DESIGN OF PRECISED ANESTHESIA INJECTOR

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ABSTRACT

Animal experimentation are necessary for better understanding of diseases and for developing new therapeutic strategies. With the establishment of rodent models as preferred models for the study of various diseases, the effects of anesthesia on rodents have become paramount for basic science. When using animals in vivo research, there is an ethical and legal responsibility to alleviate or at least reduce pain to an absolute minimum. The problems that arise when anaesthetizing rodents are related primarily to the small body size of these species. Their high surface area to body weight ratio makes them particularly susceptible to the development of hypothermia; intravenous drug administration is limited by the size of the superficial veins and the small & relatively inaccessible larynx makes endotracheal intubation difficult. A further consequence of the small size of these species is that the volumes of anesthesia required may be very small. With practical constraints, it is often simplest to select an inhalational anesthetic agent. In contrast to injectable anesthesia, inhaled anesthesia provides a stable and depth with less cardio respiratory influence, as induction can be achieved smoothly and rapidly in an anesthetic chamber and also using a face mask with anesthesia maintained breathing system. This project deals with the methodologies for delivering anesthesia through inhalation method using Arduino unit.

Key Words: *Embedded Systems, Arduino controller, Isoflurane, Sevoflurane, Anesthesia, Face mask, Inhalation method.*

I. INTRODUCTION

To achieve surgical anesthesia in animal experiment it is necessary to select the appropriate anesthesia protocol by considering its pharmalogical properties and surgical procedures to be performed. General anesthesia produces loss of consciousness so the animal can't consciously perceive pain. Providing the most appropriate and effective anesthetic regimen is an essential part of good experimental design. Anesthesia has profound effects on the physiological processes of animals and this can have a marked effect on experimental data. Other effects such as hypothermia may be secondary to the depression of various body systems. Some effects persist only during the period of anesthesia, other effects may continue for hours or days. When such interventions have been completed, the goal is often to have no other significant effects on the animal's physiology. Achieving these goals can be frustrated by the use of inappropriate anesthetics and a failure to provide high standards of peri-operative care. To provide anesthesia of the standard requirement in modern research laboratories, it is essential that adequate preparations be made before attempting to anesthetizean animal. Good pre-operative care will reduce the incidence of many of the complications that can occur during anesthesia and thorough preparation of facilities and equipment contributes to the smooth running of a research protocol. It is very important to consider the preparation of not only the animals to be anaesthetized but also the equipment, drugs, facilities and personnel involved in the procedure.

II. PROPOSED SYSTEM

This paper deals with the design and implementation of Anesthesia injector for small animal like rats, rodents and mice using Arduino controller. The method utilized in this paper is inhalation method using induction chamber and face mask to get best outcome. The health of the animal is continuously monitored by the parameters like heartbeat rate and respiration rate using the respective sensors. The dosage of anesthesia is calculated based on the weight of the animal sensed by the weight sensor. Finally the calculated anesthesia is induced by the motor pump into the induction chamber for the calculated time period to induce the calculated percentage of dosage and then to the face mask to induce remaining percentage of anesthesia.

III. SYSTEM ARCHITECTURE

The software used in this paper is Arduino IDE (Integrated Development Environment) open source hardware feature which enables users to develop their own kit using already available one as a reference source. It comes with an easy provision of connecting with the CPU of the computer using serial communication over USB as it contains built in power and reset circuitry. Embedded C is most popular programming language in software field for developing electronic gadgets. It is used because it is easy to understand, high reliability, portability, scalability. Hardwares used in this paper are ARDUINO MEGA (ATmega2560) microcontroller which acts as brain of the system, because the entire system program instruction is stored in it. The heartbeat sensor, respiration sensor, weight sensor, LCD display, air pump motor, 12V solenoid valve, relay, induction chamber and face mask are connected to the Arduino controller. The power supply to the Arduino is supplied by the PC or computer. The analog value of the sensors is converted to equivalent digital value by the Arduino itself, since Arduino has in-built A/D converted.

3.1 Arduino Software (IDE):

The Arduino Integrated Development Environment or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

3.1.1 Embedded C:

Embedded C is most popular programming language in software field for developing electronic gadgets. Each processor used in electronic system is associated with embedded software.

