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The Effect of Throwing Angle and Motor Speed on the Ash Ring Thrower of the Indonesian ABU Robot Contest (KRAI)

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Abstract
The Indonesian Robot Contest (KRI) is an activity of the Student Creativity Program in the field of robotics held by the government through KEMENRISTEK DIKTI, where this activity is a forum for students to develop their creativity and abilities in the field of science and technology. Indonesia has held several Indonesian Robot Contests (KRI). The ring has a round shape, this is a separate problem for designing mechanics in the throwing system, the difficulty of determining the mechanical shape so that the thrower can adjust the ring to fall right on the pole (target). The Parabola method is one approach that is often used in forecasting to predict future values based on historical data. This method is based on the use of a parabolic equation, which mathematically describes the relationship between the variable to be predicted and time or other relevant factors. In this context, data that has been collected in the past is analyzed to find patterns or trends that are parabolic in shape. This model is then used to project future values with a relatively high degree of accuracy.

Keywords:
KRAI; DC Motor;
PWM, Throwing Angle, Parabola

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INTRODUCTION

The Indonesian Robot Contest (KRI) is an activity organized by KEMENRISTEK DIKTI as part of the Student Creativity Program in the field of robotics. KRI provides an opportunity for students to develop creativity and abilities in the field of science and technology. In 2023, KRI was held online, divided into two regions, namely the western and eastern regions. The contest took place at each university with the final held offline at the University of Semarang (USM). This activity is still running even though Indonesia is still affected by the Covid-19 pandemic.

The 2023 Indonesian ABU Robot Contest (KRAI) will be held at Morodok Techo Stadium, Phnom Penh, Cambodia. The theme of the contest is “Casting Flowers over Angkor Wat,” which is the 23rd international competition for Indonesian robot teams. The competition brought together Asia-Pacific Broadcasting Union (ABU) member countries to compete in making robots that fit the culture and rules of Cambodia. In facing this competition, the KRAI team from Ahmad Dahlan University has designed a robot consisting of mechanical and electrical. This robot designs are expected to compete at the international level.

The KRAI 2023 competition uses two robots, the rabbit robot (RR) and the elephant robot (ER), which must work together to throw the team color rings onto 11 poles in the Angkor Wat Area. The team that has the top ring on the pole gets an extra point. The rabbit robot has much more freedom of movement compared to the elephant robot, which can only move in the red and blue zones. The challenge in designing the robot involved mechanical adjustments to place the rings with accuracy on poles of different heights, namely 80 cm and 150 cm. The throwing angle and speed of the ring are important factors that must be optimized.

In the robot design process, SolidWorks software was used to design the mechanical and electrical models. The dimensions of the rabbit robot are 50x50x50 cm, while the elephant robot has a size of 100x100x100 cm, with a maximum weight of 50 kilograms for both robots. A PG 45 DC motor was chosen as the prime mover due to its sufficient power to throw the rings stably, as well as its ability to adjust the speed as requested. Design optimization also focused on setting the robot's center of gravity and power to comply with contest rules.

The throwing accuracy of the ring is influenced by precise parabolic trajectory calculations, based on PWM signals that set the speed and throwing angle. These calculations ensure that the ring can be thrown with high accuracy, even when the distance and height of the pole varies. The robot design is also customized to adapt to various scenarios in the competition, including the possibility of the ring being snatched by the opposing team. The combination of mathematical calculations and precise robot mechanics allowed the team to optimize each throw during the match.

METHOD

The Parabola method is an approach used in forecasting to predict future values based on historical data, using a parabola equation to describe the relationship between variables and time. Past data is analyzed to find parabola-shaped patterns that are used for future predictions with a high degree of accuracy. This method is useful in various fields such as economics, engineering, and social sciences where historical data helps make measurable predictions. In addition, the parabolic method is able to minimize prediction errors through parameter optimization in the parabolic equation so that predictions are close to the actual data trends. Its use provides more accurate and scientifically justifiable results, allowing researchers to make strategic decisions based on robust statistical analysis. Overall, the parabolic method is a reliable predictive solution for projecting future trends.

System Design

The design of the robocon ring thrower system in this study is described in the system block diagram, system flow diagram and frame design of the robot. To get the best results with the expected, it is necessary to design this system referring to the theory and datasheet that has been reviewed from various sources.

