DESIGN AND MANUFACTURING OF A DRIVERLESS CART

Pooja Shevade[1], Poorva Wanpal[2], Prerana Sethiya[3], Shounak Joshi[4]

[1] Mechanical Department, Maharashtra Institute of Technology, Pune, Maharashtra, India
[2] Mechanical Department, Maharashtra Institute of Technology, Pune, Maharashtra, India
[3] Mechanical Department, Maharashtra Institute of Technology, Pune, Maharashtra, India
[4] Mechanical Department, Maharashtra Institute of Technology, Pune, Maharashtra, India

ABSTRACT

The objective is to design and manufacture a robotic cart having an ability of user recognition (voice and gesture), capable of accompanying a person wherever he/she moves. It can be used in hospitality purpose for carrying luggage as well as in shopping malls. The robot should maneuver in any possible direction and be capable of taking 20 kg load without failure. The major design aspects of this model are the mechanical frame, steering mechanism, user recognition / sensing device, electronic interface between the software input and actual mechanical output. Microsoft Kinect, launched in November 2011 for the Xbox 360 gaming console, a motion sensing input device capable of tracking the user and taking audio data is used. The capability of the Kinect sensor to detect joints of the human body can be utilized to track a human being and follow him. Arduino Uno, an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board is used to control and steer the cart in desired direction by giving differential input to the rear wheels through motors. L298 motor driver is used as an intermediate device between the microcontroller, power supply or batteries, and the motors to cater for different current requirements. To provide high strength and rigidity to the cart, high grade aluminium base and wheels are being used. For the robot to be used in different scenarios as an autonomous companion, the main aim is recognizing and tracking a human target while avoiding obstacles. A system capable of doing this efficiently and the accurate movement of the robot is the focus of this study.

Keyword: - *Maneuver, Steering Mechanism, Microcontroller, Motor Driver, Kinect, Autonomous Companion.*

Introduction

'Rachkham' developed by Clodic et al [1] is an interactive robotic tour guide developed based on visual human robot interaction. Kirby et al [2] designed 'Grace' in 2007 to accompany a person side-by-side and engage him like a human would do, while maintaining a minimum space between the human and robot. A laser based tracking method was implemented in using direction following and path following. If the user goes out of the sensor range, it was informed by the robot. But it was found that the robot responds only to the person's speed and location, ignoring aspects such as the person's identity or personality, spoken or gestured commands from the person. 'Minerva' is tour guide robot developed by Thrun et al [3] to escort visitors in the Smithsonian Museum of American History. Johnny developed in 2012 by Breuer et al [4], based on the RoboCup@Home challenge [5], was designed to serve in a restaurant-like environment, where it received seat reservations, waited on guests, and delivered orders to them. Another wellknown service robot is 'BIRON', developed in 2004 by Haasch et al. [6], and designed to actively interact with its user by means of natural user interface. MKR is an omni-directional mobile transfer robot system, developed in 2010 by Takahashi et al [7], for hospital applications. Using virtual potential field methods, the robot could transfer luggage, specimens and other important materials to its goal avoiding obstacles in the path.

1. Problem Specifications:

Our objective is to design and manufacture a robotic companion, with ability of user voice and gesture recognition, capable of accompanying a person wherever he/she moves, avoiding all obstacles hindering its path.
It can be used in hospitality purpose for carrying luggage as well as in shopping mall to carry goods and then follow a person wherever he/she walks.
The basic idea was to design a robot which will fulfill all the requirements which were needed for its efficient working. The requirements were as follows:
1. It should be able to maneuver in any possible direction.
2. It should be capable of taking 20 kg load without failure.

2. Mechanical Design of a Robotic Cart:

Constraints:

1. Load: 20kg
2. Speed: 100rpm
3. Dimensions: 800mm * 550mm * 1100mm (L*B*H)
4. Weight limit: 10kg
5. Ground clearance: 60 mm

3. Electronics Involved:

Sensor: Kinect X-Box 360
Microcontroller board: Arduino Uno
Motor driver: L298 dual Full-bridge
Motors: 100rpm, 12V Bi-directional DC Motors (2 nos), Make: Johnson.

3.1. Process Flow:

Kinect – Laptop – Arduino – Motor Driver - Motor

4. Manufacturing:

4.1 Prototype 1:

According to our requirements we bought the material and the instruments that were needed.
Material procurement mainly consisted of:

1. Box sections of 19×19 mm
2. Nuts and bolts of size: 4, 5, 6 mm respectively
3. Flexible plastic sheet
4. Rubber wheels of 100 mm diameter
5. 4 motors of rating speed 100rpm
6. Instruments: Drilling machine, Hacksaw, Plyer

Structure was designed and manufactured for required size of 800×550mm by cutting the box sections into required size and then joining them using nut bolts and L-brackets.
Now the motor was assembled with the structure using the motor fixture and then the wheels were placed on the motor shaft using the grub.
A vertical stand was also made for placing the Kinect.

