# CSE 316

A Report On

# ATMega32 Based Micro-controller Project

**Project Title**

Smart Cart: An ATMega32 Based Autonomous Follower Robot


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# 1 Introduction

In this era of modernization, technology has easily grasped our lives from every end. We are surrounded by tech innovations so much that we use them instinctively now-a-days. In every aspect of our lives we can find reliance on well made innovations, which make our lives easier and allow us to focus on more important tasks. Though we might think that there is not much to innovate, everyday thousands of new ideas are found that help us be more seamlined with our lives and unlock more potential from us.

Human physical labor has always been an inefficient way to achieve some physical chore. Humans cannot do repetitive jobs with perfect accuracy every time. Humans were not made for accuracy. But we're smart enough to build precise and useful tools that can do our chores for us. And in this era of automation, this fact has become widely accepted to all. For example, all large production factories are now automated, which means they are run by precise machines, and only a few human engineers to monitor them.

Automation is reaching our daily lives too, and it's just a matter of time when most of the things around us will be automated. For which, smart innovations need to be made.

Let us introduce our project idea. We attempted to make an automated cart, which automatically follows a specific person and avoids any obstacles. Since carts are a really basic and old tool to humans, automating it would really decrease a lot of manual effort.

# 2 Description

## 2.1 The Plan

Since we are creating a smart cart, we need to decide what it does and how it will work. Also we need to set goals for our smart cart. What dimensions should the cart have? Should it be 2-wheel drive or 4-wheel drive? How would it react to certain scenarios? What should it do? So, here are a list of features we want our smart cart to at least have:

- **The cart should follow a specific point of interest.** The point of interest could be a human/another cart/a fixed destination point etc. We have, for now, decided to make it follow a moving object that would simulate a human's movements.

- **It should have some sort of collision prevention.** Since our point of interest is moving, there could be a point in the travel period of the cart that it detects an obstruction, e.g. another human, a wall, a box, etc. in its path. It needs to detect it and avoid collision.

- **It should be remotely controlled.** To know how far a cart is from the human. Or to know how much it is carrying. Also, it should have remote start/stop. Since, the cart should not follow everywhere. There might be certain scenarios where the user might want to park it. Also, the user might want manual control on the cart.

- **The items carried might need to be measured/tended to.** The cart might carry sensitive items which might need special treatment. For example, a cart carrying vaccines that need to be kept at a certain temperature might need to have auto temperature control mechanism, etc.

## 2.2 Implementation Ideas

Initially there were a lot of ideas/concerns raised which we tried to address by modifying our plan/scope a bit. Some concerns we faced were:

- Following a specific point could be done by blindly following an object which enters the cart's vision. But, following a specific person may require complex face detection algorithm/precise geo-location to the scale of centimeters, for which implementation skills/modules were still not available.
- Addressing the last point of the previous sub section, implementing freezing/air conditioning would be costly and would require a lot of effort which would be out of the scope of this project. Thus, a simple fan was used as place holder.

## 2.3 The Final Implementation

Finally, after addressing the concerns/shortcomings, we agreed upon a final idea. We discuss each aspect of the implementation plan paired with the components that would be required in that part.

- **Car Movement:** The car will have four wheel drive and it will move forward, backward, left and right.
  - *Components*: Arduino UNO R3, L293D Motor Driver Shield.
- **Sensing Holder Arm:** There will be a rotating bay on the cart which can rotate 180 degrees and it will house all the distance sensors. This movement will ensure we have enough range around the cart.
  - *Components*: Sonar Sensor, IR sensor.
- **Remote Controller:** This will be a seperate part of the cart which the user will carry in his hands. This is the control station for the cart, and the user can send commands to the cart, change mode, manual control etc. This will be made with a micro-controller and some buttons etc.
  - *Components*: ATMega32, SPST push buttons, gyroscope, 16x2 LCD.
- **Cart Basket:** The cart's basket may have additional components inside it to maintain and control the items that it will carry. This can also be done by use of micro-controllers and required modules. We have planned to implement weight measurement, temperature measurement and climate control, hazard alarm etc.
  - *Components*: ATMega32, Load Cell, HX711 ADC, Temperature Sensor, Buzzer, DC Fan.

