



ADVANCED TARGET LOCKING SYSTEM- LockTron

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The primary objective of our documentation embraces the development of an **advanced target-locking system, LockTron**, to create a sophisticated system capable of **detecting, tracking, and predicting** the movement of a dynamic target in real-time. The model must be solidly built, have minimal latency, and offer high accuracy in locking onto a target in varying conditions like:

- **Predict the target's trajectory:** it should anticipate the future position of the target by continuously analyzing its movement.
- **Real-time adjustments:** reacting to sudden and unpredictable changes in the target's motion to make real-time corrections ensuring continuous and smooth tracking without losing the target.
- **Adapting to the motion** of the object's speed, direction, and acceleration where response time is minimized to ensure that tracking and target locking are maintained without delay.
- Deliver high tracking accuracy using a precise control mechanism.

Our ultimate goal is to achieve real-time processing and communication between the webcam, microcontrollers, and mechanical systems to handle various movement speeds and design a control system that can adjust dynamically ensuring minimal lag and maintaining lock on the target for all rapid changes.

I. FABRICATION OF MODEL

I.1 Design Structure:

I.1.a

Components	Qty	Dimensions	Use
Base platform (wood)	1	300x300x16 mm	Bot support
Disk (wood)	1	Diameter: 15mm	Mount motors
Channel	3	50x25x150mm 50x25x41mm 50x25x60mm	Support webcam
Reinforced Channels	3	150x50x25 mm	Support base
Flange Coupler	1	Hole: Diameter- 5mm Outer circle: Diameter- 45mm PCD: 35mm	Connect shaft of stepper to disk
L clamp	9	-	Secure mount parts
U clamp	1	255x30mm	To mount webcam

Total weight of LockTron: 3.5 kg approx.

Total height:450mm

I.1.b Base Model

LockTron is designed on Solidworks to envision the component placement, simulations & analysis working of motors & the webcam. The disc stands on the base built using reinforced aluminium channels and a wooden platform. A stepper is secured with sheet metal over which the flange

coupler is mounted and connected to the disk for rotation.

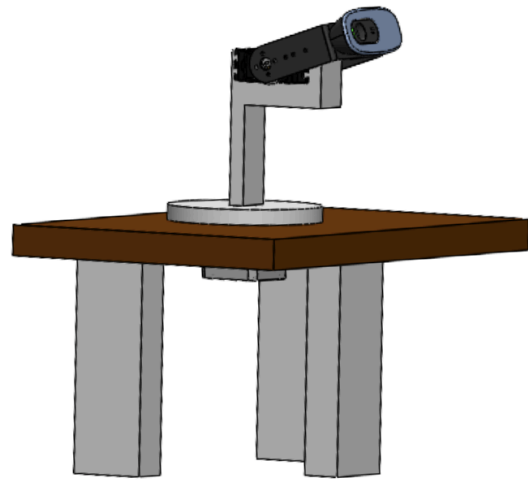


Fig 1.1.a CAD Model

I.1.c Motor Mounting

The camera, a pivotal component of the model, is mounted on a servo motor to enable precise y-axis movement, with a stepper motor managing its x-axis positioning. Both motors and the camera are mounted on a robust wooden disk, which is securely attached to a coupler positioned at the bottom of a long channel, ensuring stability and accuracy in alignment and motion control.

I.2 Final Framework

The framework consists of servos and stepper motors, connected to a coupler for efficient power transmission. These motors provide rapid angular adjustments and fine elevation control. Reinforced channels support the structure securely, minimizing vibrations and maintaining alignment for stable operation. This enhances its accuracy in every situation.

