Horseback Riding Simulator

ABSTRACT

Horseback riding is a popular sport with a long human history as it improves the flexibility and sense of balance of rider. It is also famous for entertainment, fitness and physical therapy As there are many risk and difficulties facing this sport, a horseback riding simulator is a good alternate option. This paper proposes the design and implementation of a safe and an inexpensive horseback riding simulator using a microcontroller Arduino UNO . This device is useful for practicing the riders and therapeutic purpose The device simulate the main three movement of the horse (walk, trot and canter) using the mechanical principle of six degree of free dome (6 DOF). Using six-servo motor to control the angular position that are attached on the base of the simulator body. The idea of controlling the movement and switching between the moods is controlled by input units that can be reacted with the rider by using the punching sensor that are placed on the prototype where it is used to switch between the mood by punching this sensor. In the other side of the design is provided with the accelerometer where the coach can control the movement. The data transferred by RF transmission are analyzed and processed by the Arduino, which feed the output devices .The Liquid Crystal Device(LCD) display the mode of the movement. This device is used for the treatment and training workout that provide a realistic movement of the real horse, which obtain to train the weakness muscles and maintaining the pelvis, hip, trunk, head and balancing in response of horse movement. This device could improve the efficiency and quality of riding experiences.

Keywords:

RF transmission, Arduino UNO**,** Liquid Crystal Device, **F**ree Dome**,** Trot, Canter.

Introduction:

Horseback riding is a widespread sport event from the old age .In addition to the entrainment side; it also helps to optimize our health and well-being. This improves the flexibility and maintains the sense of balance of the rider. Upholding a good posture is always associated with the sense of balance. In spite all these medical benefits, the person who lives in city, has very less chance to explore the feel of riding a real horse in a proper environment. This horse-riding simulator will help in providing more practices for improving the skills (Kang et al.2013). In addition to it, practicing with a real horse is more dangerous and costly. Hence, horse riding in Oman is condensed. To assist and protect the rider, this horse ride simulator device will be helpful as it replicate the three main movements (walk, trot and canter) to practice using a limited workspace. Riding a horse in a saddle is not good enough for some people. In Oman , there are a special show that be happened on celebration called (ARTHA) it is kind of a tricky riding show to entertain people which a difficult and unusual physical act on horseback while the horse is run . Normally there are more than 250 tricks are done during the event

The followings points makes needs of a horse ride simulator.

1. Practicing to a real horse at beginning is time consuming and dangerous
2. A skilled trainer presence is very important whole time as any unfamiliar reaction with horse can cause a huge injury or even death
3. The rider is on a risk all the time till the various skills are trained to ride safely and with more confident.

The horseback riding simulator is an electronic machine that impersonate the movement of the real horse movements like walk, canter and trot. A mechanical structure connecting with motors and actuator to arduino to realize the input from the sensor to the output. The wireless control to the device will add more features to it instead of connecting wires that cause some obstacles to the movement of the device and the riders. Hence it possible to perform training of riders without being close to the machine. Beside the training on riding back the horse, can be used to tie the dressed and equipment for the horse All that will minimize the risk that could occur during the training . Designing a transmitting and receiving circuit can achieve this approach . the arduino will inform the machine through the receiving circuit (Galadima, 2014). The main benefit of the horse riding simulator is that it helps to improve postural balance related with neurological disorder.

Related Work:

The article" A new robotic horseback-riding simulator for riding lessons and equine assisted therapy"(Lee et al. 2018) presented the study of new robotic horseback riding simulator and provide the significance of using the simulator as the real horses in areas of riding lessons, therapy, fitness, and entertainment . The author emphasize the differences in motion, response, and feeling between a real horse and a simulator, which could result in incorrect posture and muscle memory for the rider Hence this article proposed a hybrid kinematic structure of horseback-riding simulator to look more realistic for detailed riding lessons . Here the system is made as a wireless robot that is designed to act as on the reception of command. The system is developed with four degree of freedom, which this will improve the orientation capability. The system is capable to capture four-horse motion, then it is normalized, filtered, and fitted to provide the motion trajectory. Furthermore, active neck, saddle, and tail mechanisms were implemented to provide realistic simulation. For interactive horse riding, bridle and beat sensors were included to control the simulator motion and a large screen was installed for virtual reality effect.

