The Development of Dance Movement in Humanoid Robot Dancing ERISA

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Abstract: Robots have become an important part of human life today, especially with today's rapid and modern technological developments. One of them is a type of humanoid robot that has been developed from time to time with various types, shapes and sizes. ERISA is the name of a humanoid robot that has the ability to perform dance moves and can also follow the accompaniment of music. In making the desired dance movement takes a long time, this is because the process in making it is still manual for each desired movement, namely trial and error. In this research using Blender software to answer these problems, where the Blender software displays a 3D design model of the humanoid robot ERISA which was made first using Autodesk Inventor Professional CAD software and then converted to Blender software. The parameters used in this Blender software are the joints in the 3D design of the ERISA robot model which is a representation of the servo motor actuator. By adjusting the position of each joint and the resulting angle value in the Blender software, the desired movement can be carried out. The process mechanism is the result of the angle data obtained at each joint in the Blender software and then converted into a pwm value which is entered into the servo motor to drive it. The results obtained in this research test are that there is an error of 3.25% from the accuracy of the angle value issued in the Blender software with the angle value on the ERISA robot when performing the same dance movement.

1 INTRODUCTION

At this time, robots are not stranger anymore and have been used by developers to complete a profession. Various types of robots have been developed, such as mobile robots, drones, humanoid robots, manipulator robots, et cetera. In this research, the topic of humanoid robots is taken as a discussion. The development of humanoid robots has become the spotlight for researchers in the field of robotics. Proven by educational institutions and technology companies that have competed to show the results of research on humanoid robots such as robots ASIMO by Honda (Sakagami, 2002), T-HR3 by Toyota (Toyota, 2017). One of the discussions in humanoid robot research is related to the balancing control system. The implementation of current balance control aims to make ERISA robot able to walk on sloped field surface in balance and not easy to fall. The test results show the addition of the balance control system gives ERISA robot capability of walking on the sloped surface up to 10° (A.H. Alasiry, 2018). The IMU (Measurement Inertia Unit) is used as a tilt detection sensor and there are accelerometer sensor and gyroscopic sensor that is used in sensor fusion algorithm of the humanoid robot. The test results show the addition of the sensor fusion algorithm in reading data, gives the robot capability of walking on the slope with maximum tilt 12° (Dian Alarmi, 2020).

Even in Indonesia, the discussion of humanoid robots is still ongoing developing. The discussion is supported by the Ministry of Education and Culture, with The Indonesian Robot Contest (KRI) is held every year. Humanoid The robot is in the Indonesian Dance Robot Contest (KRSTI) division against several robot teams from several colleges in Indonesia. Every year the theme of the dance constantly changes with the level of difficulty in the dance moves, and the competition arena changes in size and placement of start and stop zones robot. The robot is programmed in such a way that it can dance to follow a rhythm that matches the theme. To make a motion, you need trial and errors that take a long

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time because it only estimates the angle of the servo. If it does not match the expected then, you need to try again, and it has an impact on the longevity of the servo motor and the time it takes quite a while.

Figure 1: ERISA robot in action.

In connection with this problem, it is motion control for choreography using the powerful Blender software was to make a 3D design of the robot then it is given 2. Bones and the frames on each servo horn will be moved to get the value from the servo, then enter the value from the resulting choreography in Blender software for creating motion, namely the KEIL Microcontroller Development Kit (MDK-ARM). This software itself is the software used on Cortex-M, Cortex-R4, ARM7, and ARM9 processors. MDK Version 5 consists of MDK Core and Software Packs. Both are central to the processor (Integrated Development Environment) KEIL IDE Vision 5 using C/C++ language or assemblies.