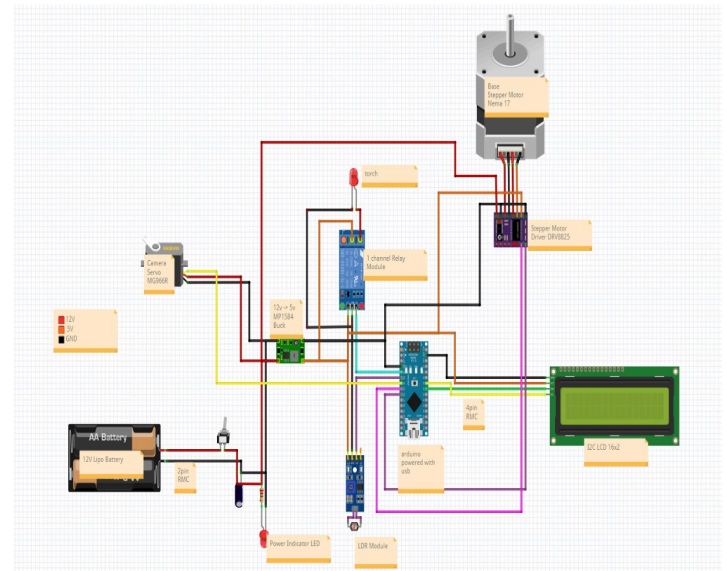
II. ELECTRONIC DESIGN:

II.1

Components	Qty	Specifications	Use
Arduino-Nano	1	ATmega328 Operating Voltage: 5V	Sensors data processing & motor movement
DRV8825 Motor driver	1	Operating Voltage: 8.2 - 45V Current: 1.3-2.2A	Controls stepper motor
LCD	1	Display: 16x2 Operating Voltage: 4.7V-5.3V	Display target coordinates
Buck Converter	1	MP183 Operating Voltage: 3.3V-5V Current- 3A	Regulates voltage
Blue Relay (Self-made module) - NPN Transistor - Diode	1	Operating Voltage: 5V	Safe switching & protects against voltage spike
	1	BC548	
	1	1N007S	
LEDs	3	2x 3mm, 1x 5mm, Operating Voltage: 2V	Visual feedback to detect flow of current
Stepper	1	Nema 17	Movement in y-axis
Servo	1	MG966R	Movement in x-axis
RMC (Female)	6	2pin x2 3pin x2 1pin x2	Power connection-battery to components
RMC (Male)	6	2pin x2 3pin x2 1pin x2	Connecting battery to components

XT60 Connector	2	100uF, 25V	high-current power connection
Toggle switch	1	SPDT	on/off functionality
Resistors	4	1K Ω	Manage current flow
Capacitors	2	100 μ F 25V	Stable power supply
Female Headers	2	30+16+8 pins	Connected to arduino

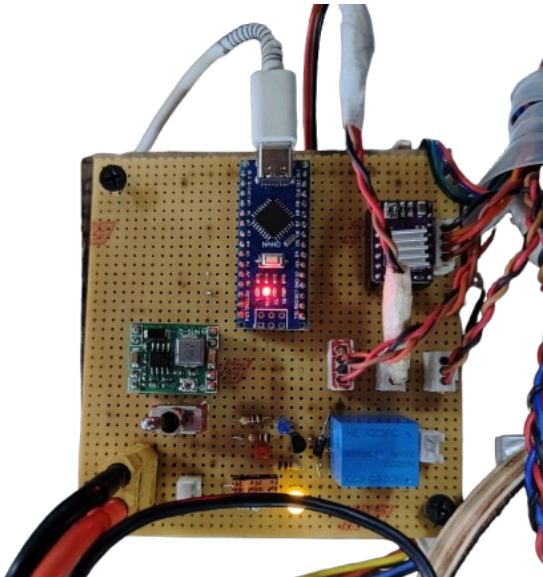
II.2 DSB Board



FigII.1.b1 DSB Circuit Diagram

The Distribution and Supply Board (DSB) serves as the **central power and signal hub**, coordinating each component used in developing LockTron. We have used a microcontroller for processing, motor drivers for controlling stepper and servo motors, a power supply module for voltage regulation, and connectivity interfaces for

sensors like the webcam and LDR, enabling seamless operation and control.



