Initial Study on Electro-Mechanical Artificial Insemination (AI) Device for Small Ruminants.

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Abstract: - This paper presents an initial prototype construction of an electro-mechanical artificial insemination (AI) device for goats. AI technique is low cost and simple to perform, however the labor cost is steep for experts. To reduce the cost and increase the accuracy of AI, a device which is capable on visualizing the os of cervix is constructed, along with a built-in circuit utilizing a PIC as its brain. The device functions well as pre-programmed in the PIC, however the operation time is quite slow hence further improvements are required.

Key-Words: - Artificial Insemination, Electro-mechanical device, Assisted reproductive Technology

1 Introduction

In the continuously growing population of the world, small ruminant's production mainly in goats is at a critical level due to the high demand from time to time as a multi-purpose animal. Demand for goat, mainly meat, exceeds the supply of meat. In consequence of this, several reasons have been identified as the potential reasons that may contribute to this factor. This includes low reproduction rate and low kidding rate. Thus, the method of breeding needs to be improved to fulfill the demand.

Various practices or methodologies have been used in different species to improve reproductive efficiency. However, how to effectively increase the kidding rate is crucial. There are several assisted reproduction technologies (ART) utilized to manage goats' reproduction. These include embryo transfer (ET), in-vitro fertilization (IVF) and artificial insemination (AI). Artificial Insemination in particular plays an important role in goats breeding, especially in intensive systems reproduction control. The application of AI has proven as one of the ART that improves genetics. One main disadvantage of AI is the accuracy rate is low and the labor cost incurred is quite steep.

In this paper, the author focuses on the application of AI using an easy-to-operate and user-friendly electronic device to increase the accuracy of AI. Continuous usage of the proposed device will subsequently eliminate the need for experts, hence reducing the labor cost significantly. Hence, the main objective of this research is to propose an electromechanical AI device, equipped with a camera and an LED light to increase the accuracy of artificial insemination technique, hence improving the reproduction of goats.

2 Problem Formulation

In dairy goats industry, there are several methods used to manage goats' reproduction. Although there is seasonal natural breeding, goats' reproduction is improved with the development in ART. The application of ART helps to enhance the differences in selection between artificial insemination and embryo transfer while other methods speed up the progress by reducing the generation gap. In addition to that, ART allows animal with good genetic to engender more progeny compared to natural breeding.

Artificial Insemination plays a significant role in goat reproduction, particularly in concentrated systems of production to control reproductive performance, and in conjunction with accurate progeny testing, to improve the production of milk, hair and meat [1]. Moreover, it has become a practical technology in commercial dairy programs in developed and developing countries. Other than that, AI is one of the most widely used ART to improve genetics [2].

Artificial Insemination is actually practiced by flying insects and later invented by human for animals' reproduction. Apart from goats, this

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technology is also used in the breed development of sheep, horses and also swine. This method involves collection of semen from buck and it is transferred to reproduction tract of selected doe. Based on the experiment that has been conducted before, AI shows about 65% accuracy of kidding rate [1].

Compared to other methods, AI has the advantages in terms of cost as well as genetic improvement. AI is not complicated and it is cheaper compared to other method, and it is widely used for spreading genes [6]. Since frozen a semen could be used at anytime, during reproductive, or non-reproductive seasons and alleviate international exchange of genetic material p7], the applicability is very wide.

In addition to that, AI enables the use of frozen semen even after the donor is dead. The semen can be stored inside a nitrogen tank for long-term use without losing the viability. Besides that, this technology provides progeny testing under environment and managerial condition which help to improve the rate and efficiency of genetic selection. Other than that, AI is very effective in controlling venereal diseases.

A successful insemination process requires the technician in charge to deposit the semen using an insemination gun into the reproductive trait of female goats during a proper time. The technician responsible on the insemination process must be someone who is an expert and well trained about the equipment as well as the reproductive cycle of goats. This is to ensure the synchronization and detection of estrus is done accurately.

