Rube Goldberg Machine

Srishti 2020

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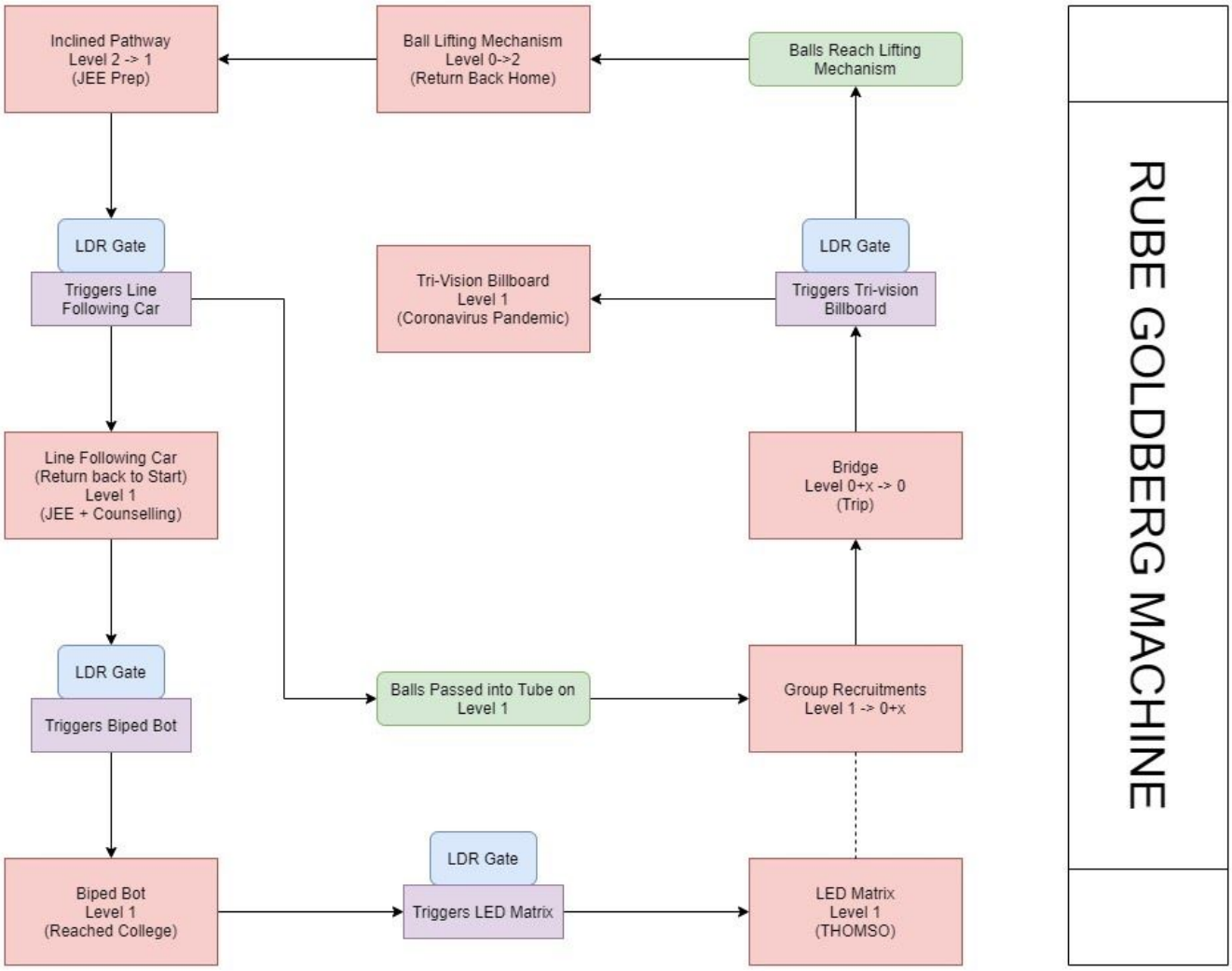
Abstract

A Rube Goldberg Machine is a contraption intentionally designed to perform a simple task in an indirect and overly complicated way. The aim of this project is to depict the life of a college student through a similar complex assembly of mechanical and electronic components linked with each other creating a metaphor between humans and machines.

