Development of the crossbow-type launcher for a small reconnaissance robot based on the axiomatic theorem

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Abstract
Recently, the development of small reconnaissance robots has been actively studied for the purpose of remote monitoring. However, difficulties related to the robot gaining access to a distant target area have been encountered in this research area. In this paper, a cross-bow-type launcher, which uses elastic energy to launch, was developed to launch a small robot to a designated target location. The design parameters were determined based on commercial users’ comments and axiomatic design methodology to optimize the launcher system. This crossbow system was developed to satisfy functional requirements, such as protecting the robot during the launching process and achieving long-range shooting over 100 m, an accurate shooting range, high portability and ease of operation. In addition, field experiments were conducted to validate the performance of the developed launcher system.

Key words: Axiomatic design, Crossbow-type launcher, Optimal design, Small robot, Reconnaissance robot

1. Introduction

The demand for unmanned reconnaissance has increased as incidents of terrorism in urban areas has drastically increased worldwide (Hahn and Zezior, 1999). Terrorism involving a hostage situation that can result high casualties may occur in complex structures, such as buildings, airports and stadiums. To minimize the collateral damage, it is essential to monitor the hostile area without being detected to obtain vital information for a successful operation. In addition, unmanned reconnaissance is required in a dangerous situation, such as a building in flames, for a search and rescue mission.

For a successful covert surveillance operation, various types of small reconnaissance robots have been developed (Barnes et al., 2005, Rudakevych, 2004, Kadu et al., 2012, Kerrebrock and Larsen, 2003, Pacis et al., 2004, Whittaker, 2012, Jung et al., 2015, Kim et al., 2010, Kim et al., 2009, Reconrobotics, 2013). These robots are designed to be lightweight and small enough to be thrown into the hostile place from a distance. In addition, the reconnaissance robots are designed to withstand the shock at the landing and to send the visual data wirelessly. An early version of a small reconnaissance robot is the ‘Six-wheel Brick’ used in the US military (Barnes et al., 2005). The robot is a skid steer type with six wheels and can flip its body to overcome obstacles. Other robots, ‘Four-wheel Brick’ and ‘Rebound’, have two flippers for lifting the body frame from the ground to overcome obstacles (Rudakevych, 2004). A robot called ‘Dragon Runner’ has a weight of 6.4 kg and is designed to be very robust to shock (Kadu et al., 2012). However, the size and weight of the above-mentioned robots that have 4 to 6 wheels are not suitable for being thrown by hand. Thus, the next generation of reconnaissance robots is being developed to be both smaller and more lightweight by implementing a two-
wheel system with a cylindrical body and a tail for posture stabilization (Kerrebrock and Larsen, 2003, Pacis et al., 2004, Whittaker, 2012, Jung et al., 2015, Kim et al., 2010, Kim et al., 2009). A robot called ‘SpinyBall’ is a spherical, small system that can be held by hand for throwing (Kerrebrock and Larsen, 2003). ‘Scout’ is small and less than 1 kg in weight, making it a popular reconnaissance robot (Pacis et al., 2004, Whittaker, 2012). Another robot, ‘EyeBall’, is a spherical system with a diameter of 8.25 cm, making it suitable to be thrown by hand.

When the robots are launched into the hostile area, it is crucial to be able to position the robot accurately and without being detected. Until now, the aforementioned robots are thrown by hand to a point at a distance of 10 ~ 20 m, depending on the robot’s weight. Throwing by hand is a convenient method that does not require extra hardware for the launch. However, the maximum distance a robot can be thrown is limited, and accurate landing onto the exact target point is difficult to control. Therefore, to address this shortcoming, a launcher system is required to throw the reconnaissance robot to a far distance accurately. For successful military operation, the launcher should meet the following performance criteria (Lee et al., 2012). The launcher should be able to throw a robot up to 100 meters. The launching should produce a low amount of sound to allow for covert operation. The launcher should be able to place a robot at the target point accurately. In addition, the launcher should be portable, safe, and convenient to use for one or two operators. However, as yet, there is no commercialized product that meets the above-described requirements, and there are only a few studies related to the development of launchable reconnaissance robots.