1.1 ERISA Robot Construction

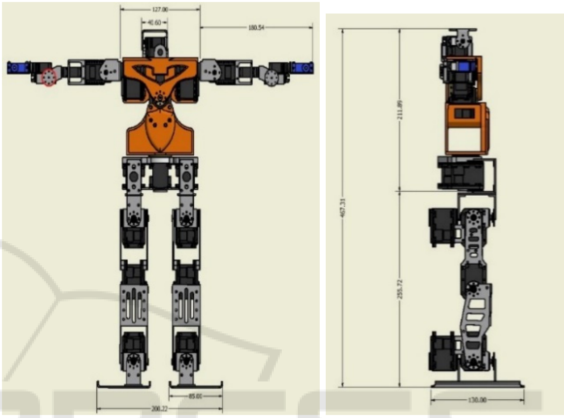
The ERISA robot is designed with 29 DoF servo motors arranged on an aluminum frame, PLA +, and using an ARM type microcontroller as the main control system. The details will be explained below.

1.1.1 Mechanical Design

The ERISA robot design has 29 DoF consisting of the head, body, hands, and feet, as shown in table 1. Figure 2 shows the front and side view of the robot design. The design is made using software Inventor, and the manufacturing process uses CNC machines for aluminium and 3D machines print for PLA+, and most robot joints use motor servo with the type is Dynamixel MX-28.

Table 1: DoF Part Detail on ERISA Robot.

No	Body of Part	Amount DoF
1	**Head**	3 (Neck)
2	**Stomach**	1 (Stomach)
3	**Waist**	1 (Waist)
4	**Hand**	6 (Shoulder) 2 (Elbow) 4 (Wrist)
5	**Feet**	6 (Waist) 2 (Knee) 4 (Ankles)
Total Number of DoF		29 DoF



(a) (b)

Figure 2: (a) Front View Robot Design, (b) Side View.

1.1.2 Electrical Design

To control all the performance, the ERISA robot uses an STM32F407VGT microcontroller with a clock frequency of up to 168MHz. This primary control is used starting from kinematic calculations, sensor access and communication. To be able to drive all these servos, a microcontroller is needed as a logic controller. Microcontroller acts like a human brain because it can give commands to the servo to rotate. In its use, the microcontroller will process the commands given by the programmer and then execute them into servo movements.

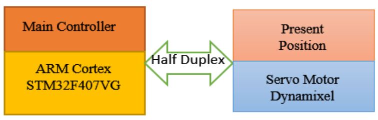


Figure 3: Electrical System Diagram of ERISA.

1.1.3 Block Diagram Process

In figure 4 is a process about the process of making movement on the robot, in the Autodesk Inventor software a design is made from the robot, then the design results from the Autodesk Inventor are imported into the Blender software to make a robot motion simulation by giving bones in each joint, then the value from the servo is taken to be entered into Keil software.

Figure 4: Block Diagram Process.

2 CONTROL SYSTEM DESIGN

2.1 Kinematic

There are two types of kinematics applied to the ERISA robotic motion system: forward kinematics and reverse kinematics. This advanced kinematics is used to control the movement of the hand servo. In comparison, inverse kinematics is used to control the movement of the legs. This inverse kinematic system is modelled on each robot's leg, where the hip is used as the base and the ankle as the end effector. This inverse kinematic uses 6 DoF in this inverse kinematic, input conditions from the ankle, X, Y, Z, and Heading Coordinates.

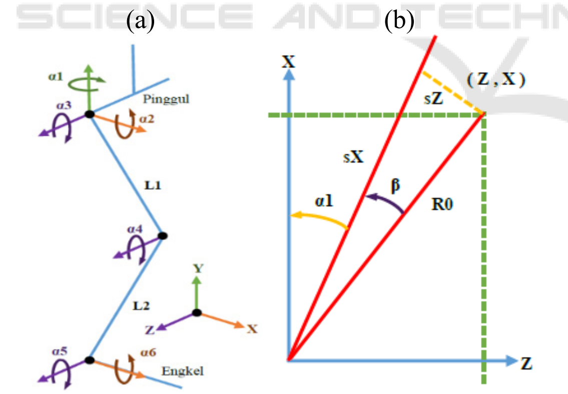


Figure 5: (a) Isometric Visible Kinematic Model, (b) Kinematic Model Top View [3].