Embedded C programming plays a key role in performing specific function by the processor. In day-to-day life we used many electronic devices such as mobile phone, washing machine, digital camera, etc. All the devices is working based upon the microcontroller that are programmed by embedded C.

In embedded system programming C code is preferred over other language. Due to the following reasons:

- Easy to understand
- High Reliability
- Portability
- Scalability

3.1.2Writing Sketches:

Programs written using Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and are saved with the file extension **.ino**. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

A. Arduino Mega 2560:

The Arduino Mega 2560 is a microcontroller board based on the ATmega 2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog input, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

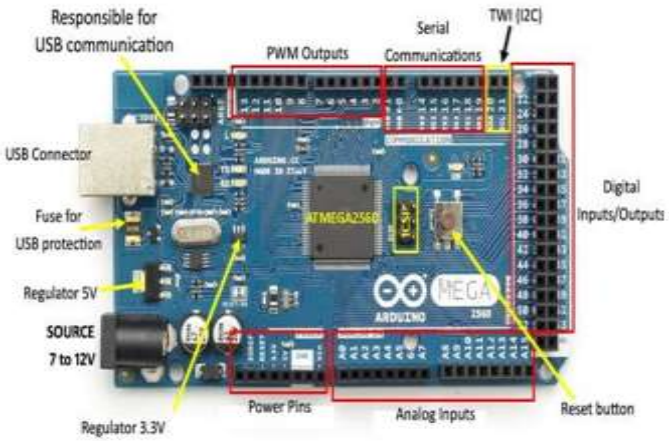

Fig.1 Arduino Mega 2560

B. Liquid Crystal Display:

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5×7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data is the ASCII value of the character to be displayed on the LCD.

C. Respiration Sensor:

Respiratory rate is a vital physiological signal in laboratory rodent's research. A non-invasive method based on resonant humidity sensor is used for monitoring respiratory rate of rats. The sensor is composed of an aluminium nitride resonant micro-cantilever coated with graphene oxide film. The sensor shows high sensitivity and good repeatability. The method has advantages of fast response, small size and low cost. Furthermore, the respiratory rate of rats can be non-invasively monitored by integrating the sensor with a face mask.

D. Heartbeat Sensor:

The heartbeat sensor used is Pulse oximetry sensor. Pulse oximetry is a measure of how much oxygen is in the blood. It measures the percentage saturation of arterial blood by detecting changes in the absorption of light across the tissues. A variety of probes of different shapes and sizes are available. Both reusable and disposable probes can be obtained. It is a simple non-invasive sensor clips, uses USB plug and play. It has high accuracy at heart rates up to 900 BPM.

E. Weight Sensor:

This is a force sensitive resistor (**FSR**) with a square, 1.75 x 1.5″ sensing area. This FSR will vary its resistance depending on how much pressure is being applied to the sensing area. The harder the force, the lower the resistance. When no pressure is being applied to FSR its resistance will be larger than 1MΩ. This FSR can sense applied force anywhere in the range of 10g-10kg. Two pins extend from the bottom of the sensor with 0.1″ pitch making it bread friendly. There is a peel-and-stick rubber backing on the other side of the sensing area to mount FSR.

F. Solenoid Valve:

12 volt solenoid valves are available in direct current (DC) and alternating current (AC) versions. Most 12V DC solenoid valves are of the 2-way type used for the simple on/off control of water, air, petrol/gasoline or diesel fuels or gases. In the case of a normally closed (fail-safe closed) solenoid valve when 12 volts is applied the solenoid valve opens allowing flow. When the 12 volts are removed from the solenoid valve then the valve will automatically close and prevent flow along the pipe. For a normally open solenoid valve then the opposite is true, i.e. the solenoid valve fail-safe position is open and when power (12v) is applied the solenoid valve will power close.

G. Relay:

Relays are the primary protection as well as switching devices in most of the control processes or equipment. All the relays respond to one or more electrical quantities like voltage or current such that they open or close the contacts or circuits. A relay is a switching device, as it works to isolate or change the state of an electric circuit from one state to another.