Therefore, this paper proposes a novel launcher system for a reconnaissance robot that can throw the robot a far distance in a silent and accurate manner. The proposed system is a crossbow that uses stored elastic energy to throw a robot to the distant target point. In addition, the system is designed to be foldable, enabling it to be portable and easy to carry, even by a single operator. In this study, the process for designing the launcher is based on the axiomatic design theorem to obtain the optimal design that meets the required design and performance criteria (Suh, 1998, Guenov and Barker, 2005). The performance of the proposed launcher system is validated with field experiments. This paper is organized as follows. In section II, the design criteria for the launcher and the hardware design based on the axiomatic theorem are fully explained. In section III, the performance of the proposed system is analyzed through field experiments. The conclusion is presented last.

2. Optimal design process

2.1 Launcher system design specification

The purpose of this study is to propose an optimal design of a launcher system to shoot a small reconnaissance robot to a distant target point. The launcher system is designed to satisfy the following functions (Lee et al., 2012): it should not damage the robot from shooting to landing, it should throw the robot up to 100 meters, and it should produce a low level of sound. In addition, the launcher system should be portable and simple to use for field operation, as summarized in Table 1.

| Specifications       | Performance                      |
|----------------------|----------------------------------|
| Shooting range       | <100m                            |
| Sound                | <60dB                            |
| Range accuracy       | <±3m                             |
| Portable             | Light weighted <20Kg, Foldable    |
| Others               | Safe and Simple to use           |
|                      | No damage to robot               |

2.2 Launcher based on a cross-bow design

For a special military operation, a portable rocket launcher can fire a small shell to a far distant target. However, such
an explosion-based launcher can damage a robot critically, thus making it unsuitable for launching a robot. Another option for a robot launcher can be a pitching machine, which is a simple mechanism of two wheels rotating at a high speed that throws a ball to a long distance. However, this mechanism can destroy the robot, because it involves strong compression of the body. Another candidate for the launcher is a compound crossbow that can shoot an arrow a far distance using elastic energy. The shooting equipment is portable and simple to use. Because the launcher uses no chemical explosion, silent operation can be achieved. In addition, the proposed system fires a robot using cocking and releasing processes, which produce a low level of sound. The loudest sound produced was measured to be less than 80 dB.

2.3 System design using axiomatic design method

This study applied the axiomatic design to design the launcher system optimally while satisfying the proposed design specifications (Suh, 1998, Guenov and Barker, 2005, Papalambros, 1995, Karl and Steven, 2008). According to the axiomatic design, an optimal design consists of independent functional requirements (FRs) and minimum corresponding design parameters (DPs). The functional requirements (FRs) are the structured functional requirements of the design, can have branched FRs and should be independent of other FRs. The design parameters should be selected to satisfy the corresponding functional requirement without affecting others. The design parameters (DPs) are the physical variables and characteristics that satisfy the correlated FR. The finalized FRs and DPs for the launcher system are shown in Table 2.

| Table 2  | Functional Requirement and Design Parameters |
|----------|---------------------------------------------|
| **Functional Requirement**          |                                             |
| FR1: Protection of the robot during the launching process |                                             |
|   FR11: Protect the robot at shooting |                                             |
|   FR12: Protect the robot at landing |                                             |
| FR2: Long-range shooting to a maximum range of 100 meters |                                             |
|   FR21: High elastic energy storage of the frame |                                             |
|   FR22: High elastic energy storage of the spring |                                             |
|   FR23: Low friction loss |                                             |
| FR3: Shooting range repeatability <3 m |                                             |
|   FR31: Consistent bow stretching |                                             |
| FR32: Control the shooting range by the shooting angle |                                             |
|   FR4: High portability |                                             |
| FR41: Low weight to be carried by one person |                                             |
|   FR42: Foldable in one piece |                                             |
|   FR5: Easy to operate |                                             |
|   FR51: Low torque for stretching bow |                                             |
|   FR52: Simple release mechanism |                                             |
| **Design Parameters**               |                                             |
| DP1: A protective cover for the robot |                                             |
|   DP11: A hard protective cover for the robot |                                             |
|   DP12: Shock absorbing mechanism in the protective cover |                                             |
| DP2: High elastic energy storage materials |                                             |
|   DP21: High elastic limb |                                             |
|   DP22: High elastic spring |                                             |
|   DP23: Low-friction guide rail design |                                             |
| DP3: A consistent bow-stretching mechanism |                                             |
|   DP31: A single level of stretching |                                             |
|   DP32: Adjusting legs to control the shooting angle |                                             |
|   DP4: High portability |                                             |
|   DP41: Slim design with weight less than 20 kg. |                                             |
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DP42: Foldable design
DP5: Easy to operate
DP51: Use a snail winch
DP52: Use a release lever