Block Diagram

In the process of making the final project entitled Ring Thrower Design Using Motor in the Indonesian ABU Robot Contest (KRAI) 2023, several materials and materials are needed for the needs in mechanical design. The materials and materials used in making the final project use a thrower using a motor that has been designed according to the concept in the research. The Block Diagram in Figure 1 is the result of the System design.

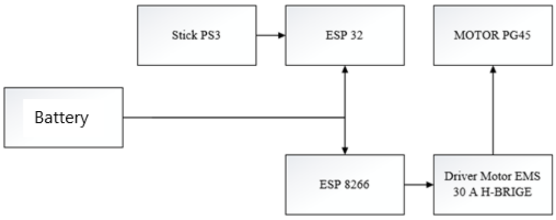

Fig. 1 System Plan

System Diagram

Figure 2 shows the system process flow involving several electronic and control components, such as the ESP32, ESP8266, PS3 joystick, motor, and H-Bridge driver. The diagram starts with the START block, which signifies the initialization of the system. This initialization process involves the initial setup of the hardware and software required to run the entire system. Once the initialization is complete, the system will wait for input from the PS3 stick, which is most likely used as a controlling device to give commands to the system.

In the next stage, once input is received from the PS3 joystick, the data is sent to the ESP32, which is a microprocessor that will receive and process information from the joystick. This ESP32 may be responsible for interpreting the inputs given by the user, such as directions or specific commands. Furthermore, the data received by the ESP32 is sent to the ESP8266 for further processing. ESP8266 is a Wi-Fi module that is often used to process data or send commands to other devices, which in this case acts as a link between ESP32 and other components.

After the data is processed by the ESP8266, the information is forwarded to the EMS 30 H-Bridge. The EMS module is an electronic circuit used to control the direction and speed of a DC motor. In this diagram, the EMS receives commands from the ESP8266 to determine what action the motor should take. The EMS controls the direction of rotation of the motor or regulates its speed according to the input from the PS3. The EMS motor driver is very important in regulating the motor so that it can operate according to the commands received.

The last stage of this diagram is the PG45 motor activation, which is depicted as a component that throws or executes a physical action. This motor may be used to rotate or drive a mechanism controlled by the user. Once the motor has completed its task, the system will return to its initial state or complete its cycle, according to the design goals of the system. This process emphasizes the use of microcontrollers and mechanical components to respond to user input in an efficient and structured way.

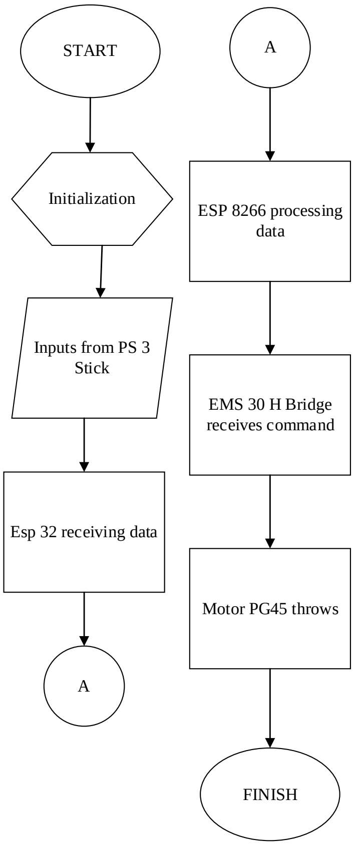

Fig. 2 System Flowchart.

Design of Robot Frame

The robot is designed in such a way and considers the mechanics that will be installed. As well as the materials needed for making robots such as making robot frames that use long iron, sheet resin, and acrylics.

Fig. 3 Robot Rabbit Design

Figure 3 is a robot frame design that has dimensions of length x width x height, namely 50 cm x 50 cm x 50 cm. The robot material used adjusts the mechanical needs of the robot, acrylic, motor, aluminum, iron, so that the material used has unquestionable strength because these materials are very light and of good quality. The thrower must also be designed in such a way that the robot can carry out the thrower design mission listed in Figure 4.