H. Air Pump Motor:

A DC motor converts direct current electrical power into mechanical power. Pumps operate by some mechanism (typically reciprocating or rotary) and consume energy to perform mechanical work by moving the fluid. An air pump is a pump for pushing air. All air pumps contain a part that moves (vane, piston, impeller, diaphragm etc.) which drives the flow of air. When the air gets moved, an area of low pressure gets created which fills up with more air. Compressed air allowed for better and more powerful pneumatic tools that helped the growth of big cities through the process of construction.

I. Induction Chamber:

Induction chambers offer an easy method for anesthetizing small animals and rodents in a research laboratory. These units are designed with sure seal lids and may be connected directly to the bio-evacuation system to prevent laboratory personnel from unnecessary exposure to the anesthesia.

J. Face Mask:

The face mask are designed to tightly and flexibly fit on various size rodents. The optically clear masks are designed to provide access to the eyes and head of the rodent. These masks provide stability of the animal for examinations and surgery and they may be trimmed for custom applications.

IV. ANESTHESIA- THE PAINLESS SURGERY:

The word **"anesthesia"** means **"loss of sensation".** Anesthesia prevents the feeling of pain and other sensations during an operation. Anesthetic is the term applied to the drugs used to produce anesthesia. There are number of anesthetic agents available these days.

Anesthetics are mainly categorized into two types:-

1. Intravenous Anesthetics – injected into patient's body through needle
2. Inhalation Anesthetics – patient has to inhale the anesthetic

4.1 Mode of Administration:

- Inhalation
- Injectable

4.2.1 Inhalation:

Inhalation anesthesia is very useful for many surgical procedures. An advantage is that, there is a rapid induction & recovery phase and less cardiopulmonary depression. Some of the commonly used inhalation agents are,

- Isoflurane
- Sevoflurane
- Halothane

4.2.1.1 Isoflurane:

1. The isoflurane is probably the most commonly used inhalant anesthetic in laboratory animals currently.
2. It is a profound respiratory depressant at higher concentrations

3. It has quick induction (3-5 minutes at 5%) and recovery times
4. It is a respiratory irritant so animals will initially hold their breath or hold their heads up to avoid breathing it in.
5. It is heavier than air in its vapour form so will "sink" to the lowest portion of the area it is being used in.
6. It reduces pain sensitivity but is not an analgesic (it simply causes unconsciousness)

4.2.1.2 Sevoflurane:

1. Sevoflurane is not yet commonly used in laboratory animals but will likely to become more popular (current about 3 times the cost of isoflurane).
2. It causes the respiratory depression at the higher concentration (though less than isoflurane)
3. It has quick induction (less than 1 minute) and recovery times
4. It does not irritate the respiratory tract so is "pleasant" to breathe (smells a bit like vanilla)
5. It is associated with increased intracranial pressure (avoid in head trauma models)
6. It reduces pain sensitivity but is not an analgesic (it simply causes unconsciousness)
7. It causes muscle relaxation
8. It has minimal effects on heart rate and blood pressure at surgical levels of anesthesia

4.2.1.3 Halothane:

1. Halothane is used to be very commonly used in both human and animal anesthesia but it has been removed from the market due to the health concerns of chronic exposure to the waste anesthetic.
2. While using halothane occupational safety is a serious concern. Inhalants must be directly vented out of the room or less reliably adsorbed in a charcoal canister filter.
3. The filters used must be weighed and replaced before they reach target weight (usually an increase of 50gm). Note that charcoal filtration is not accepted as a safe scavenging system by UBC Health, Safety and Environment.

4.2.2 Injection:

Injectable anesthetics are used for the induction and maintenance of a state of unconsciousness. Anesthetists prefer to use intravenous injections, as they are faster, generally less painful and more reliable than intramuscular or subcutaneous injections. There are two anesthetic agents such are

- Xylazine (i.e. Rompun) & Dexmedetomidine (i.e. Dexdomitor)
- Ketamine (i.e. Ketalean, Ketaset)

V. PROPOSED SYSTEM:

The flow chart describes the process of work which is shown in figure.2. This flowchart has the three sensors namely temperature sensor, blood pressure sensor and heartbeat sensor. The values from these are measured using computer interface. Based on the measured weight value, the dosage of anesthesia is calculated. The calculated anesthesia is induced through induction chamber and face mask.