# 3 Components Used

In this section, we provide the list of components we've finally used, short description of each component, and the use cases in our scenario. This section will be helpful for understanding of the internal working of our project, and will also be helpful to understand the circuit diagram later.

## 3.1 ATMega32

Figure 1: ATMega32.

- **Description:** The Atmel AVR ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture.
- **Uses in our Project:**
  - Used in the cart for cart climate control, weight measurement and alarm system.

## 3.2 Arduino UNO R3

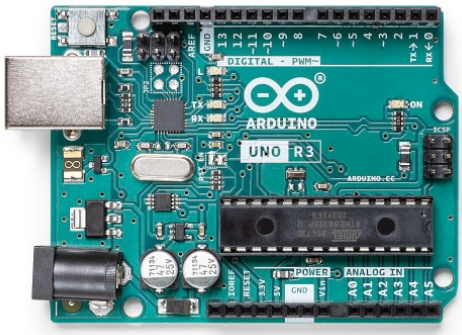


Figure 2: Arduino UNO R3.

- **Description:** Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller
- **Uses in our Project:**
  - Used in the cart to control the motor driver, Sonar and IR sensors and the servo motor.

## 3.3 L293D Motor Driver Shield

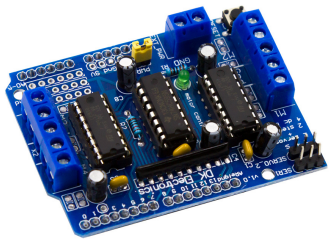

Figure 3: Arduino UNO compatible L293D Motor Driver Shield.

- **Description:** The L293D is a dual-channel H-Bridge motor driver capable of driving a pair of DC motors or single stepper motor. As the shield comes with two L293D motor driver chipsets, that means it can individually drive up to four DC motors making it ideal for building four-wheel robot platforms. The shield also comes with a 74HC595 shift register that extends 4 digital pins of the Arduino to the 8 direction control pins of two L293D chips.
- **Uses in our Project:**
  - Used for driving 4 TT Motors and 1 Servo motor in the cart.

## 3.4 HC-SR04 Ultrasonic/Sonar Sensor

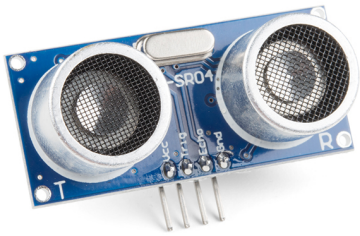

Figure 4: HC-SR04 Ultrasonic/Sonar Sensor.

- **Description:** the HC-SR04 is an ultrasonic distance sensor. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit.
- **Uses in our Project:**
  - Used in the cart for distance measurement. Housed on a rotating shaft to get range up to 180 degrees around the cart.

## 3.5 Infrared (IR) Sensor

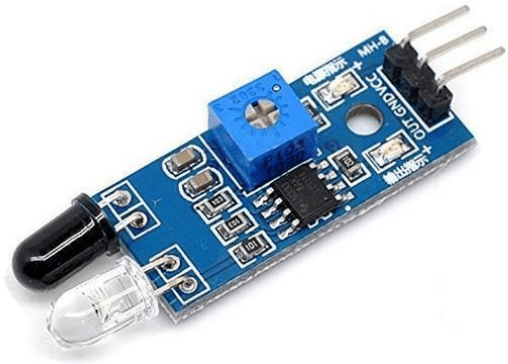

Figure 5: Infrared (IR) Sensor.

- **Description:** An infrared sensor (IR sensor) is a radiation-sensitive opto-electronic component with a spectral sensitivity in the infrared wavelength range 780 nm to 50 µm. In a defined angle range, the sensor elements detect the heat radiation (infrared radiation) that changes over time and space due to the movement of people.
- **Uses in our Project:**
  - Used in the cart for movement detection and position determining of the user. Housed on a rotating shaft to get range up to 180 degrees around the cart.