Limitations of prototype 1:

1. It is difficult to drive a 4 motor structure because of continuous and simultaneous control of each motor.
2. Maintaining 4 point contact on the surface was difficult.
3. The Kinect stand was too long and hence the vibrations in the stand during motion were amplified due to lack of support.
4. The plastic sheet used was bending under the load and needed to be changed.
5. Rubber wheels were not of enough strength to take the load on the cart and hence wheels of greater material strength are required.

4.2 Prototype 2:

Considering the drawbacks of the first model the required changes are made to strengthen the design.

- The front wheels were removed and replaced with a single castor.
- The rear wheels (polymer) were replaced by aluminium wheels. These were initially designed and then manufactured on the lathe machine.
- The flexible plastic plate was replaced by a harder stronger and more rigid acrylic plate of size 550×800 and then was assembled using nut-bolts.
- A slant supporting structure was provided to Kinect stand to reduce its vibrations while in motion.

4.3 Transition from manual to automatic:

- We manually simulated the cart to check its motion through a given path, to check its maneuvering capabilities and its radius of curvature.
- Then we simulated using toggle switches, switching circuit and battery (12V DC) to drive the motors to move the cart, to make it semi-automatic.
- To make the cart completely automatic and self-intelligent we replaced the toggle switches and the circuitry by: Arduino board, motor driver and Kinect which were controlled by computer programming.
- Hence the cart is fully automated and can perform its function without human interference.

Fig: 1 (a)

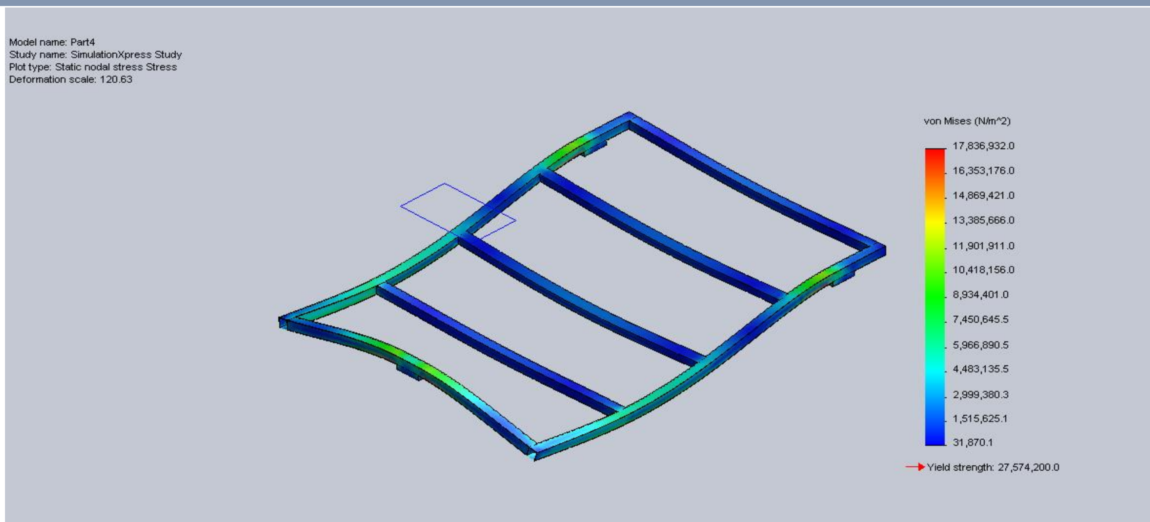
Fig: 1 (b)