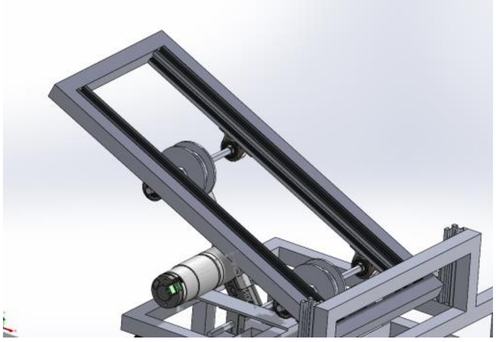

Fig. 4 Thrower Design

RESULTS AND DISCUSSION

After designing the hardware and software, system performance testing was carried out to ensure the system was working properly. Testing begins with checking the PG 45 motor, including checking the motor rotation and testing the EMS 30 A H Bridge motor driver. Before testing, safety measures such as the use of safety shoes and personal protective equipment need to be considered. Testing should be done by at least two people to avoid accidents, with caution and prayer before starting.

Robot Electroclinical Testing

Measurements of the rabbit robot mini system circuit are carried out by providing a voltage of 12 V from a 11.4 V / 4000 mAh Lipo battery, which is then regulated using an LM2596 stepdown regulator to 5V. ESP 32 is used as the main controller and forwarded to ESP 8266 to control the motor. Additional voltage is provided from a 22.2V/5500mAh Lipo battery. The test results show the input voltage from the battery is 12.4 Volts, the LM2596 output is 5.1 Volts, and the EMS 30 A H Bridge motor driver output is 25.4 Volts.

Result of Making Rabbit Robot

Robot mechanics are made by designing using Solidworks 2023 software. The robot is designed by prioritizing a design that is able to walk in a balanced and stable manner when passing through uneven terrain. The mechanical design of the robot is based on the Center of Gravity (CoG) which is the midpoint of the heavy rotation axis of an object. This midpoint refers to the center of gravity associated with balance. Rabbit robots require the concept of CoG so that in the movement of the robot can be balanced to pass through uneven terrain.

The parts of the rabbit robot consist of wheel mechanics, throwing mechanics and take-up mechanics. Mechanics on the thrower there is a close loop belt, pulley, pillow block mounted bearing, iron axle rod and PG 45 motor. PG 45 motor is located in the middle of the thrower circuit shown in Figure 5. In the thrower mechanic there is also an actuator as an angle on the throw and as a support for the thrower mechanic found in Figure 5. Figure 5 also has several mechanics that can be seen, namely the wheel mechanic and the take-up mechanic.

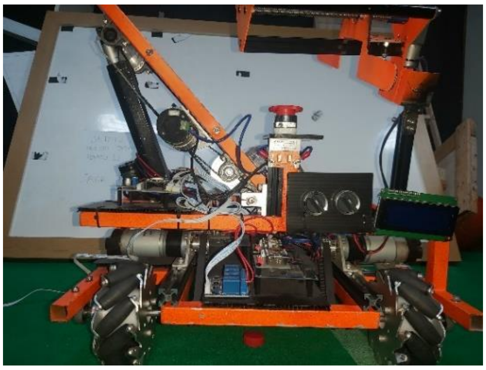

Fig. 5 Rabbit Robot Left View

Ring Thrower Testing

Parabolic throwing tests are carried out using the PS 3 Stick as input. The throwing experiment must be carried out in a flat and spacious place with a minimum rectangular room with a length of 4 meters and a width of 2 meters and a height of approximately 2 meters. The place to test is very influential on several parameters, one of which is the gravitational force in that place. In addition to gravity, the slope of the test site can interfere with the range of the throw.

The formulation of the parabola used in the test is done mathematically to compare the error value of the calculation and the actual reality. Battery voltage to drive the motor is very influential and must provide a battery range of about 25-25.2 Volts, therefore checking the battery must be done frequently. The throwing angles given are 40 and 45 degrees. Each test is given 28 tests given different PWM inputs. The following is the formula used as a reference for data collection.

$$xmaks = \frac{{v_o}^2 sin2\theta}{g}$$

$$R = \frac{{v_o}^2 sin2\theta}{g}$$

$$Rg = {v_o}^2 sin2\theta$$

$${v_o}^2 = \frac{Rg}{{v_o}^2 sin2\theta}$$

$$v_o = \sqrt{\frac{Rg}{sin2\theta}} = \sqrt{\frac{Rg}{2sin\theta cos\theta}}$$

$xmaks$ = R= maksimum distance

θ = throwing angel

g = gravity force

v = object speed

m = object mass

Throwing Angel 40^0

In the Ring thrower test using a 40 ° angle, namely setting the position of the thrower at an angle of 40 ° to the degree circle placed at point 0 on the thrower, while the position of the degree circle is horizontal to the thrower. after setting the angle of the thrower then do the throwing test. Throwing tests were conducted 28 times with a testing distance of ± 1 m. Tests are shown in table 1 for the upper points in the test there are input and output parameters. The input of these parameters is PWM and the output is distance.