2.2 Choreography Making

Blender is a 3-dimensional (3D) processing software for creating 3D animations, which can be run on Windows, Macintosh and Linux. Blender is also the same as 3D software in general, such as 3DS Max, Autodesk Maya and Lightwave. Their fundamental differences include work projects in Blender that can be done in almost all other commercial 3D software. The appearance can be adjusted at will, has the rigidify feature that makes it easy to make motions in 3D designs (James Chronister, Edition 4).

The armature is a framework used to change the shape of the mesh. It can be used to create characters, suspensions on cars and much more. In making the choreography, to make bones and skeletons in the ERISA robot design, which uses the Blender software.

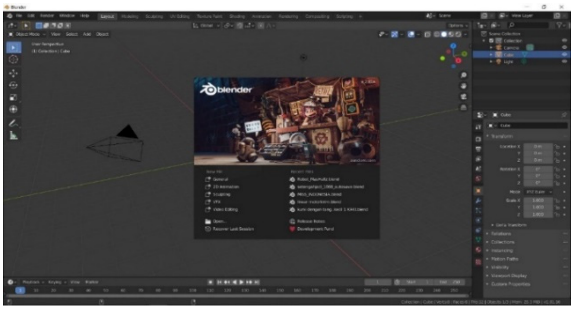


Figure 6: Blender Software Version 2.82.

3 RESULT

In this section is the result of making motion robot motion in Blender software.

3.1 Simulation Information

Figure 7 below is a condition where the robot is first turned on (SetPos). It is assumed that all values are zero with the SetPos. The robot above has 29 DoF, which for convenience is labelled on each servo joint to make it easier to operate.

The Image below in figure 8 is a label to make it easier to make a choreography.

Information:

1. Right Hand Servo 1 (T.KN-1)
   If you want to move the joint (T.KN-1) outward away from the robot body, then the value entered is positive.
2. Right Hand Servo 2 (T.KN-2)
   If you want to move the joint (T.KN-2) outward away from the robot body, then the value entered is positive.
3. Right Hand Servo 3 (T.KN-3)
   If you want to move the joint (T.KN-3) outward away from the robot body, then the value entered is positive.
4. Right Hand Servo 4 (T.KN-4)

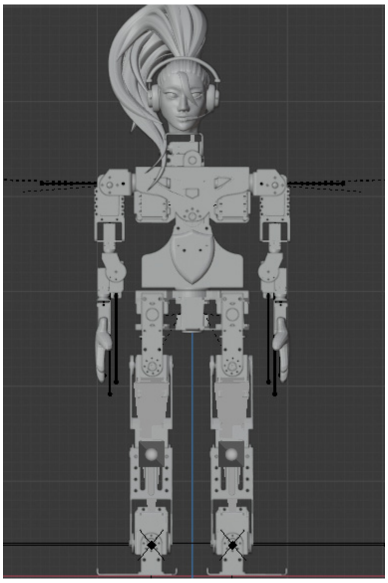


Figure 7: Robot Initial Position Front View.

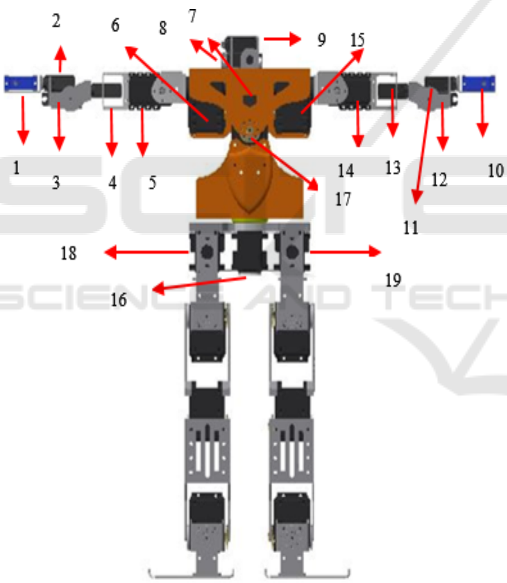


Figure 8: Joint Robot Description.

If you want to move the joint (T.KN-4) outward away from the robot body, then the value entered is positive.