During AI, a normal operation requires a minimum of two persons to handle. The hindquarter of the doe is lifted up for easier insertion of the speculum and insemination gun as shown in Fig 1. An AI light can be used to assist in the visualization inspection. Although the AI process itself is simple and low cost, the application however, is very limited since the cost to hire an expert is very high.

Figure 1. Manual AI process

3 Hardware Construction

Since AI is the most commonly used method in ART, its applicability is then extended so it can be conveniently used by breeders in general. Hence an insemination device with built-in sensors and visual is proposed for the convenience of the inseminator. This in turn will indirectly improve the reproduction of goats.

To perform the tasks pre-defined for the device, the author uses a microcontroller a PIC 16F877A in particular, as shown in Fig. 2. Microcontroller can be defined as an integrated electronic computing device that includes three major components on a single chip, which are microprocessor, memory and input/output (I/O) ports. This particular PIC is utilized since it has 40 pins, hence many I/O connections are allowed to one PIC. This PIC serves as a brain of this device whereby all the instructions are written in *C* language and then installed into the PIC. Three basic requirements for PIC are power, which is V_{dd} (5V) and V_{ss} (0V), oscillator – that used to determine the speed of microcontroller to execute the program, read input and write outputs, and also Reset (MCLR) to reset microcontroller to the start of the program. The pin diagrams for PIC16F877A are as shown in Fig. 2.

To perform any task in the device, a motor and its driver is requires. As an initiation, the author uses a brushed DC motor and its driver, MD10C. The low cost and its ability to drive high current brushed DC motor of 10A continuously, makes this motor and its driver a significant choice.

To control the degree of gun during the insemination process, a potentiometer is used. There are a few options to be chosen by the technician, depending on the goats' size. The standard degree is ranged between 20˚ to 30° from the vulva.

To control the distance of the gun movement, an IR sensor is used. IR sensor is a detector that reacts to infrared (IR) radiation. In the proposed device, this sensor is placed below the slider so that it can detect the black and white strap on the steel.

The schematic diagram for the PIC kit is shown in Fig. 5 in Appendix.

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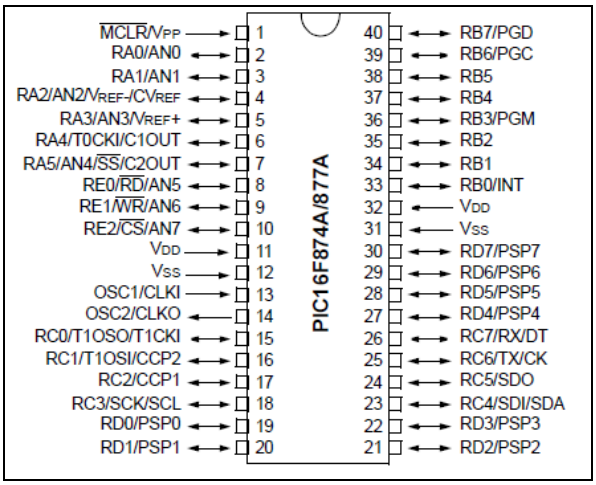

Figure 2. PIC pin diagram

4 Software Development

To configure the PIC microcontroller, MPLab, in *C*-language environment is used. MPLab is used to simulate the program that controls the whole system Adjustable parts include the length of *X*, *Y* and *Z*-axis as well as the angle gun, depending on the goats' sizes.

After the program is successfully assembled, it will be transferred or burnt into the PIC using PICkit2 in the MPLab environment. The working flow of the device are now stored in PIC. Next, the integration of software with proposed device was done.

5 Problem Statement

The research is focused on creating a semi-automated AI device with an additional camera and light on the insemination gun for easier operation. The function of the camera is to accurately visualize the os of cervix hence making the insemination process easier.

In dairy goat industry, this device will be very helpful especially when handling a large amount of goats. In addition to that, with the addition of the camera and light, the person in charge could handle the process themselves without the need for an expert. Therefore, labor cost can be significantly reduced, subsequently. Other than that, this device is able to handle mass production better compared to the existing manual method.