FigII.1.b2 DSB Connections

III. PROGRAM CODES

In developing LockTron, two separate coding algorithms are implemented: one for object detection using webcam feeds with background masking techniques using **OpenCV** and another for **controlling the electronic components on the DSB and motors**. The object detection code implements background masking to isolate and track moving targets against static backgrounds, for enhanced detection. Meanwhile, the movement code works for the motors and other electronic components through the Arduino Nano, giving precise commands for positioning adjustments. This dual coding approach enables seamless coordination between visual tracking and mechanical response.

IV CALCULATIONS

1. Torque of stepper:

$$\begin{aligned}\tau &= (m_1 \times \text{radius} + m_2 \times \text{length}) \times g \\ &= (.5 \times .007 + .2 \times .15) \times 9.8 \\ &= 0.3283 \text{ N.m}\end{aligned}$$

m_1 - mass of disk in Kg

m_2 - mass of channel in Kg

2. Torque of servo:

$$\begin{aligned}\tau &= m \times g \times l \\ &= 1 \times 9.8 \times .23 \\ &= 2.254 \text{ N.m}\end{aligned}$$

m - mass of load

L - length of mount attached to the servo

3. Current limit for DRV8825:

$$\begin{aligned}I_{\text{max}} &= V_{\text{ref}} \times 2 \\ V_{\text{ref}} &= I_{\text{max}} / 2 \\ &= 1\text{Amp} / 2 \\ &= 0.5 \text{ V}\end{aligned}$$

4. RPM for stepper:

(Theoretical):

$$\begin{aligned}\text{RPM} &= N/T \times 60 \\ &= 4/5 \times 60 \\ &= 48 \text{ rpm}\end{aligned}$$

(Experimental): 46.28 rpm

N - no. of rotation

T - time taken in secs

5. RPM for Servo:

(Theoretical)

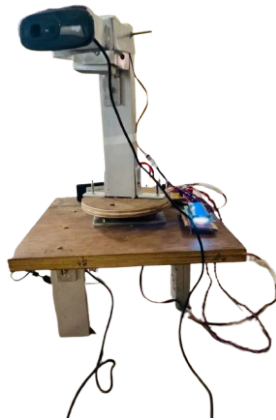
$$\begin{aligned}\text{RPM} &= (\text{Degree of rotation}/\text{time}) \times 1/6 \\ &= 180/.567 \times 1/6 \\ &= 52.91 \text{ rpm}\end{aligned}$$

(Experimental): 56.4 rpm

V WORKING & TESTING

Working:

The electrical crew worked on motors on the base model to ensure smooth rotation and power for the stepper. A **webcam** detects the object, which is processed by **ML algorithms** to locate the target's position. The system operates on a **12V battery**, with a **buck converter** and **5V internal circuitry**. The LCD updates tracking data, while the **servo MG966R** allows quick adjustments based on predicted movement. The **Arduino** controls a **stepper motor** for horizontal alignment and a **servo motor** for vertical positioning. A **self-made relay module** manages high-power switching efficiently. The **Arduino Nano** processes signals and runs predictive algorithms to adjust tracking speed and direction, ensuring the model maintains a lock on the target and adapts to sudden changes with high precision.



FigV. Locktron

Testing:

During testing, the webcam is put efficiently to ensure accurate detection, while the stepper and servo motors are adjusted for precise movement. Power stability is confirmed, and the entire system is tested for smooth, responsive target alignment. Adjustments were made as per requirement, ensuring the bot's reliability in real-time tracking applications.

VI CONCLUSION & LIMITATIONS

Building a target-locking system bot enhances our understanding of inculcating the use of machine learning for control mechanisms, showing how real-time data from object movement can be processed. The bot also showcases the use of computer vision through OpenCV and webcam integration, showcasing the ability of image processing in real-time applications. The use of a mechanical base ensures stability and smooth movement. With evolving technology, target locking systems will gradually enhance its capabilities, making it crucial in fields that require precision.

Limitations:

The target-locking system faces several limitations, such as poor object detection due to poor lighting or rapid target movement, and chances of friction or misalignment issues in the mechanical channel setup, which can affect the accuracy of stepper and servo motors, indicating the need for further improvements.