5. Right Hand Servo 5 (T.KN-5)
   If you want to move the joint (T.KN-5) outward away from the robot body, the value entered is positive.
6. Right Hand Servo 6 (T.KN-6)
   If you want to move the joint (T.KN-6) forward, the value entered is positive.
7. Servo Head 1 (Kpl-1)
   If you want to move the joint (Kpl-1) to the right, the value entered is positive.
8. Servo Head 2 (Kpl-2)
   If you want to move the joint (Kpl-2) to the right, the value entered is positive.
9. Servo Head 3 (Kpl-3)
   If you want to move the joint (Kpl-3) downwards, the value entered is positive.
10. Left Hand Servo 1 (T.KR-1)
    If you want to move the joint (T.KR-1) outward away from the robot body, then the value entered is positive.
11. Left Hand Servo 2 (T.KR-2)
    If you want to move the joint (T.KR-2) outward away from the robot body, the value entered is positive.
12. Left Hand Servo 3 (T.KR-3)
    If you want to move the joint (T.KR-3) outward away from the robot body, then the value entered is positive.
13. Left Hand Servo 4 (T.KR-4)
    If you want to move the joint (T.KR-4) outward away from the robot body, the value entered is positive.
14. Left Hand Servo 5 (T.KR-5)
    If you want to move the joint (T.KR-5) outward away from the robot body, the value entered is positive.
15. Left Hand Servo 6 (T.KR-6)
    If you want to move the joint (T.KR-6) forward, the value entered is positive.
16. Body 1
    If you want to move the Body 1 joint to the right, then the value entered is positive.
17. Body 2
    If you want to move the Body 2 joint to the right, then the value entered is positive.
18. Heading 1
    If you want to move the joint heading one outwards, the value entered is positive.
19. Heading 2
    If you want to move the joint heading two outwards, the value entered is positive.

Meanwhile, for the legs, using inverse kinematic to make the legs of robot moving. The x-axis is for forwarding, the y-axis is for upwards, and the z-axis is for the robot's tilt. To make a simulation using Blender software, one of the features in the Blender software is used with the name timeline, which contains a keyframe where we move or rotate the robot joint and then lock it in the desired position.

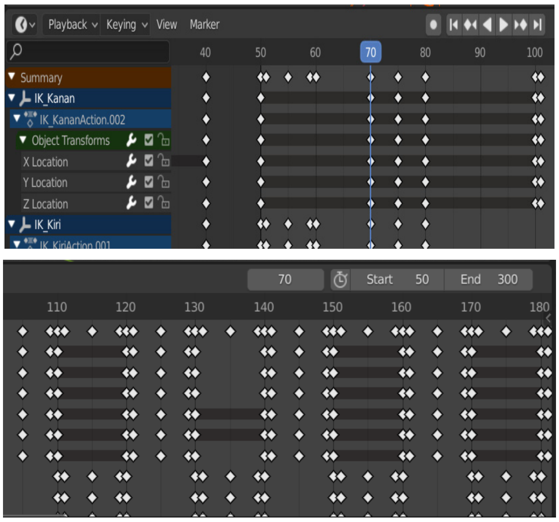


Figure 9: Timeline in software Blender.

3.2 Opening Prayer Movement

The opening prayer movement is a respectful gesture to start a dance. In this opening prayer, it starts from frames 50 to 70

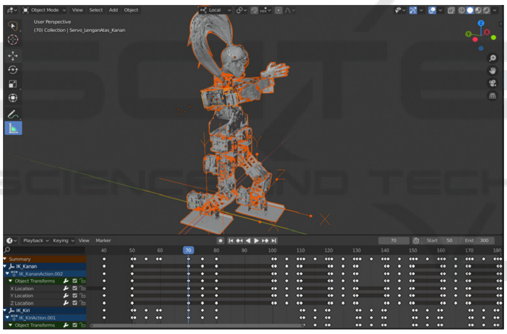


Figure 10: Opening Prayer Movement.

Table 2: Prayer Movement Opening the body, hands and head on a 70 Frame.