Table. I Upper Points 40^O

No	PWM	Success or Failure	Point	Distance (m)	Starting Speed (m/s)
1	254	Failed	0	3,73	5,988367
2	250	Failed	0	3,7	5,964236
3	245	Failed	0	3,67	5,940008
4	240	Failed	0	3,63	5,907548
5	235	Failed	0	3,49	5,792509
6	230	Failed	0	3,37	5,692053
7	225	Failed	0	3,33	5,658171
8	220	Failed	0	3,28	5,615532
9	215	Failed	0	3,04	5,406183
10	210	Success	10	2,73	5,123129
11	205	Success	10	2,63	5,028424
12	200	Success	10	2,57	4,970734
13	195	Success	10	2,35	4,753220
14	190	Failed	0	2,23	4,630271
15	185	Failed	0	2,2	4,599020
16	180	Failed	0	1,95	4,329834
17	175	Failed	0	1,44	3,720791
18	170	Failed	0	1,29	3,521671
19	165	Failed	0	1,37	3,629228
20	160	Failed	0	1,27	3,494265
21	155	Failed	0	1,23	3,438797
22	150	Failed	0	0,97	3,053795
23	145	Failed	0	0,71	2,612662
24	140	Failed	0	0,64	2,480527
25	135	Failed	0	0,61	2,421692
26	130	Failed	0	0,59	2,381661
27	125	Failure	0	0,57	2,340946
28	120	Failure	0	0,47	2,125705

The test was continued with the aim of obtaining the same bottom point as the previous results, performed 28 times. Each throw was made at a 40o angle, ensuring consistent conditions so that the data generated would be reliable and easy to compare. The main focus of this test was to see if the bottom point could be achieved repeatedly within the specified number of throws. This process aims to evaluate the consistency of the throw under uniform conditions. With the results obtained, it is expected to provide more insight into the effect of throw angle on the position of the bottom point, shown in Table 2.

Table. II Bottom Points 40^O

No	PWM	Success or Failure	Point	Distance (m)	Starting Speed (m/s)
1	254	Failed	0	3,73	5,988367
2	250	Failed	0	3,7	5,964236
3	245	Failed	0	3,67	5,940008
4	240	Failed	0	3,63	5,907548
5	235	Failed	0	3,49	5,792509
6	230	Failed	0	3,37	5,692053
7	225	Failed	0	3,33	5,658171
8	220	Failed	0	3,28	5,615532
9	215	Failed	0	3,04	5,406183
10	210	Failed	0	2,73	5,123129
11	205	Failed	0	2,63	5,028424
12	200	Failed	0	2,57	4,970734
13	195	Success	10	2,35	4,753220
14	190	Success	10	2,23	4,630271
15	185	Success	10	2,2	4,599020
16	180	Success	10	1,95	4,329834
17	175	Failed	0	1,44	3,720791
18	170	Failed	0	1,29	3,521671
19	165	Failed	0	1,37	3,629228
20	160	Failed	0	1,27	3,494265

No	PWM	Success or Failure	Point	Distance (m)	Starting Speed (m/s)
21	155	Failed	0	1,23	3,438797
22	150	Failed	0	0,97	3,053795
23	145	Failed	0	0,71	2,612662
24	140	Failed	0	0,64	2,480527
25	135	Failed	0	0,61	2,421692
26	130	Failed	0	0,59	2,381661
27	125	Failure	0	0,57	2,340946
28	120	Failure	0	0,47	2,125705

$$E = mc^2 \quad (1)$$

Throwing Angel 45^0

In the Ring thrower test using a 45 ° angle, namely setting the position of the thrower at a 45 ° angle to the degree circle placed at point 0 on the thrower, while the position of the degree circle is horizontal to the thrower. after setting the angle of the thrower then do the throwing test. Throwing tests were carried out 28 times with a testing distance of ± 1 m. Tests are shown in table 3 for the upper points in the test there are input and output parameters. The input of these parameters is PWM and the output is distance.