## 3.6 Load Cell

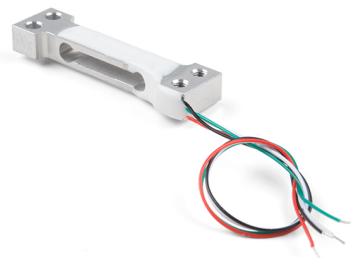

Figure 6: Load Cell.

- **Description:** This miniature straight bar load cell (sometimes called a strain gauge) can translate up to 100g of pressure (force) into an electrical signal. Each load cell is able to measure the electrical resistance that changes in response to, and proportional of, the strain (e.g. pressure or force) applied to the bar.
- **Uses in our Project:**
  - Used under the cart's cage to measure weight of the products carried.

## 3.7 LM35 Temperature Sensor

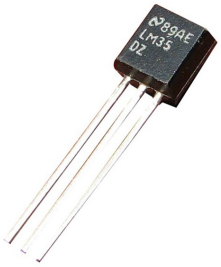


Figure 7: LM35 Temperature Sensor.

- **Description:** LM35 is a temperature measuring device having an analog output voltage proportional to the temperature. It provides output voltage in Centigrade (Celsius). It does not require any external calibration circuitry. The sensitivity of LM35 is 10 mV/degree Celsius. As temperature increases, output voltage also increases.
- **Uses in our Project:**
  - Used in the cart to measure temperature of surrounding. Data used for climate control.

## 3.8 Load Cell Amplifier

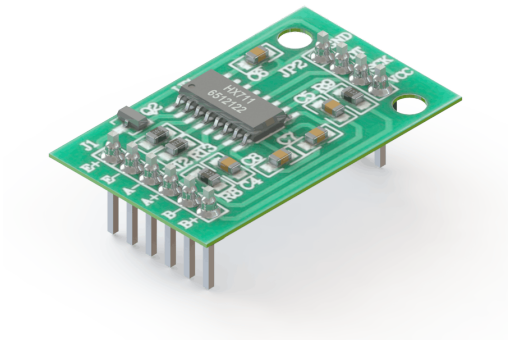

Figure 8: Load Cell Amplifier containing HX711 24 bit ADC IC.

- **Description:** Load Cell Amplifier is a small breakout board for the HX711 IC (24 bit ADC) that allows to easily read load cells to measure weight. By connecting the amplifier to the microcontroller the changes in the resistance of the load cell can be read, and with some calibration very accurate weight measurements can be carried out.
- **Uses in our Project:**
  - Used with the load cell for converting minuscule load cell output voltage to perceivable output to be fed to the microcontroller.

## 3.9 16x2 LCD Display

Figure 9: 16x2 LCD Display.

- **Description:** An LCD screen is an electronic display module that uses liquid crystal to produce a visible image. The 16×2 translates o a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7 pixel matrix.
- **Uses in our Project:**
  - Used with the cart's cage to show additional info e.g. weight, temperature, fan status.

## 3.10 12V Brushless DC Fan

Figure 10: 12V Brushless DC Fan.

- **Description:** A 3" brushless DC fan used with a DC power source.
- **Uses in our Project:**
  - Used with the cart's cage for climate control.

### 3.11 Servo Motor

Figure 11: Servo Motor.

- **Description:** A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.
- **Uses in our Project:**
  - Used with the cart's rotating shaft for rotating it from 0 degrees to 180 degrees.