Joint	Value (Deegre)	Joint	Value (Deegre)
T.KN-1	45	T.KR-1	45
T.KN-2	-10	T.KR-2	-10
T.KN-3	-45	T.KR-3	-45
T.KN-4	0	T.KR4	0
T.KN-5	-10	T.KR-5	-10
T.KN-6	100	T.KR-6	100
Heading 1	0	Kpl-1	0
Heading 2	0	Kpl-2	0
Body 1	0	Kpl-3	20
Body 2	0		

Table 3: Opening Prayer Movement on the leg 50^{th} to 70^{th} legs of the frame.

Axis	Value (cm)	Axis	Value (cm)
X Right	0	X Left	11.5
Y Right	0	Y Left	3.3
Z Right	3.5	Z Left	0

3.3 Closing Prayer Movement

The closing prayers is a respectful gesture to end a dance. This movement is the last movement of the simulation in the Blender software, it starts from frames 280 to 290

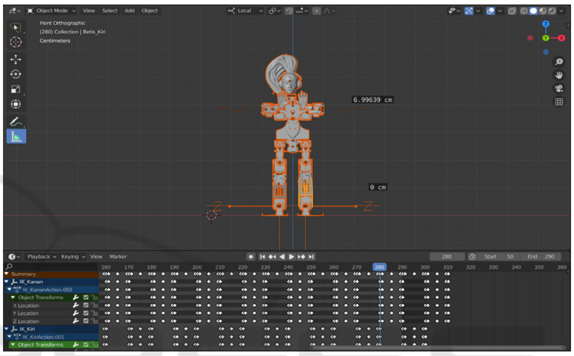


Figure 11: The Closing Prayer Movement on the 280 Frame.

Table 4: Closing Prayer Movement Data on Body, Hands and Head Frame to 280.

Joint	Value (Deegre)	Joint	Value (Deegre)
T.KN-1	90	T.KR-1	10
T.KN-2	0	T.KR-2	0
T.KN-3	0	T.KR-3	0
T.KN-4	90	T.KR-4	90
T.KN-5	10	T.KR-5	10
T.KN-6	60	T.KR-6	90
Heading 1	0	Kpl-1	0
Heading 2	0	Kpl-2	0
Body 1	0	Kpl-3	0
Body 2	0		

Table 5: Closing Prayer Movemnt Data at the Foot of Frames 270 to 280.

Axis	Value (cm)	Axis	Value (cm)
X Right	0	X Left	8
Y Right	0	Y Left	3.3
Z Right	3.5	Z Left	0

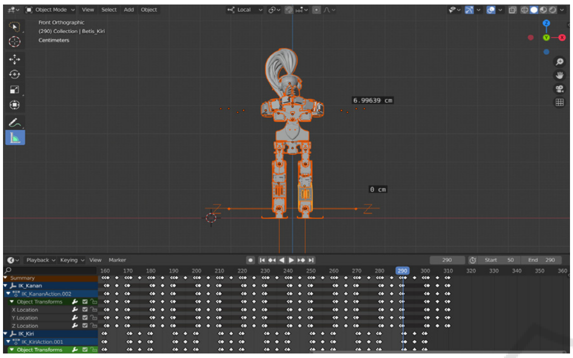


Figure 12: The Closing Prayer Movement on the 290 Frame.

Table 6: Closing Prayer Movement Data on Body, Hands and Head Frame to 290.

Joint	Value (Deegre)	Joint	Value (Deegre)
T.KN-1	45	T.KR-1	45
T.KN-2	-10	T.KR-2	-10
T.KN-3	-45	T.KR-3	-45
T.KN-4	0	T.KR4	0
T.KN-5	-10	T.KR-5	-10
T.KN-6	100	T.KR-6	100
Heading 1	0	Kpl-1	0
Heading 2	0	Kpl-2	0
Body 1	0	Kpl-3	20
Body 2	0		

Table 7: Closing Prayer Movement Data at the Foot of Frames 280 to 290.