The second article : Development of a horseback riding simulator" (Yamaguchi & Iguchi, 1991)proposed the structure which consist of the horse which acts as body, swing mechanisms, control unit and an imaging device. Here also the basic three riding motions walk, trot and canter is implemented. In addition to this the developed system has the capability of controlling the horse movements like start, stop, and change of the riding pace. An analysis the measurement of the movement of the real horse using a high speed photography and plot the movement in a horizontal and vertical graph which refer to the path of movement was performed and this data is used to develop the system to become more realistic.

The article "Hippotherapy without a horse: The effects of passive movement on core control ", (Barton et al., 2015) mainly concentrated more on o the medical and historical sides which are mainly theoretical and doesn't give enough value to the scientific design. This research can be improve by adding details to demonstrate the device as one part of different output to enhance the understanding the concept of mechanical movement with different orders.

The article "Learning a Dynamic Horse Walking Model for a Simulator using Dynamical Movement Primitives",the author proposed the dynamic movement and the Transformation system Dynamic simulation such as Xenma using a Dynamical Movement Primitives (DMPS) which is a method of nonlinear dynamical system which can generate complex behavior by configuration the system regarding to the desired output . It is mainly used for uncoupled agent system. It contains two types of sensors input which has two avoidance sensors touch and vision sensors and also two interaction relevant sensors, the displacement and force sensor. On this article, the goal is to learn to interact in away that the forces between the rider are minimized (Steven ,2013)

Comparing to the previous research (Afzal 2018) , the six degree of freedom could be provided with more movement and achieve the real sensitivities comparing to the method of this article. But in other hand of using the measurement of changing direction of saddle referring to the movement of the whole body of the horse, this is a helpful technique to collect the data of the desired movement(Pataky 2019).

The article "The modified inverse kinematics on variable crank for XENMA pelvis rehabilitation robot "(Lim et al.,2013)proposed inverse kinematics on variable crank on designing a robot to stimulate the movement of the real horse by modifying it with XENMA pelvis rehabilitation robot. Here generating the motion using variable crank structures by focusing on trigonometric of pelvis motion. Designing this device for patient using two cranks-slider mechanisms and variable crank structure, which control the movement. This design is develop to work with both geometrical and resolved motion. This design using variable crank and crank slider to generate trigonometric desired trajectory. The rotation of the crank will transfer the motion directly to control the length of the crank and this rotation will affect to the end of the rotation. On this research they use inverse kinematic method to design the system by implementing the concept of the end effectors to control the motion(Sukumaran ,2020)

The related works are summerised in Table 1

Table 1. Summary of Literatures

Title,Author, Year	Concepts, approach, methods and analysis,	Inconsistencies, and gaps	Advantages
"New robotic horseback-riding simulator for riding lessons and equine-assisted therapy" (Lee et al. 2018)	Wireless Control	Visual system is more expensive and need more experience to design. Sizeof the device is huge .	The visual system no need for physical exercises.
Development of a horseback riding simulator, (Yamaguchi & Iguchi, 1991)	Simple and flexible design. Presenting the history of developing the horseback riding simulator.	The system is design for therapy purpose only	Utilizing the device to train the players
Hippotherapy without a horse: The effects of passive movement on core control, (Barton, 2015).	Ability to reproduce different motion. The design has six degree of freedom. Arduino can be programmed easily.	Request more experience to program each legs of the system. The speed of the motion is limited.	Using the only the front and back side movement to achieve the 3 moods
Learning a Dynamic Horse Walking Model for a Simulator using Dynamical Movement Primitives (Lim et al., 2016).	Has four degree of freedom. Has more ability to control the speed	This design is limited with walking model. Requiring more time to achieve comparing to the others.	It is design for three movement (walk, canter, trot)

Proposed System:

The mainly aim of this project is utilizing the capabilities of the electronics and telecommunication to serve and help the people who riding horse by stimulate the movement of the horse using a mechanical structure feeding with special instructions to act as planned.
The implementtation is done by the following steps

- Study the mechanical walk, trot and canter movement of the real horse.
- Design and implement a mechanical structure to achieve a three movement (walk, trot and canter).
- Design an interface circuit with an arduino to make all the motors works together achieving the behavior of walk, trot and canter movements.
- Design an interface circuit to control the speed with the Arduino as requested with a control unit .
- Build a wireless hand gesture to control the activities of the movements using Arduino

The block diagram of the proposed system is shown in figure 1.