### 3.12 Other Components

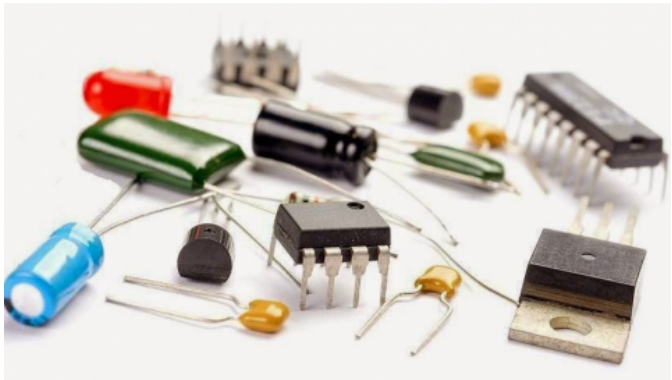

Figure 12: Some Passive Circuit Components.

- **Items Used:** SPST Switches, Resistors, Capacitors, Inductors, Potentiometer, Jumper wires, 3.7V Batteries, Battery Holder, TT Motors, Rubber Tires, Car Structure etc.

## 4 Circuit Diagram

Our project has two separate circuits working with harmony with each other. Both of the circuits reside in the moving cart. In the following sub-sections, the circuits with short description is provided.

## 4.1 Arduino Circuitry (Cart Driver Module)

*Arduino* is the main micro-processor used for this circuit. The arduino, interfaced with the *motor driver shield*, runs 4 *TT motors*, 1 *servo motor*, 1 *sonar sensor* and 2 *Infrared sensors*. 4 *rubber tires* are connected with the TT motors, enabling 4 wheel drive. Also, 3 *3.7V AA batteries* were connected to this circuit giving it mobile power unit. The servo motor is connected with a *moving shaft*, which houses the sonar and IR sensors. Thus, the car gets a range of vision. The figure given below illustrates the circuit described.