Axis	Value(cm)	Axis	Value(cm)
X Right	8	X Left	0
Y Right	3.3	Y Left	0
Z Right	0	Z Left	3.5

The following is a summary comparison of the values entered on the Keil MDK ARM and the direct values taken one of the variation movement is executed on the robot. To calculate the error in the table below use the formula:

Error = |(input value − output value) / input value)|*100%

Table 8: Servo Error Value in Variation Movement 1.

Servo	Input value	Output value	Error
T.KN-1	90	86	4.4%
T.KN-2	60	57	5%
T.KN-3	-70	- 67	4.2 %
T.KN-4	5	5	0%
T.KN-5	-30	-31	3%
T.KN-6	95	93	2.1%
T.KR-1	-90	-88	2.2%
T.KR-2	-70	-67	4.2%
T.KR-3	55	57	3.6%
T.KR-4	-5	-5	0%
T.KR-5	-30	-28	6.6%
T.KR-6	85	80	5.8%
Kpl-3	-30	-32	1.5%
Average Error			3.2 %

Table 9: Servo Error Value in Variation Movement 2.

Servo	Input value	Output value	Error
T.KN-1	70	73	4.2%
T.KN-2	55	56	1.8%
T.KN-3	-90	- 87	3.3%
T.KN-4	25	24	4%
T.KN-5	-50	-51	2%
T.KN-6	85	84	1.1%
T.KR-1	-75	-78	4%
T.KR-2	-62	-63	1.6%
T.KR-3	90	88	2.2%
T.KR-4	-35	-37	5.7%
T.KR-5	-50	-52	4%
T.KR-6	79	77	2.5%
Kpl-3	-45	-42	6.7%
Average Error			3.3%

In the table above from table 8 and table 9, it can be seen that the error values for each servo on the robot are mostly not in accordance with the input values, and the test results of the 2 variations of the movement, an average error of 3.25% is generated. Several factors causing the discrepancy of the output value on the robot, one of which is the servo's age which is quite long and can also be due to human error when measuring the output value of the robot's servo. The other factor can be in terms of mechanics and can also be in terms of hardware, for example too tight or too loose the bolts installed on the robot can affect the movement of the servo

4 CONCLUSION

Based on the results of the experiment both in simulation using the Blender software in determining and making dance movements with the output in the form of degrees of each joint which is then implemented and proven by entering the data after being converted into pwm data to drive the servo motor, there are differences that have either a slight or a slight difference large with an average error of 3.25%. Using Blender software can reduce the time in making dance moves and can immediately see the results and forms of movements made.

REFERENCES

Y. Sakagami, R. Watanabe, C. Aoyama, S. Matsunaga, N. Higaki, dan K. Fujimura, 2002, *"The intelligent Asimo: System overview andintegration," in Intelligent Robots and Systems (IROS), IEEE/RSJ International Conference on, vol. 3, pp. 2478.2483.*J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

Toyota Global Newsroom. (2017, Nov) Toyota Unveils ThirdGeneration *Humanoid robot* T-HR3. [Online]. Available: https://newsroom.toyota.co.jp/en/download/20110424K. Elissa, "Title of paper if known," unpublished.

James Chronister. *Blender Basics Classroom Tutorial Book. Edition 4*

A. H. Alasiry, N. F. Satria and A. Sugiarto, "*Balance Control of Humanoid Dancing Robot ERISA while Walking on Sloped Surface using PID*," 2018 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), 2018, pp. 577-581, doi: 10.1109/ISRITI.2018.8864447.

R. Dian Alarmi, A. Husein Alasiry, N. Fajar Satria and B. Sumantri, "*A Sensor Fusion Algorithm in Humanoid Robot PD Balancing Control for Walking on Slope*," 2020 International Electronics Symposium (IES), 2020, pp. 289-296, doi: 10.1109/IES50839.2020.9231674.

R. Dimas Pristovani. 2017. Walking Optimization Algorithm for Robot Humanoid Soccer On Artificial Grass. PENS.

A. Sugiarto, Kontrol Keseimbangan Robot humanoid Dancing ERISA Menggunakan Feedback Tilt Sensor. Surabaya, 2018