Other than that, the functionality of previous insemination gun is not used friendly and one crucial requirement is that the handler must have a lot of experience to ensure the semen is deposited at the right point during the process. Hence, many local goat farmers choose to use natural breeding method for

6 Results

The proposed device include an installment of gate at the front of the stand, the leg strap at the back stand and an insemination gun on top of the device as shown in Fig. 3. The insemination gun is not installed as yet since it is not readily available, and the cost to purchase one is very high.

The function of the gate is to protect the goats during the insemination process. The gate will be closed once the goat entered and will be opened when the insemination process is done. For the leg strap, it is added to make the process easier. After the legs are safely tied, the doe's hindquarter is lifted up to a certain degrees depending on the goat's size.

Insemination will be attached on the top part of the stand where the camera and an LED light will be installed.

Figure 3. Proposed AI device

PIC microcontroller is used to control this device as it serves as the brain. To control the device, four motors are used. These motors are located at four different points as shown in Fig. 4. These locations enable the movement of the device in *X*, *Y* and *Z* direction as well as at an angle between 20º to 30°.

In Fig. 4, motor A is used to control the up and down movement of the slider. Motor B moves the slider in forward and reverse direction while the motor C controls the angle of the insemination gun. Finally motor D controls the left and right movement of the insemination gun.

Since the motors cannot be directly connected to the PIC, motor drivers are used to

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drive the motor and to provide sufficient voltage to the motor. A PS2 controller is used to control the operation whereby the person in charge could monitor the movement of the PS2 controller starter kit or SKPS is used as an interface between the controller and PIC.

7 Functionality

To observe the functionality of the completed device, the operation time and the maximum and minimum adjustable angle of the speculum is recorded.

For the operation time, ten working samples are recorded as shown in Table 1. The average times for the *X* and *Y* axis are calculated to be between 50 to 60 seconds. While the angle movement takes 15 seconds and the speculum takes 2-5 seconds to operate.

8 Limitation

The proposed device yields a slow and noisy operation; hence better motors need to be used. The replacement motors will incur significant additional costs since a quiet and fast operating motor is expensive. In addition to that, some of the dimension of the device needs to be altered to accommodate the need of the AI process for local breeders. On top of that, when the device was studied more closely, there exists redundant amount of motors, hence few needs to be eliminated.

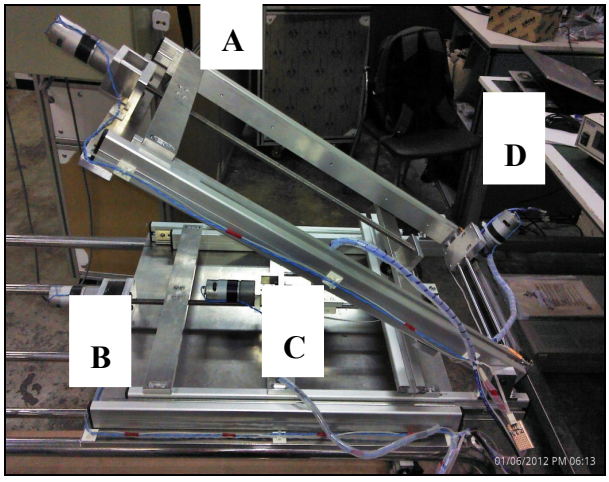

Figure 4. Motor Locations

9 Conclusion

In this paper, an electro-mechanical AI device is constructed. The device enables the operation of AI to be performed more accurately and subsequently reducing the labor costs. The device provides many advantages to the breeders as well as the technician in charge hence can be commercialized in the future. However, there are numerous weaknesses identified and highlighted that require further improvement from the manufacturer before this device can be implemented fully.

TABLE 1. Operation Time

Step	Length	Time (sec)
Reverse	20cm	60
Forward	20cm	60
Down	40cm	50
Up	40cm	50
Yaw up	20-30	15
Yaw down	20-30	15
Speculum	10cm	2-5

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