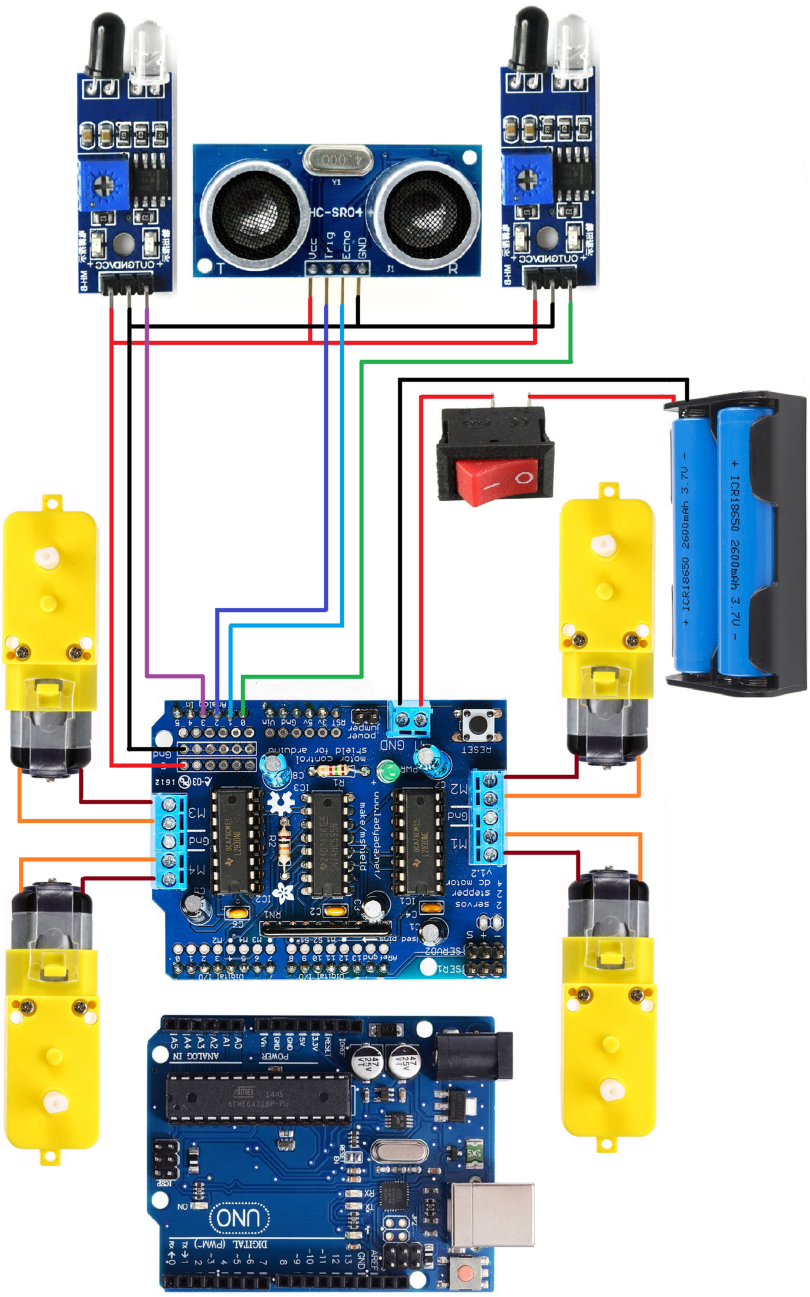


Figure 13: Cart circuit with Arduino UNO R3 as microprocessor.

## 4.2 ATMega32 Circuitry (Cart Cage Module)

*ATMega32* is the main micro-processor used for this circuit. It is interfaced with 3 distinct sections - the weight measurement section, the climate control section & the display. Each part works as follows:

1. **Weight Measurement:** This module consists of *100 grams load cell* & a *HX711 based load cell amplifier*. The amplifier is just a 24 bit ADC (Analog to Digital converter) and it takes the load cell's minuscule voltage and converts it to perceivable voltage fed to the ATMega32.

2. **Climate Control:** This module consists of a *LM35 temperature sensor*, a *12V DC fan*, a *NPN Transistor*. If the temperature $\geq$ 25 degrees, then the fan turns on.

3. **Display:** A *16x2 LCD Display* module is used for displaying the weight being carried, surrounding temperature, and fan state (fan on/off).

The circuit diagram given below illustrates the circuit in detail.