After analyzing the proposed final design, the design parameters can be expressed in terms of the functional requirement matrix form as like this.

\[
FR = \sum_{i} A_{i}(DP_{i})
\]  

\[
\begin{bmatrix}
FR_{11} & FR_{12} & FR_{21} & FR_{22} & FR_{23} & FR_{31} & FR_{32} & FR_{41} & FR_{42} & FR_{51} & FR_{52}
\end{bmatrix}
\begin{bmatrix}
DP_{11} \\
DP_{12} \\
DP_{13} \\
DP_{21} \\
DP_{22} \\
DP_{23} \\
DP_{31} \\
DP_{32} \\
DP_{41} \\
DP_{42} \\
DP_{51} \\
DP_{52}
\end{bmatrix}
\]  

(1)

The matrix A is similar to a diagonal matrix, which is the ideal case for the optimal design.

FR1: Protect the robot during the launching process

One of the foremost important functions of the launcher is that the robot should not be damaged during the launching process (FR11) and at landing (FR12). For this purpose, this study designed a protective cover for the robot, as shown in Fig. 1. The cover is composed of two parts: the body and the head. First, the robot is inserted into the body as shown in modified Fig. 1. Then, the protective head is closed over the robot wheel as shown in Fig. 1.

![Fig. 1 Protective cover and escape mechanism for a reconnaissance robot](image)

DP11: The protective cover is constructed from the hard material polyoxymethylene to maintain the structure of the
robot and protector system during the launching process. This protector is only decomposed when the axial force is applied to the spring of the protector head during the landing process.

DP12: The head of the protective cover holds the robot tightly with spring arms and can attenuate the shock transferred to the robot at the landing.

In addition, we added the shock absorbing material of foam-clay between the axial direction spring and the robot body. We performed shock impact tests of several shock absorbing materials, such as sylgard 527, sylgard 184, Styrofoam, clay and foam-clay using rotation hammer equipment (Weissman and Anderson, 2015). The 1-axial acceleration sensor was attached to the robot wheel frame without the wheel rubber located on the end of the hammer, as shown in Fig. 2.

The specific experimental conditions are shown in Table 3. The final results of the impact test are shown in Table 4. The case of the no-damper system showed that the maximum shock acceleration was 2983×g. However, the foam-clay material system in conjunction with the wheel of the robot showed the best result of only 304×g, absorbing 90% of the shock acceleration compared to no damper. Therefore, we chose foam-clay as the shock absorbing material between the head of the protective case and the robot.

In addition, total shock testing of the robot combined with the protector was performed, as shown in Fig. 3. The acceleration data and dynamic signal were acquired by acceleration sensors and an NI 4496 board. The acceleration sensors were attached to the inner body of the robot and a bottom plate of the shock test machine to compare the original shock amount and determine a reduction value. The shock test was performed under various conditions of drop height, namely, 30, 50, and 70 cm.

According to the response spectrum, the robot and the protector system showed a high reduction rate of 80% at a drop height of 70 cm, as shown in Table 5. Moreover, the maximum shock at the robot was delayed for 3 ms after the shock starting time at the bottom plate by the shock absorbing mechanism of the protector, as shown in Fig. 4. Moreover, the high shock acceleration was applied over 1000 Hz, according to the frequency analysis, as shown in Fig. 4. Therefore, we can model the acceleration using eq (3) (David et al., 2014), and when we shoot the robot system from the crossbow for a distance of 100 m, the shock acceleration of the protector is 4450×g (robot 1 kg, drop height 30m, restitution coefficient 0.8, and contact time 1 ms). In addition, the shock acceleration of the robot at the shock reduction rate of 75% would be reduced to 1110×g. This value is smaller than the design parameter of the maximum acceleration of this robot of 1500×g.