Project Motivation

College life may seem to be full of excitement and surprises for many, but little do they know of the struggles that the student had to face to reach that milestone and the difficulties that are masked by the brand college name. So our team of 5 freshers decided to cover the important moments of the journey beginning with exams to the major events of 1st year and what we think is to come next for us. We attempt to display it in a visually appealing format making use of our mechanical and electronics expertise.

Elements and Linkages



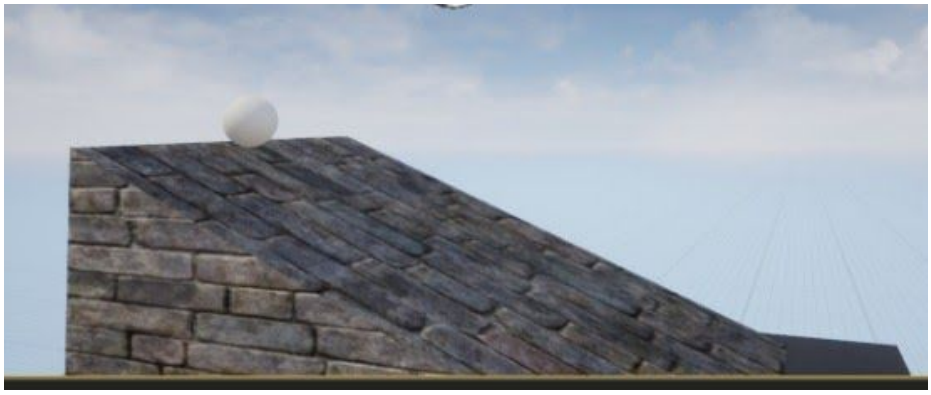
- The entire project is divided into 8 major elements depicting a distinct phase in the life of a student who is represented by spherical balls of different sizes.
- The Tower of Exams(Inclined Pathway) illustrates the ups and downs, successes, and failures in each of the competitive exams.
- The First LDR Gate represents the path to the major JEE Exam after which students seek admission to colleges through counseling and finally enter college after years of hard work.
- Similar to the biped bot, the students stumble here and there in the college exploring various things many of which are new to them and then comes the first major college fest of their lives, THOMSO, depicted using LED Cube. The matrix laden with its bright colors succeeds in depicting the aura of the fest.
- Entering the next semester, students are overwhelmed with all the groups releasing recruitment notices. This period involves a lot of stress and confusion, but it is fun nevertheless.
- After this stressful and dilemmatic process comes the adventurous trip which is depicted by the bridge (Lakshman Jhula, Rishikesh).
- Next comes the second semester's Mid-Term Examinations and following End-Term Examinations which is well shown by the Trivision Billboard.
- Then we all head back to our respective hometowns for spending the summer breaks that are depicted by the Ball lifting mechanism and the journey goes on for the next and their next batch of freshers as our Rube Goldberg machine works in a loop.

Mechanical Aspect of the Design

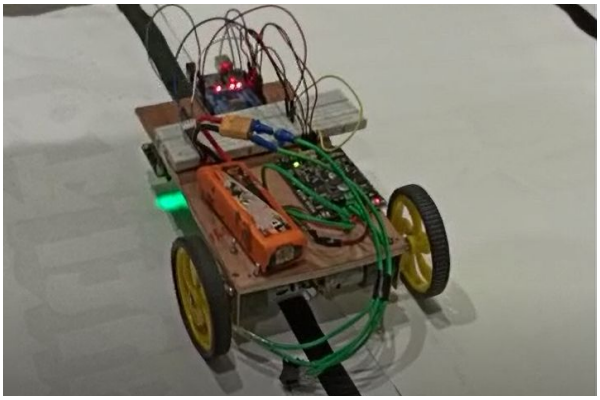
Rubber balls 3 of radius 2.5cm and 3 of radius 3cm each are used to denote the students.