Table. III Upper Points 45^o

No	PWM	Success or Failure	Point	Distance (m)	Starting Speed (m/s)
1	254	Failed	0	3,51	5,711412
2	250	Failed	0	3,4	5,621205
3	245	Failed	0	3,23	5,478873
4	240	Failed	0	2,98	5,262572
5	235	Failed	0	2,87	5,164531
6	230	Failed	0	2,7	5,009240
7	225	Failed	0	2,59	4,906139
8	220	Failed	0	2,54	4,858551
9	215	Failed	0	2,5	4,820143
10	210	Failed	0	2,41	4,732585
11	205	Success	10	2,23	4,552420
12	200	Success	10	2,17	4,490760
13	195	Success	10	2,09	4,407203
14	190	Success	10	1,76	4,044327
15	185	Success	10	1,62	3,880140
16	180	Failed	0	1,37	3,568208
17	175	Failed	0	1,53	3,770819
18	170	Failed	0	1,49	3,721200
19	165	Failed	0	1,28	3,449014
20	160	Failed	0	0,8	2,726685
21	155	Failed	0	0,68	2,513879
22	150	Failed	0	0,64	2,438821
23	145	Failed	0	0,63	2,419693
24	140	Failed	0	0,61	2,380975
25	135	Failed	0	0,55	2,260848
26	130	Failed	0	0,54	2,240200
27	125	Failed	0	0,53	2,219361
28	120	Failed	0	0,35	1,803532

The test was continued with the aim of obtaining the same bottom point as the previous results, performed 28 times. Each throw was made at a 45o angle, ensuring consistent conditions to make the resulting data reliable and easy to compare. The main focus of this test was to see if the bottom point could be achieved repeatedly within the specified number of throws. This process aims to evaluate the consistency of the throw under uniform conditions. With the results obtained, it is expected to provide more insight into the effect of throw angle on the position of the bottom point, shown in Table 4.

Table. IV Bottom Points 45^o

No	PWM	Success or Failure	Point	Distance (m)	Starting Speed (m/s)
1	254	Failed	0	3,51	5,711412
2	250	Failed	0	3,4	5,621205
3	245	Failed	0	3,23	5,478873
4	240	Failed	0	2,98	5,262572
5	235	Failed	0	2,87	5,164531

No	PWM	Success or Failure	Point	Distance (m)	Starting Speed (m/s)
6	230	Failed	0	2,7	5,009240
7	225	Failed	0	2,59	4,906139
8	220	Failed	0	2,54	4,858551
9	215	Failed	0	2,5	4,820143
10	210	Failed	0	2,41	4,732585
11	205	Failed	0	2,23	4,552420
12	200	Failed	0	2,17	4,490760
13	195	Failed	0	2,09	4,407203
14	190	Success	10	1,76	4,044327
15	185	Success	10	1,62	3,880140
16	180	Success	10	1,37	3,568208
17	175	Success	10	1,53	3,770819
18	170	Success	10	1,49	3,721200
19	165	Success	10	1,28	3,449014
20	160	Success	10	0,8	2,726685
21	155	Failed	0	0,68	2,513879
22	150	Failed	0	0,64	2,438821
23	145	Failed	0	0,63	2,419693
24	140	Failed	0	0,61	2,380975
25	135	Failed	0	0,55	2,260848
26	130	Failed	0	0,54	2,240200
27	125	Failed	0	0,53	2,219361
28	120	Failed	0	0,35	1,803532

CONCLUSION

Throwing angle tests conducted at 40°, and 45° angles showed that the 45° angle produced the most points. Therefore, the 45° angle was chosen as the throwing angle used in the race. In addition, analysis of the throwing results shows that the optimal PWM input value for the race, especially for rabbit robots, is in the range of 180-210 PWM. This test used a battery power source of 25V and an EMS 30A H-Bridge motor driver.

In the future, the input treatment will not only involve RPM settings, but will also be equipped with an encoder sensor to detect motor speed. By using an encoder, the system can provide more accurate feedback regarding the rotational speed of the motor. This will improve control and efficiency in operation, especially in applications that require high precision. The integration of the encoder sensor is expected to optimize the overall performance and responsiveness of the system.

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