously but when given user input it should replan its path.`

Feedback

- Give haptic feedback to the user if they are navigating in the wrong direction. If they still tend to deviate from the path, replan a new path to safely reach the destination.

Additional Features

- While crossing the road, robot should communicate with the traffic lights to keep the light red ensuring safety and hassle free road crossing experience.

Power and Cost

Robot Weight: ~30 Kg (including 2 motors and batteries)

Cost :

Input weight: 50 to75 Kg (100% user weight)

Operation Time: 300 min (80% efficiency)

Maximum Velocity: 0.8 m/s

Maximum Inclination: 10 degrees

Battery: 12V 44Ah (~10kg)

Cost : 140 USD

Motor Rating: Dayton Model 52JE52 DC Gear Motor 17 RPM 5nm 12V Cost : 180 USD (2 units) (~ 2kg)

Processor: Intel NUC 7 Essential Kit. 12V, 40W

Total cost of the Robot: ~2000 USD (including frame)

- Sensor power consumption:

Sensor Type	Size (cm^3)	Weight (g)	Power (W)	Voltage (V)	Current (mA)	Cost (USD)
GPS (ublox M10)	0.3	5	0.1	+1.8 to +5.5V	10	21
IMU (VN-100 SMD)	10.7	15	0.2	+3.2 to +5.5V	40	540
LIDAR (RPLidar 30M range)	230	190	2	5V	40	350
Camera (Intel Real sense D455)	93.5	20	3.5	+0.9 to 3.3V	700	400
Pressure sensor	0.49	8	5	5	1000	40
Total	**334.5**	**320**	**5.8**	**5V**	**1790**	**1351**

Sensing & Hardware

- Overview:
  - The platform is equipped with a sensing network that enables the walker to perceive and navigate in indoors and outdoor environment. Sensing the status of the walker and the user are crucial for intelligent control to ensure user's safety and maximize system performance. This requires equipped sensors to achieve precision, timeliness, and robustness when dealing with various situations.
  - All the sensors should be placed
- Positioning:
  - Use IMU data, fuse it with GPS dead reckoning to precisely determine the position with higher precision. Inertial measurement units (IMUs) typically combine multiple accelerometers and gyroscopes and magnetometers. Instantaneous pose (position and orientation) of the robot, velocity (linear, angular), acceleration (linear, angular) and other parameters are obtained through the IMU in 3D space.
- Mapping:
  - Use LIDAR and cameras to localize the robot in GPS denied environments. Using Computer vision and deep learning on the sensor data to aid object detection, tracking and avoidance. We can use visual SLAM in indoor and outdoor environments where lightening conditions are reasonable and can be maintained.
- Fusion:
  - All the above sensors are used to create a multi-modal sensing network. Using Extended Kalman Filters to estimate the state of the robot much more accurately.

NAVIGATION

- The robot should be able to localize and map the environment using visual SLAM while taking inputs from the human leg movement and steering angle and predict the next steps.
- Using Reinforcement learning to navigate from the user based inputs from the pressure sensor. We will reward the model for each correct decision and punish for each wrong decision. This allows the user to navigate dynamically and will have the control over the robot while it replans its path to reach the final goal.
- The walker should be able to navigate through the confined spaces by achieving very small turning radius. (use omni-wheels).
- While navigating the robot is able to communicate to the traffic lights through infrared keeping them red until the user finishes crossing road.
- Since most of the intersections have cameras installed, we can send signal to those traffic lights via these cameras and maintain the light red
- Since the robot is equipped with stereo cameras, it will be able to detect pedestrians/oncoming traffic and warn the user through haptic vibration feedback.
- Since the wheels are motor controlled, if the user tends to fall, a controller will prevent the wheels from any sudden jerks and remain stationary for user's safety.
- To further increase safety, a brake mechanism that can respond to emergency in a timely manner is to be implemented.

Additional thoughts

- We can also implement voice control through acoustic sensors to make it voice enabled.
- When the robot is in a different room and is voice activated, we can summon the robot to immediately come to the elderly to help him travel.
- To robot can also predict fall detection using another camera facing the user and position itself to protect the user.
- Despite the existing walkers owned by people with walking disabilities, 33% of people over 60 years fell at least once. So, it is essential to integrate intelligence into the robot walker
- We can integrate an iPad for the user to interface with the robot in a more interactive way and track his motion and control the robot path.
- All the numbers mentioned like walking speed, weight etc., are from actual studies for elderly people with waking disabilities.