Transition from Manual to Automatic Cart

5. Strength Analysis of Cart Base:

Table 1: Stress Analysis

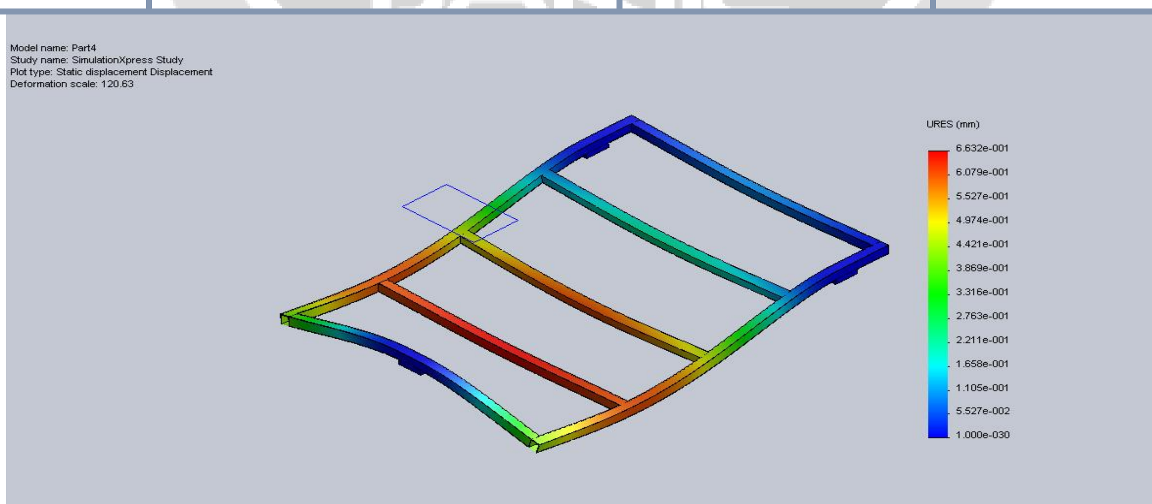
Name	Type	Min	Max
Stress	VON: von Mises Stress	31870.1 N/m^2 Node: 13263	1.78369e+007 N/m^2 Node: 1700



Cart-SimulationXpress Study-Stress-Stress

Table 2: Displacement Analysis

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0 mm Node: 608	0.663194 mm Node: 18234



Cart-SimulationXpress Study-Displacement-Displacement

6. Conclusions:

For the robot to be used in different scenarios as an autonomous companion, the main aim is recognizing and tracking a human target using avoiding obstacles. The problems that have to be tackled are:

- Identifying a certain person and tracking only the identified person.
- The robot should be capable of understanding the commands of the user
- Once a user is identified, the robot should only follow the commands given by the primary user.
- The robot should be able to communicate with the user.
- Human target tracking while keeping a minimum distance to the target
- While following it should be able to detect any obstacle which may obstruct its path.
- Once an obstacle is detected, the robot should stop moving and then move again avoiding the obstacle.

For meeting these objectives, different mechanisms were explored. The Microsoft Kinect sensor is the best solution for this scenario. It helps to track the human and at the same time, the robot can follow the user avoiding obstacle.

7. Acknowledgement:

We thank Prof. Dr. Sandip T. Chavan for his valuable support and helping us throughout our project with his expert opinion and guidance.

8. References:

1. Aurélie Clodic , Sara Fleury , Rachid Alami , Raja Chatila , Gérard Bailly , Ludovic Brèthes , Maxime Cottret , Patrick Danès , Xavier Dollat , Frédéric Eliseï , Isabelle Ferrané , Matthieu Herrb , Guillaume Infantes , Christian Lemaire , Frédéric Lerasle , Jérôme Manhes , Patrick Marcoul , Paulo Menezes , Université Paul Sabatier, "Rackham: An Interactive Robot-Guide," In Robot And Human Interactive Communication, 2006. Roman 2006
2. R. Kirby, J. Forlizzi, and R. Simmons, "Natural person-following behavior for social robots," in Proceedings of HumanRobot Interaction, March 2007, pp.17–24.
3. S. Thrun, M. Beetz, M. Bennewitz, W. Burgard, A. Cremers, F. Dellaert, D. Fox, D. H¨ahnel, C. Rosenberg, N. Roy, J. Schulte, and D. Schulz, "Probabilistic algorithms and the interactive museum tour-guide robot Minerva," International Journal of Robotics Research, vol. 19, no. 11, pp. 972–999, 2000.
4. T. Breuer, G. Giorgana Macedo, R. Hartanto, N. Hochgeschwender, D. Holz, F. Hegger, Z. Jin, C. Mller, J. Paulus, M. Reckhaus, J. lvarez Ruiz, P. Plger, and G. Kraetzschmar, "Johnny: An autonomous service robot for domestic environments," Journal of Intelligent and Robotic Systems, vol. 66, no. 1-2, pp.245–272, 2012.
5. T. Wisspeintner, T. van der Zant, L. Iocchi, and S. Schiffer, "RoboCup@Home: Scientific competition and benchmarking for domestic service robots," Interaction Studies, vol. 10, no. 3, pp. 393–428, 2009.
6. A. Haasch, S. Hohenner, S. Huwel, M. Kleinehagenbrock, S. Lang, I. Toptsis, G. A. Fink, J. Fritsch, B. Wrede, and G. Sagerer, "Biron - the bielefeld robot companion," in Proc. Int. Workshop on Advances in Service Robotics, 2004, pp. 27–32.
7. M. Takahashi, T. Suzuki, H. Shitamoto, T. Moriguchi, and K. Yoshida, "Developing a mobile robot for transport applications in the hospital domain," Robotics and Autonomous Systems, vol. 58, no. 7, pp. 889–899, Jul. 2010.