The following steps help one understand the journey by providing a mechanical description of every component:

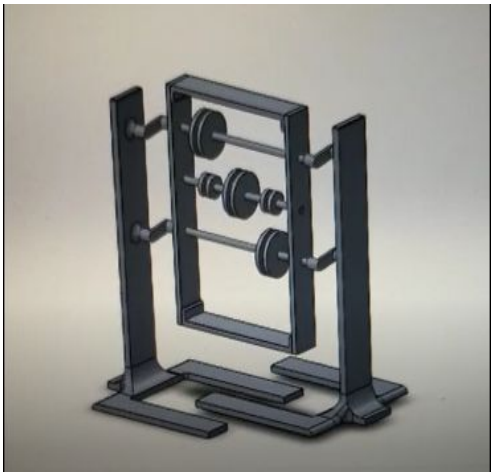
1. **Tower of Exams:** A vertical assembly of MDF towers inter-connected via loophole paths describes the difficult journey before getting into IIT.



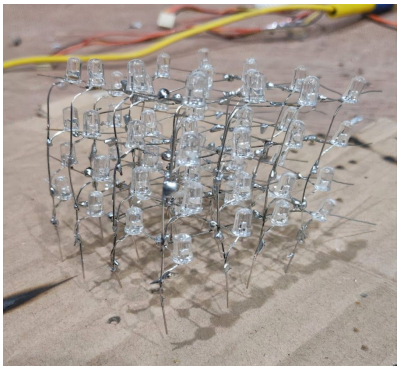
2. A smooth MDF path transitions into the LDR Gate triggering the **Line-Following Car**. Running on a parallel track is another MDF platform taking each ball to the chain lift. Line-follower traverses through the LDR gate and then triggers the Biped Bot.



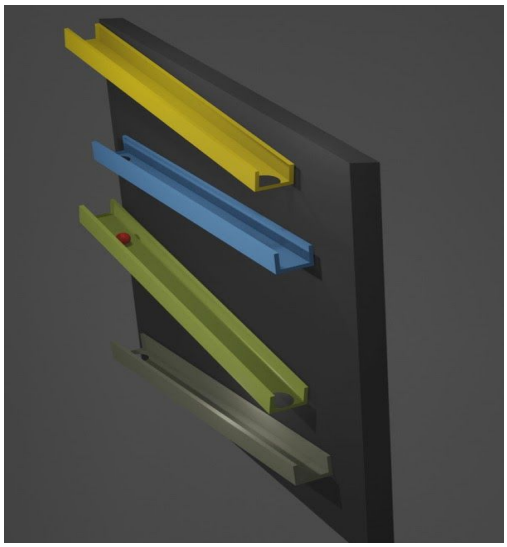
3. **Biped bot** is a working prototype of a two-legged robot contained in an MDF frame with an assembly of 3 big and 2 small acrylic pulleys linked with elastic bands and held in place by 6mm shafts, propelled by using a simple DC motor. It mounts an Arduino Uno on one side to control the motor via a motor driver. Reference