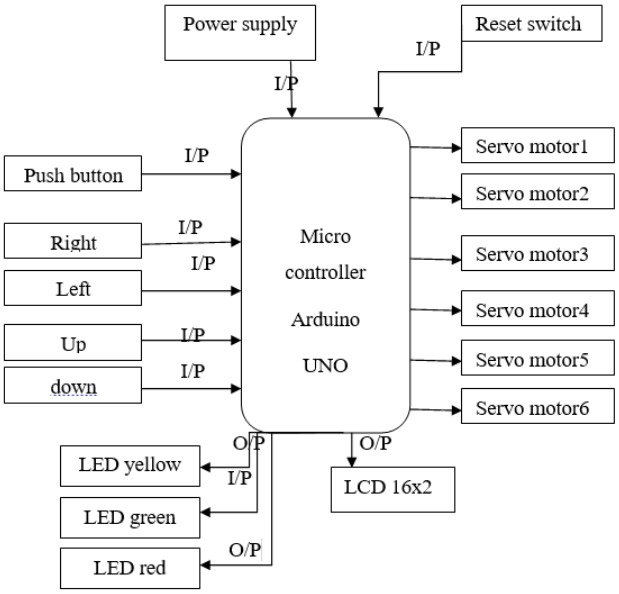

Figure 1. Block diagram of the Proposed System

The function of different block are:
Accelerometer: is a micro electro mechanical system it works by sensing the acceleration of the gravity.(in this case, replaced the accelerometer by the switch , because the component not existed in the protuse)
Arduino: it is a microcontroller board works as the brain of the system. It processes the data given and transfer it to
Crystal oscillator: it use to control the frequency which help to control the signal the feeding to the microcontroller. It has high frequency stability.
Servo motor: it is a mechanical device that supplied by commands to operate regarding to the instruction that given from the arduino to act as its request to move the six angle of the body.

The flow chart of the implemented system is provided in figure 2

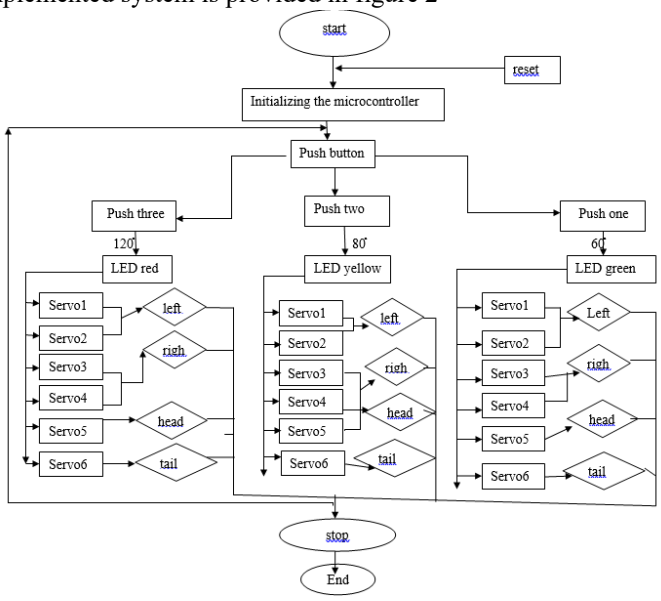

Figure 2 Flow Chart

System Implementation:

The proteus 8, professional simulation software is used for simulating the design. The visual design of simulating the 6 degree of freedom that representing the three movement of the horseback riding. The figure 3 shows the debugging component of the project and replacing switch as in control as input of the system.