Additionally, this system of the robot and the protector has the escape mechanism after landing process as shown in Fig. 1. The binding part of the protector between protector head and body will be destroyed by the shock. Even if bonding sites are not destroyed after landing process, the protector has the escape mechanism. The protector head has the rotation plate and this part are connected to the wheel of the robot as shown in Fig. 1. Additionally, this rotation plate is locked to the screw which is connected to the three spring arms of protector head. Therefore, the robot can rotate after landing and then simultaneously rotation plate also rotates. After rotation motion of screw, the leaf arms of the protector head are spread and then protector head and body can be separated (as shown in supporting material).

\[ a = \frac{v(1+\epsilon)}{\Delta t} = \frac{\sqrt{2gh(1+\epsilon)}}{\Delta t} \]  

(3)
Fig. 2 Shock impact test using a rotation hammer

Table 3  Experiment conditions of impact test

|                          |          |
|--------------------------|----------|
| Length of specimen (mm)  | 245      |
| Width of specimen (mm)   | 35       |
| Thickness of specimen (mm)| 7       |
| Initial angle of hammer (deg) | 90   |
| Weight of hammer (g)     | 500      |
| Rotation radius of hammer (mm) | 650 |
| Sensing range of acceleration sensor (gravity, g) | 10,000 |
| Sensitivity of acceleration sensor (mV/g) | 0.5    |
| Sensing range of board (db) | 114   |
| Sensing speed of board (kS/s) | 204.8 |
| Resolution of board (bit)| 16       |

Table 4  Results of impact test

| Type          | Max impact acceleration (gravity, g) | Impact absorption ratio (%) |
|---------------|--------------------------------------|-----------------------------|
| No damper     | 2983                                 | 0                           |
| Sylgard 527   | 496                                  | 83                          |
| Sylgard 184   | 496                                  | 83                          |
| Styrofoam     | 834                                  | 72                          |
| Clay          | 371                                  | 88                          |
| Foam-clay     | 304                                  | 90                          |
Fig. 3 Shock testing machine of the robot and the protector system with acceleration sensor.

Table 5 Reduction rate of shock acceleration of the robot and protector system

| Drop height(cm) | Protector (gravity, g) | Robot (gravity, g) | Reduction rate (%) |
|-----------------|------------------------|--------------------|--------------------|
| 30              | 875                    | 214                | 75                 |
| 50              | 1413                   | 301                | 79                 |
| 70              | 1856                   | 362                | 80                 |

Fig. 4 Shock response spectrum at drop height of 70 cm

FR2: Long-range shooting to the maximum range of 100 meters

According to a military operation manual, the urban operation area is within 100 meters. This paper designed the
launcher system for an urban military operation to cover a fire range of up to 100 meters.

As the proposed launcher is based on a cross-bow mechanism, the robot is fired based on the principle of stored elastic energy. When the bow is cocked by pulling back the harpoon rubber string to its maximum extent, high elastic energy is stored. When the string is released, the stored energy is converted into kinetic energy to shoot the robot. The total elastic energy of the launcher (FR21 and FR22) must be high enough to shoot the robot as far as 100 meters. The elastic energy of the system depends on the stiffness of both the limb (DP21) and the coil spring (DP22) that are pulled back with the bow string, as shown in Fig. 5.

DP21: To obtain a high elastic energy, the limb is designed to be highly stiff by using two layers of leaf spring, as shown in Fig. 5. As the string is pulled back, it also bends the limb backward through the pulley to increase the tension. From the experiment, the maximum bending displacement of the limb is measured to be 0.29 m, and the stiffness, $K_l$, is 5577 N/m.

DP22: A coil tension spring is positioned inside the boom of the launcher, as shown in Fig. 5. The string of the bow is connected to the end of the coil tension spring, and as the string is pulled back in cocking, the tension spring is stretched to store elastic energy. The maximum displacement of the string is measured to be 0.46 m, and the stiffness is $K_s = 1600$ N/m.

The required elastic energy ($E$) to shoot a small robot to a distance of $x$ meters can be calculated under the assumption that the elastic energy is fully converted to kinetic energy and the air friction and other external disturbances are negligible.