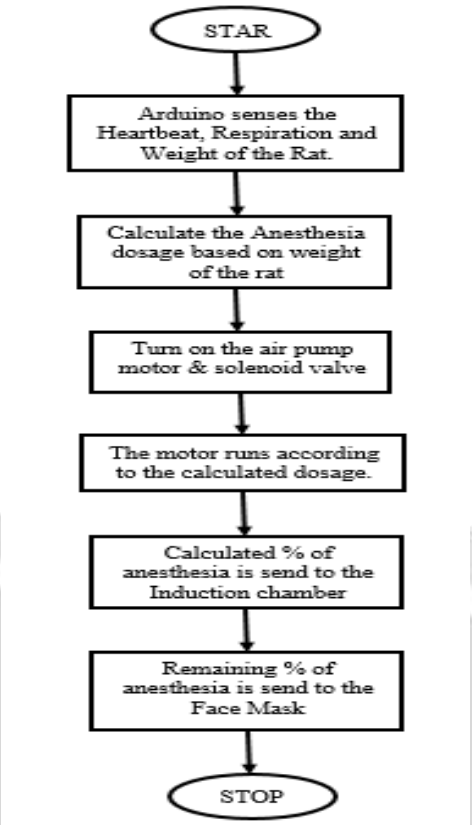

Fig.2 Flow Chart of the proposed system

In our proposed system, ARDUINO MEGA (ATmega2560) microcontroller acts as brain of the system as the entire system program instructions are stored in it. The heartbeat sensor, respiration sensor and weight sensors are used. The dosage calculations are done by the Arduino Mega controller. After the dosage calculation, the air pump motor is turned on by the Arduino based on the calculated dosage through relay. Which in turn connected to the 12V solenoid valve, so the anesthetic gas is first injected into the induction chamber and then to the face mask according to the calculated time period. The heartbeat rate and respiration rate of the animal will be monitored throughout the process.