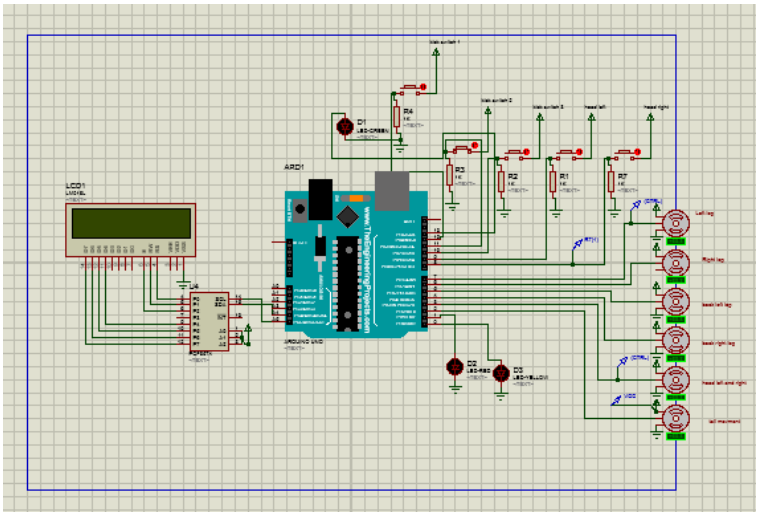

Figure 3. Simulation Implementation

Results

The verification power supply voltages at various test points are provided in Table 2.

Table 2. Testing point for the power supply

Test cases at test points	Design Value	Simulation value	Implemented value
T1	5V	6.05	5.4 V
T2	5 V	5.06	5.8 V
T3	5 V	5.03	5 V
T4	5 V	5.04	5.5 V
T5	5 V	5.08	5 V

For each test case scenario of the project verifies the requirements and test them that consists the inputs and their reaction on the system through the interference. In other words ,checking the procedures of the whole project and comparative the values with the expected values that help to improve the performance of the system. The Table 3 shows the hardware scenario and the results expected.

Table 3. The hardware scenarios and the results obtained.

NO.	Scenario	Expected result	Actual result
Test scenario 1	Verifying the reset mode	Sending position information to all servo motors. (0)	The angle of the position verifies till reach 0
Test scenario 2	Verifying the walking mode	Sending position information from 0 to 30 clockwise and LED green turns ON	The angles of the servo motors change in sequence as a loop through motors

Test scenario 3	Verifying the trotting mode	Sending position information from 30 to 60 clockwise and LED yellow turns ON	There is a delay in changing the values of angle
Test scenario 4	Verifying the cantering mode .	Sending position information from 60 to 90 clockwise and LED red turns ON	The speed is limited of the servo motors

Discussion

The system is a smart modern technology that utilize to improve this field of the sport. Replacing the hand gesture and the punch sensors by switches which are available in the protus tools . this switches refer to the rider punching to give the instruction to the system to move in a specific mode of movement . The three switches are connected to the arduino to give the servo motors commands to operate by a specific feature. one switch are design to form the walk mode of movement which make the servo motors that connected to the right front leg rotate with the same direction and speed of the left back leg and also same as the left front leg and right back leg . For the switch two are programmed to form the TROTT Mode which control the servo motor that connected to the legs to act as the real horse trotting which mean the two front legs move with same direction and same speed , also the back two legs move together with same direction. The third switch is design to form the CANTTERING mode which is the same as the TROTTING Mode but with more speed . with considering the angle of each servo motor to act smoothly with each others and deciding the direction of the rotation by determining the signal as positive or negative. Furthermore, there are two switches are programmed to move the head and the tail through each mode of motion at the same time.
Beside the switched , there is LED for each mode of the movement that blending through the movement to alarm the users. The green LED refer to the WALK Mode , the Yellow LED mode refer to TROTT mode and RED LED refer to the CANTTERING mode. This LEDs are programmed to blind with each movement as alarming and educating purpose . Added to that , LCD 16*2 connected to the arduino to display the mode as characteristics and its program to act with three modes .
The system is design with different scenario based on the concept of the main movement of the horse and the rotation of the servo motors that connected to legs to control the motion of the body (Yukun 2010). The arduino process the data and flow through the components connected to acts as the data based that given in the program. This design prototype based of internet of things (IOT) to control a body remotely and display information based on the orders that given .

Conclusion

The aim of the proposed system shows the design of horseback riding simulator that make riding horse for whatever reason is more efficient and scalability. Also producing a model of horse movements using data flow to make it acts as such requirements and transfer this requirements into a complete designed system and controlling it according to the switches that sent by the users . The angle of each servomotor are design with respect to the body of the rider, because by increasing the rotation angle may cause hurt to the rider. On programming the servomotor, considering that can't give more than one order in the same time, and adding the loop feature to repeat the movement repeatedly. The response of the system showed on the simulation was very good and can be more effective in the real life as a product.

Limitations

The main limitations of the implemented systems are

- There is no visual field that can interact with the rider,
- The horse movements and facilitating data collection is difficult
- Postural control training various from age to another

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