# 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 | 300x300x18 mm | Bot support |
| Disk (wood) | 1 | Diamter: 15mm Base thickness: 16mm | 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 & 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.

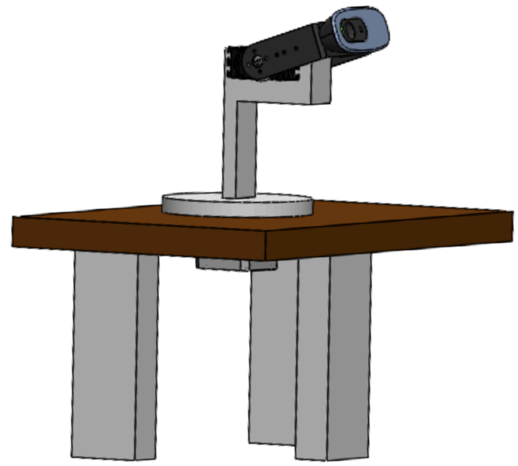


Fig 1.1.a CAD Model

### 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.

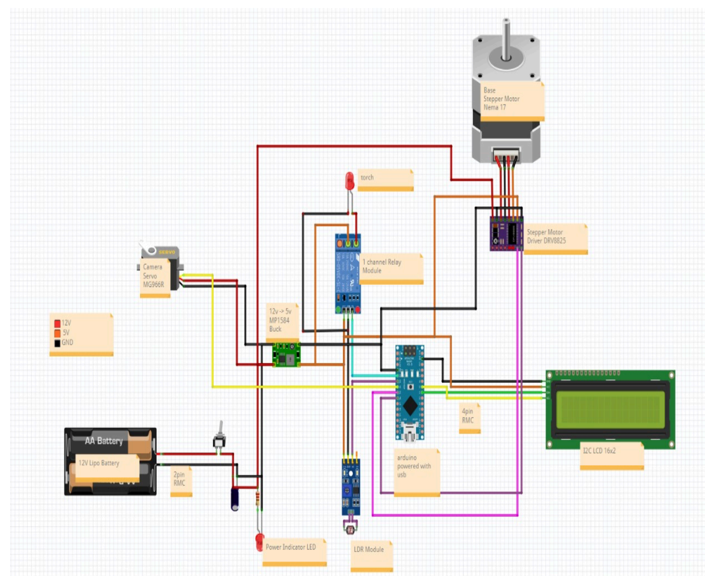
### I.2 Final Framework
The framework consists of servos and stepper motors, connected to a coupler for efficient power transmission. These motors provide rapid angular adjustments and fine elevation control. Reinforced channels support the structure securely, minimising vibrations and maintaining alignment for stable operation. This enhances its accuracy in every situation.

## II. ELECTRONIC DESIGN:

### II.1

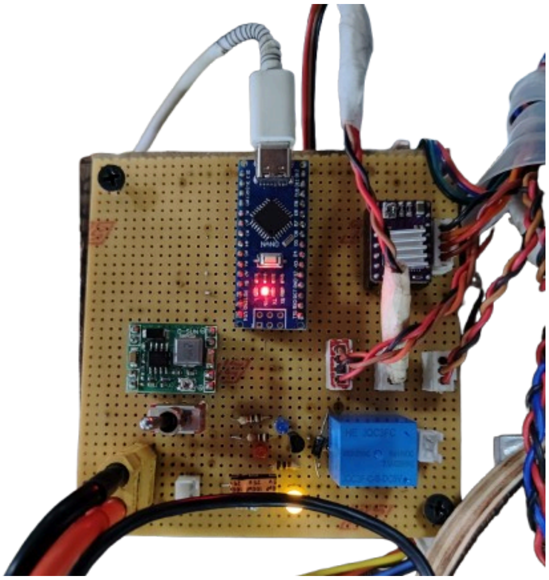
| Components | Qty | Specifications | Use |
|---|---|---|---|
| Microcontroller | 1 | Arduino-Nano: ATmega328 | Sensors data processing & motor movement |
| Stepper Motor driver | 1 | DRV8825 | Controls stepper motor |
| LCD | 1 | I2C 16x2 | Display target coordinates |
| Buck Converter | 1 | MP1584 | Regulates voltage |
| Blue Relay (Self-made module)<br>- NPN Transistor<br>- Diode | 1<br>1<br>1 | 1 channel<br>BC548<br>1N007S | Safe switching & protects against voltage spike |
| LEDs | 3 | 2x 3mm,<br>1x 5mm, | 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<br>3pin x2<br>1pin x2 | Power connection-battery to components |
| RMC (Male) | 6 | 2pin x2<br>3pin x2<br>1pin x2 | Connecting battery to components |
| Battery Connecttor | 2 | XT60 | high-current power connection |
| Toggle switch | 1 | SPDT | on/off functionality |
| Resistors | 4 | 1x3.3KΩ<br>3x1KΩ | Manage current flow |
| Capacitors | 2 | 100μF<br>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 DSB serves as the **central power and signal hub**, coordinating each component used in developing LockTron. We have used a microcontroller for processing, motor driver for controlling stepper and servo motors, a buck module for voltage regulation, and connectivity interfaces for webcam, enabling seamless operation and control.



FigII.1.b2 DSB Connections

## III. SOFTWARE DESIGN

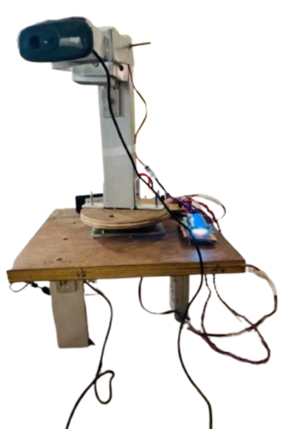
In developing LockTron, two separate coding algorithms are implemented: one for object detection using webcam feeds with background masking techniques using **OpenCV** and another for **controlling the electronic components on the DSB and motors**. The object detection code implements background masking to isolate and track moving targets against static backgrounds, for better 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:**
   $\tau$ = (m1 x radius + m2 x length) xg
   =(.5 x .007 + .2 x .15) x 9.8
   = 0.3283 N.m
   m1- mass of disk in Kg
   m2- mass of channel in Kg
2. **Torque of servo:**
   $\tau$ = m x g x l
   =1 x 9.8 x .23
   =2.254 N.m
   m- mass of load
   l- length of mount attached to the servo
3. **Current limit for DRV8825:**
   I max = Vref x 2
   Vref= I max /2
   = 1Amp/2
   = 0.5 V
4. **RPM for stepper:**
   **(Theoritical):**
   RPM= N/T x 60
   = 4/5 x 60
   = 48 rpm
   **(Experimental):** 46.28 rpm
   N- no. of rotation
   T- time taken in secs
5. **RPM for Servo:**
   **(Theoritical)**
   RPM= (Degree of rotation/time)x1/6
   = 180/.567 x1/6
   = 52.91 rpm
   **(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 orientation and a **servo motor** for vertical positioning. 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 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 it’s 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.