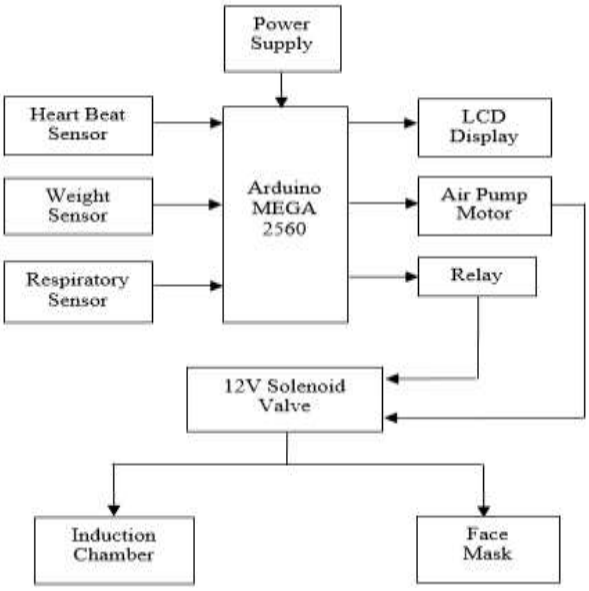

Figure.3 Block diagram of the system

VI. HARDWARE SETUP:

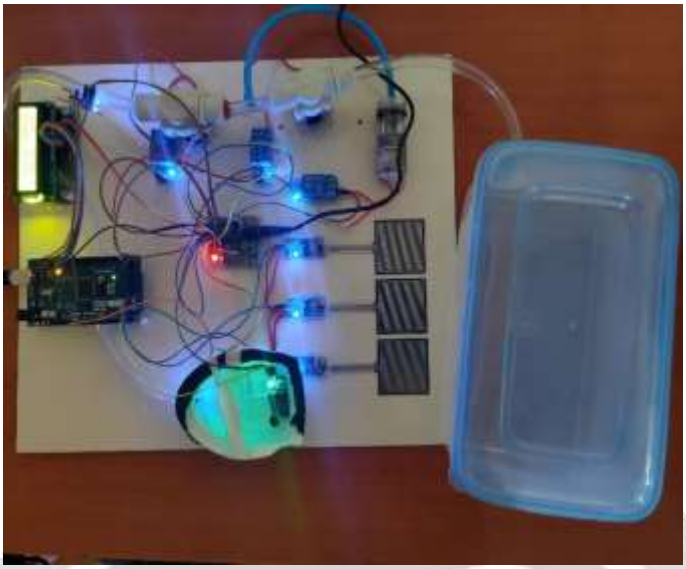

Fig.4 Hardware Setup

VII. SOFTWARE RESULTS:

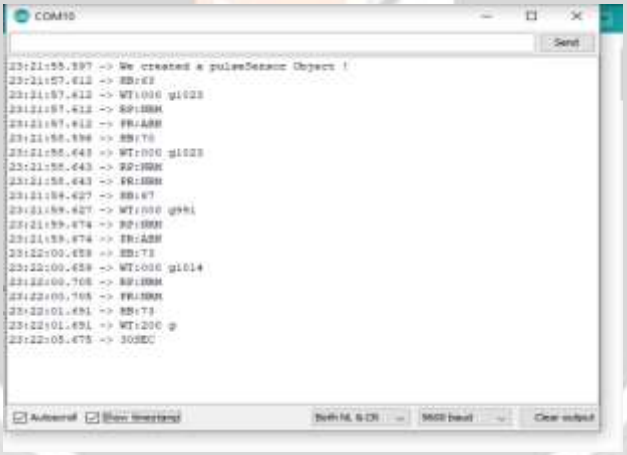

Figure.4 Software result for weight=200g

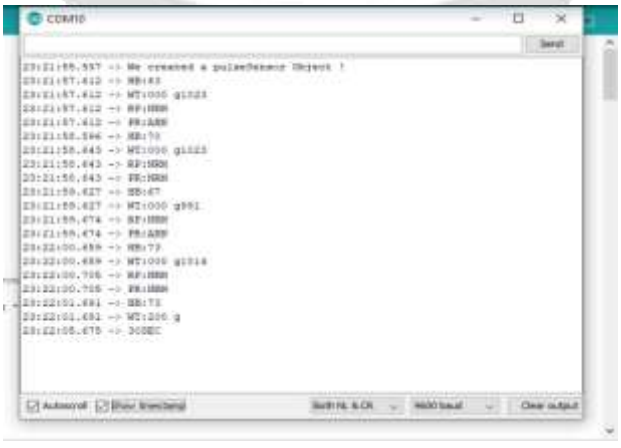

Figure.5 Software result for weight=150g

VIII. HARDWARE RESULTS:

Figure.6 At normal condition

Figure.7 Anesthesia is injected for 30sec

Figure.8 Pressure Rate is abnormal

Figure.9 Respiration Rate abnormal

IX. ADVANTAGES OF THE PROPOSED SYSTEM:

- Dosages are calculated accurately.
- The procedure is technically feasible and often preferred because it is precise, rapidly adjustable, safe and effective especially for procedures lasting more than 1-2 hours.
- The anesthetic agents used are not metabolized and therefore have little or no toxic effects. Also they are relatively insoluble in blood and therefore are "blown-off" quickly, providing a quick recovery.

X. CONCLUSION:

The proper use of anesthetics for surgery or other potentially painful procedures is crucial not only for the animal's wellbeing, but also for the integrity of the scientific data collected during the procedure. There are many variables that factor into choosing the appropriate anesthetic regiment. The depth of anesthesia must be closely monitored, as each individual animal can respond differently to the drug. With the use of the proper anesthetic and careful monitoring, painful procedures can be accomplished with no pain and minimal physiological changes in the animal.

XI. FUTURE SCOPE:

This paper can be implemented for the treatment of humans. So that the need of Anesthetic can be eliminated in the hospitals. And also during the emergency conditions, this project is very effective to calculate the dosage of anesthesia within short duration of time. Further when this project is implemented for humans some more parameters should monitored such blood pressure, neuron functions, etc. The dosage calculation of anesthesia can be improved by using both height and weight of the patient. So that most accurate anesthesia dosage can be calculated.

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