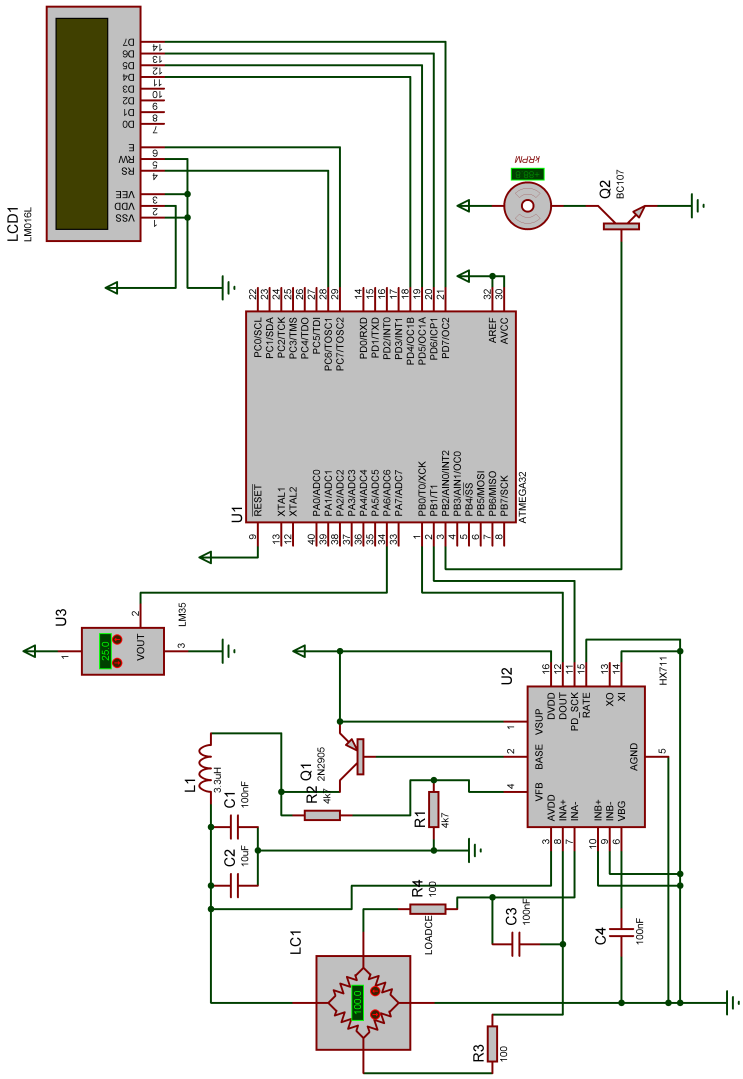


Figure 14: Cage circuit with ATMega32 as microprocessor.

# 5 Difficulties Faced

Since this was our first time working with any micro controller hands on, there was a steep learning curve. Formulating an idea and finally implementing it by one's own hands is a really rewarding experience. But the path was not so easy. So, a lot of experiences were gathered. Here, we are mentioning a few of them and solutions we've found to be working for each case.

1. **Soldering.** Without proper soldering, many components cannot be interfaced with the microprocessor, since many components come without pre-soldering.

   - *Solution* - Buy pre-soldered components / learn soldering, since it is a useful skill. Always give more solder than necessary. And the hotter the soldering iron the better.

2. **Buying Components.** There are variety of models for the same component, and it may seem daunting which one to buy.

   - *Solution* - Do thorough research which components you're going to buy. And if there are multiple options available, always buy the component with more price, as they'll likely provide better performance and be easier to work with. Also, try to buy extra components.

3. **Wireless Communication.** Wireless communication might always not work seamlessly/as expected. Something that works in simulation might not work in real life.

   - *Solution* - Add antennas to cheaper modules which don't come with pre-soldered antennas. Also, add dummy delays in software side for things to work, as real life environments have noise.

4. **ATMega32 Clock Speeds.** Clock speeds are useful for fast working.

   - *Solution* - Learn about fuse bits and use necessary clock speed as required.

5. **Burning program to MCU.** Sometimes burning code to a fully connected circuit may cause errors and the program may not run as expected.

   - *Solution* - Disconnect components that require separate power sources to run from the MCU before burning it. E.g. servo motors, motor driver, LCD screen.

6. **Simulation.** Without simulating beforehand, a circuit may be really hard to debug in real life. Also, it may lead to damage of components.

   - *Solution* - Always test your circuit in simulation beforehand. This step reduces a lot of debugging and time required for implementation.

7. **Capacitors.** Many a times noise might get introduced to the circuit because of not having ideal conditions.

   - *Solution* - Use small capacitors e.g. 100nf, 22nf etc in power lines, wires as needed. These help reduce noise in the circuit.

8. **Connecting Power.** Connecting wrong power source and higher voltage power sources may ruin a component.

- *Solution* - Research thoroughly the maximum voltage a component can handle. E.g. an LED can handle 2-3 volts maximum. Connecting more voltage may burn it. So, use resistors to connect it to the power source.

9. **COVID.** Due to *covid situation* and lack of planning, we faced a lot of issues. Two of our teammates were sick during the time, and due to lock-down we couldn't collect necessary components. So, we had to switch some of our work to software simulation later on. *We just hope the situation improves for every one and no one has to face such saddening moment in their lives.*

# 6 Conclusion

Working hands on on a hardware project was a good opportunity to explore a lot about real life implementations. Working with hardware requires a lot of planning beforehand. And the more thorough the plan is discussed before execution, the better the outcome.

*"Smart Cart"* was an idea which if implemented in real life may reduce a lot of effort and make transportation more seamlined, easier and faster. We hope this idea may oneday revolutionize micro-transportation.

We would like to thank all the helpful resources online, the seniors and colleagues who helped us, and our supervisor for helping us along the way.

Here is a helpful video demonstration of our project if the reader is interested in seeing the working prototype.

YouTube Video Link