To simplify the calculation, it is assumed that the initial height of the robot is at ground level in the equation. The time taken for the robot to land on the ground at the target point with a launching angle of $\theta$ and an initial velocity $v_0$ is like eq (4).

$$t = \frac{2v_0 \sin \theta}{g} \quad (4)$$

The maximum horizontal shooting range ($x_{max}$) of the robot becomes eq (5).

$$x_{max} = v_0 \cos \theta \left( \frac{2v_0 \sin \theta}{g} \right) \quad (5)$$

The kinetic energy required to shoot the maximum horizontal range at the launching angle $\theta$ can be calculated as eq(6).

$$E = \frac{1}{2}mv_0^2 = \frac{mgx_{max}}{4\sin \theta \cos \theta} \quad (6)$$

The stiffness of the limb and the tension spring bow to store the required energy to shoot the robot to the target range.
is eq(7), where \(K_l\) and \(K_s\) are the stiffnesses, and \(\delta\) and \(x_l\) are the displacement of the limb and the spring, respectively.

\[
E = K_l \Delta \delta^2 + K_s \Delta x_l^2 = \frac{mgx_{\text{max}}}{4 \sin \theta \cos \theta} \tag{7}
\]

Let the launcher be set at an angle of 45 degrees to obtain the maximum shooting range. The required energy to shoot a robot of mass 1 kg for a distance of up to 100 meters is calculated to be 490 J. The prototype has a maximum limb displacement of 0.29 m and boom stiffness, \(K_l\), of 5577 N/m, which allows for stored energy of \(E_l=469\) J. The maximum displacement of the string is 0.46 m, and the stiffness is \(K_s=1600\) N/m. The maximum elastic energy obtained for the spring alone is \(E_s=317.4\) J. Thus, the maximum elastic energy (\(E\)) of the launcher that can be stored is eq (8), which is greater than the elastic energy required to shoot a 1 kg robot to a distance of 100 meters.

\[
E = E_l + E_s = 469 J + 317 J = 786 J > 490 J \tag{8}
\]

DP23: The rail on the boom is designed to have low friction and to be parallel to the shooting direction. The friction between the rail and the robot’s protective casing must be as low as possible to reduce both the energy loss and the unwanted noise.

FR3: Repeatability of shooting range < 3 m
The repeatability of the launcher is vital for urban anti-terrorism operations. Considering the distance, the shooting range repeatability should be within 3 meters for a 100 meter target, considering environmental factors and other uncertainties.

Assuming there is no environmental factor, a consistent shooting range can be achieved if consistent elastic energy is used. In this case, the shooting range can be controlled by varying the launching angle.

DP31: To guarantee the repeatability of the elastic energy, the system is designed such that the limb and the tension spring are stretched within a linear stiffness range and with consistent displacement. Thus, the proposed system allows only a single level of stretching.

DP32: The shooting angle can be adjusted by controlling the length of the support, as shown in Fig. 6. A precise laser 1-D sensor can be used to measure the distance to calculate the angle for shooting. The angle adjustment support can be pulled out or pulled in to control the angle of the shooting as shown in Fig. 6.

FR4: High portability: Low weight to enable the launcher to be carried by one person and the ability to be foldable in one piece
The launcher system should be portable to allow for high mobility and should be carriable by a single operator. Considering that a small rocket launcher weighs approximately 20 kg, the proposed system is designed to be just less than 20 kg.

DP41: The launcher is designed to be light-weight and portable. For the robustness and durability of the design, hard steel is used for the frame.

DP42: The support legs and the main body are designed as one piece and are foldable to enhance the portability. When the system is folded, as shown in Fig. 7, the size of the system can be reduced from 800 mm \(\times\) 1600 mm to 130 mm \(\times\) 1600 mm, which is sufficiently compact to be carried by one or two persons.
FR5: Easy to operate, low torque for the stretching limb and a simple release mechanism

DP51: To pull the spring and limbs easily with low force, we used a snail-type winch (Fig. 8). The elastic strain energy of the limbs and the springs at the winch system can be obtained by analysis of the change of the limbs and springs for pulling the strings at different winch radii (Table 6). At the outer radius of the winch until (3), the limb’s elastic energy constitutes most of the energy of the system. However, as more of the strings are pulled at the inner radius of the winch, the portion of the elastic strain energy of the springs is increased. Therefore, as calculated above, a high force is required to pull the stiff limbs and the spring. However, if we use a snail-type winch, then the required force can be reduced. The winch has a varying radius, decreasing outward. We can model the torque and the force required to pull the spring and limbs using eq (9). When the required force $F_{\text{need}}$ is constant, the applied torque would be reduced as the radius of the winch is decreased.

$$F_{\text{operator}} \times R_{\text{handle}} = T = F_{\text{need}} \times R_{\text{winch}}$$

(9)
Fig. 8 Sprocket gear to wind the string.