4. The Biped Bot passes through the LDR gate and triggers the LED Matrix.

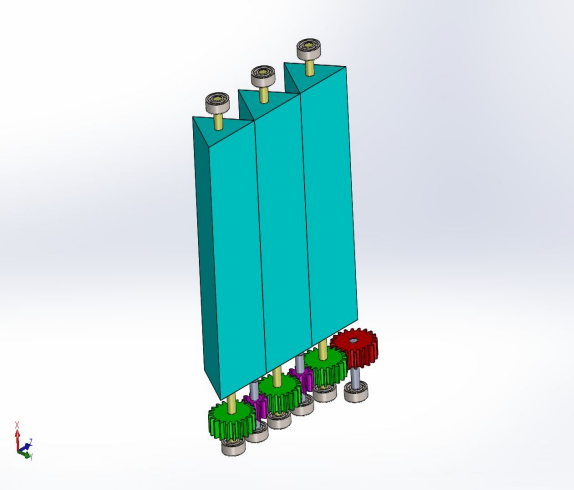


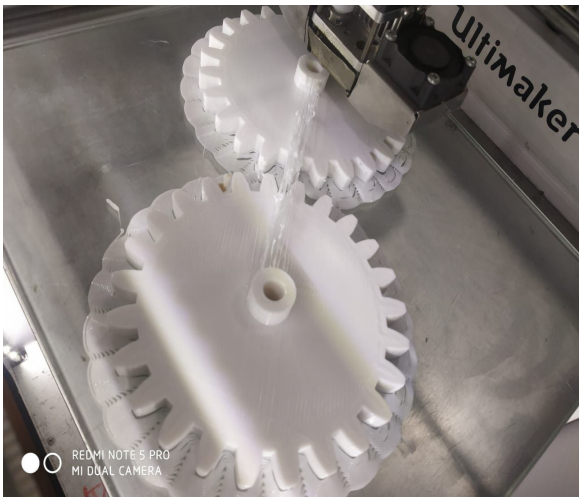
5. Meanwhile, the balls approach the **Group Recruitment Phase** where they pass through a series of inclined ramps that contain holes at their ends and get segregated along the way as per their size. This symbolizes the segregation of students into various tech and cultural groups based on their skills and interests.



6. The balls emerge from the Group Recruitments at a certain height above the ground level and roll down a slope passing through a simple bridge made using cardboard. This signifies the trips that students go on after the onset of the spring season. After this, the balls pass through another LDR gate and trigger the next element.

7. Balls then trigger the final LDR gate activating the **Tri-Vision Billboard**. It is an assembly of 3 triangular prism-shaped boxes made using MDF and L-brackets mounted on a gear each through steel shafts held in place using a Plywood base and are free to rotate about its axis. A stepper motor is coupled with a driving gear, which transmits the actuation to all the three parts of the billboard, also employing two idler gears, so that all the prisms rotate in the same direction and in phase with each other. The gears and the base have been carefully 3d printed using PLA in the Tinkering Lab. Reference (Heavily modified from the aforementioned).





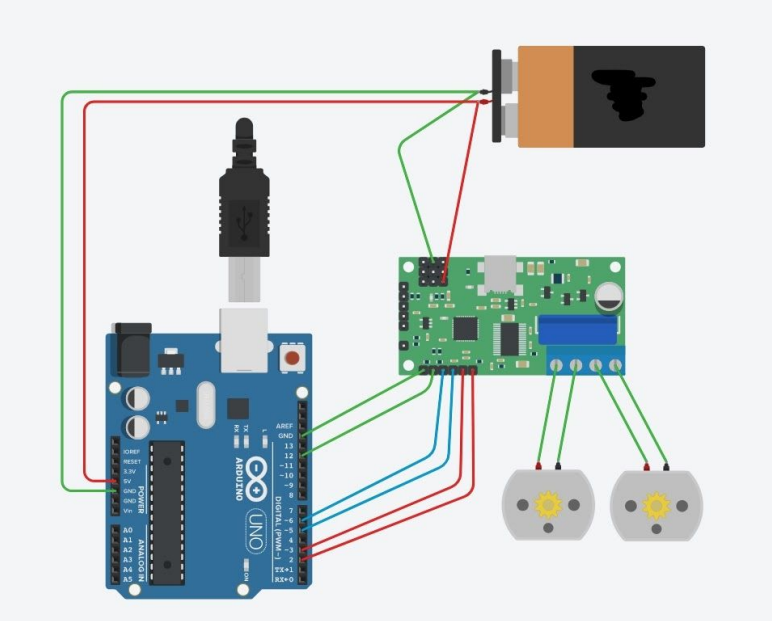
8. In the end, a **chain lift mechanism** lifts the balls back to level 1. The mechanism uses a 48-inch ladder chain and sprockets powered by a 12V DC motor. Reference.

Electronics Aspect of the Design

Microcontroller: Arduino Uno 2560 R3 is used as the microcontroller board in each of the bots.

Line Following Car:

Hardware Architecture of the Line Following Car:

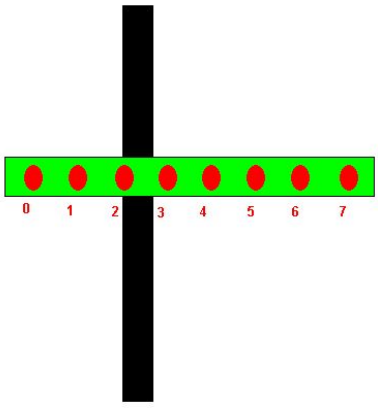


LSA CONNECTION TO ARDUINO	
LSA08 Pin	**Arduino Uno board**
1	RX (pin 0)
2	TX (pin 1)
3	Digital pin 2
4	Not Used
5	Digital pin 4
6	Not Used
7	Not Used
8	Not Used
9	Vin
10	GND

LSA08 Settings:
LINEMODE: Dark-ON detecting black line in white background.
THRESHOLD: 7
JUNCTION WIDTH: 8

LSA gives 1-byte output data ranging from 0-70 with 35 being the base level.