Table 6  Reduction rate of shock acceleration of the robot and protector system

| Winch state   | Initial | (1) | (2) | (3) | (4) | (5) | (6) |
|---------------|---------|-----|-----|-----|-----|-----|-----|
| Change of limbs (cm) | 0   | 8   | 14  | 19  | 23  | 26  | 29  |
| Change of spring (cm) | 0   | 0   | 4   | 13  | 24  | 35  | 46  |
| Elastic strain $E$ of limb (J) | 0   | 36  | 109 | 201 | 295 | 377 | 469 |
| Elastic strain $E$ of spring (J) | 0   | 0   | 2.4 | 25  | 86  | 184 | 317 |

DP52: To release the cocked bow with low force, a simple release mechanism is designed. The compressed spring and bent limb are pulled back until the shooting bracket is hooked, as shown in Fig. 9. When the release lever is rotated, the compressed bow is released to shoot the robot.

Fig. 9 The release mechanism of the compressed limb and the tension spring. When the lever is pulled back, it releases the robot on the shooting bracket.

3. Field experiments

Field experiments are conducted to validate the performance of the proposed launcher system, as shown in Fig. 10. A robot of mass 1 kg is shot from the launcher at various shooting angles of 35°, 40°, 45° and 48°. For each shooting angle, the experiment was repeated three times, and then the shooting range of the robot was measured and recorded in Table 7. The field test was conducted under almost no wind condition.

From the results of the experiment, the shooting range has a resolution of within 2 meters, thus satisfying our requirement. The maximum shooting range was 82.4 meters, which is shorter than the expected range of 100 meters.

A possible reason for the shooting range error could be due to loss of energy when the elastic energy is converted to kinetic energy due to the following design limitations: friction of the rail guide, the rail guide not being parallel to string motion, and low elastic energy in cocking.
As shown in Fig. 9, the robot system is launched via the shooting bracket. There is friction between the shooting bracket and the rail. Therefore, this friction can decrease the rate of conversion of elastic energy to kinetic energy. In addition, the non-parallel relationship between the shooting direction and the rail direction greatly reduces the kinetic energy, as shown in Fig. 11. Therefore, to maximize the rate of conversion from elastic energy to kinetic energy, the spring direction should be aligned with the rail direction.

Table 7  Experiment result

| Test No. | Shooting range (m) |
|---------|--------------------|
|         | At 35°  | At 40°  | At 45°  | At 48°  |
| 1       | 64.7    | 72.5    | 79.8    | 78.5    |
| 2       | 66.4    | 74.6    | 82.4    | 77.9    |
| 3       | 63.2    | 70.2    | 78.2    | 75.7    |
| Average | 64.8    | 72.4    | 80.1    | 77.3    |

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To analyze the loss of energy, a high-speed camera capturing 200 frames per second is used to observe the motion of the limb and the spring during the shooting process. The robot is marked with white color and is shot from the launcher, as shown in Fig. 12. It is observed that the stretched torsion spring is not fully recovered because it remains in a partially stretched state at the instant that the robot is released from the rail guide of the launcher, i.e., the total elastic energy of the spring coil is not fully converted to kinetic energy to shoot the robot. Thus, the design should be modified to obtain full recovery of the spring before the robot is released.

Another cause of the shooting range error could be experimental errors in measuring the stiffness of the limb and the
spring.

![Image showing the analysis of energy loss in the shooting process with a high-speed camera.]

**Fig. 12 Analyzing loss of energy in shooting process with a high speed camera**

4. **Conclusion**

This paper proposed a launcher that is designed to throw a reconnaissance robot over a long distance silently and accurately. The designed system is based on a crossbow mechanism and is portable and easy to use. The launcher is designed optimally using the axiomatic design theorem to meet the stated performance requirements. The results of the experiments show that all of the design criteria were satisfied, except for the maximum shooting range. It was determined that a loss of energy occurred due to design faults, such as the rail guide not being parallel to the string motion. To improve the overall performance, the design should be modified to reduce the loss of energy. In addition, the relationship between the air speed and the shooting direction should be studied to increase the shooting accuracy. For the further work, the wind velocity should be considered and the protective casing should be designed with better aerodynamics to shoot the robot at further distance and with better accuracy.

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