Working Principle:



The car remains stable and follows the straight line if Level=35.
For Level<35: Speed of the left motor increases such that it comes back on track by moving to the right.
For Level>35: Speed of the right motor increases such that it comes back on track by moving to the left.

PID:

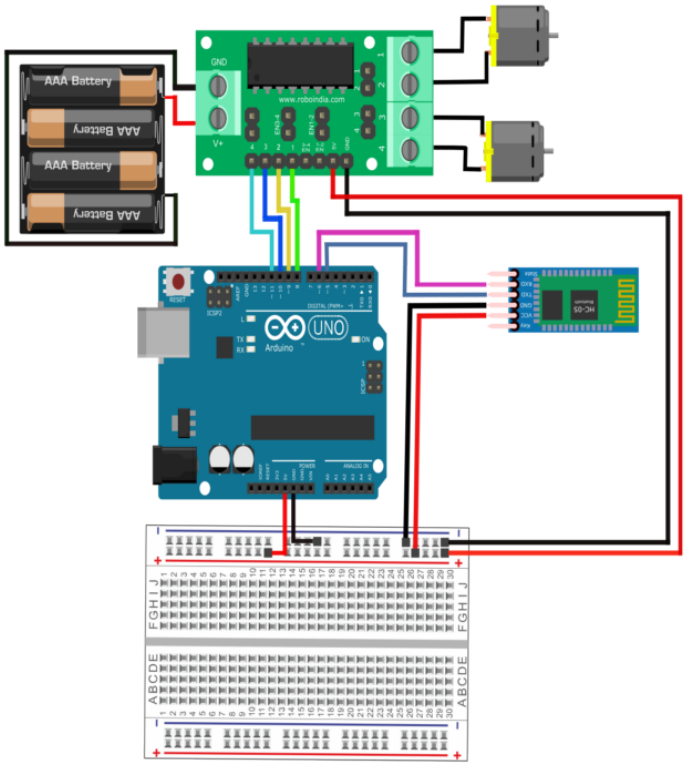
PID is short for proportional, integral, and derivative. The PID is used to correct the error of the bot while traversing.

The correction value is given as

Correction = kp(error) + kd(error- previous_error)

Biped Bot:

A DC motor interconnected to three pulleys using bands which is responsible for the movement of a bipedal bot was driven by a motor driver which is connected to the Arduino Uno, battery, and also to HC-05 (which is used to pair Bluetooth) through a common ground. HC - 05 is also connected to the Arduino Uno through which the instructions given from the phone via Bluetooth can be transmitted to the Arduino Uno and so to the Motor Driver. The speed of the motor and direction can be controlled using the Bluetooth module.

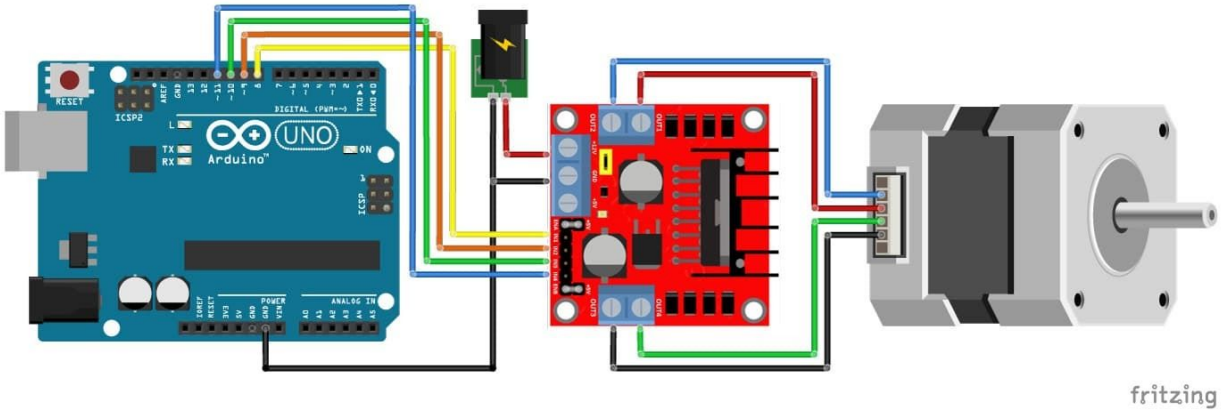


LED Matrix:

It is a cube matrix built using 64 Light Emitting Diodes(LEDs, blue colored) carefully soldered, and is capable of displaying various patterns as per the code fed into it using the Arduino Mega board.
The positive terminals of all 4 LEDs in a vertical line are connected to each other and form a node. And the negative terminals of all the LEDs in a horizontal layer are connected. This results in 16 positive nodes and 4 negative nodes, connected to different pins on the Arduino Mega board. Each LED can be controlled individually or collectively along with other LEDs, depending upon the code. Reference

Tri Vision BillBoard:

Uses a stepper motor to control the movement of the steel shafts about its axis controlled through the L298A motor driver, triggered by balls passing through the LDR gate.

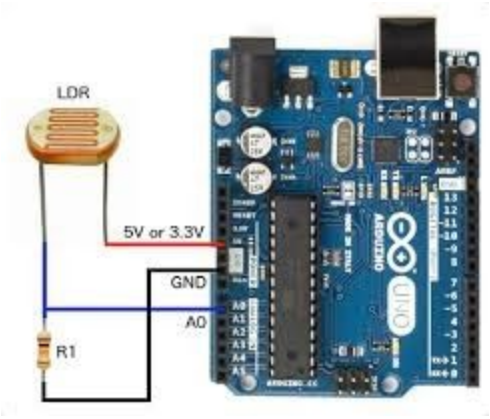


Chain Lift:

Uses a 12V DC Gear motor to rotate the chain vertically stabilized via sprockets.

LDR Gates:

A simple setup of an LDR along with an Arduino Uno board is used to trigger elements in various places throughout the loop. Reference



Motor Driver:

We have used the Cytron MDD10A and L298A motor drivers. MDD10A is a dual-channel version of the MDD10C. Like MD10C, MDD10A also supports a locked-antiphase and sign-magnitude PWM signal.

Cost Structure

Components	Quantity	Cost (in INR)
Auto-Calibrating Line Sensor LSA08	1	5000
Arduino Uno Rev3	5	2000
Digital LDR Module	4	400
LED	64	100
Motor Driver	4	8000
LiPo Battery 11.1V	5	1500
Motor Bracket	2	200
DC Motor	1	300
Stepper Motor	1	500
HC-05	1	300
48-inch Stainless Steel Ladder Chain	1	1000
Other components		1000
TOTAL		**20300**

Applications

The project succeeds in providing a visual description of a student's life.

Limitations

- Some of the systems are not mechanically and electronically robust. For eg: The platforms used to carry the balls are hand-crafted and hence prone to obstruct the paths.
- Although an attempt was made to automate all the things and create a loop, several phases in the project still require manual handling. For eg: We need to collect the balls sorted and collected in the group recruitment phase and place them back in the starting point.
- Due to the Covid-19 pandemic, the actual Srishti event got canceled. This created the most terrible impact as our team could not manufacture some of the parts like the chain lift mechanism.

Future Improvement

- Manufacture the remaining components and make the project display-ready.
- Include several components for automating the process. A Ball-collecting robot making use of OpenCV for ball detection can be made to address this issue. It will significantly help to reduce the amount of manual work required to make the platforms.

Acknowledgment

We would like to thank the Indian Institute of Technology Roorkee Administration and Student Technical Council for providing us an opportunity to do this project and show our skills by organizing Srishti, our Annual Technical Exhibition. We would also like to thank the Models and Robotics Section, IIT Roorkee for mentoring us and providing the components and tools for the project.