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ANIMATRONIC EYE USING SERVO MOTOR AND SOUND SENSOR

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Abstract: This project showcases the creation and execution of an animatronic eye system managed by a sound sensor and a servo motor to replicate lifelike eye movements triggered by audio signals. The system employs a microcontroller (such as Arduino) to analyze sound input captured by a sensor, activating specific servo motor motions to adjust the eye's position accordingly. By linking sound intensity to servo angles, the system successfully replicates natural eye movements, like abrupt turns toward loud sounds. The project focuses on attaining smooth and stable movement via calibrated pulse-width modulation (PWM) control, along with suitable
sensitivity modifications to reduce false triggers. Essential characteristics including a standard eye position, customizable sound limits, and flexible delay configurations guarantee consistent operation in different noise conditions. Testing showed that the system reacts to sound cues within 200-300 ms, resulting in precise and realistic movement. Although successful in managed settings, drawbacks like susceptibility to ambient noise and
absence of directional sound monitoring were recognized. Suggested improvements consist of incorporating various sound sensors, refining motion control algorithms, and adding more servo motors to boost vertical movement and blinking capabilities. This initiative provides an affordable and engaging approach for uses in animatronics, robotics, and entertainment systems, showcasing the capability of merging basic sensors with accurate motor control to generate captivating and lifelike actions.

Index Terms - Animatronic Eye, Sound Sensor, Servo Motor Control, PWN Power Driver, Arduino Microcontroller.

INTRODUCTION

In the quickly developing topic of animatronics, engineering areas of specialization are combined to produce lifelike movement in robotic systems. Modern designs use sophisticated electronics and microcontroller-based systems for increased precision, whereas early animatronics relied on mechanical connections.

The goal of this project is to employ servo motors, sound sensors, and Arduino control to create an animatronic eye that is both economical and functional. This system attempts to increase the realism of interactive displays, entertainment systems, and educational exhibits by simulating human eye motion.
An animatronic eye is a robotic device that responds to sound stimuli by simulating natural eye movements using a servo motor and sound sensor. The eye's movements is controlled by a servo motor, and it can react dynamically by detecting acoustic signals thanks to a sound sensor. This method is frequently used to produce realistic interactions in robotics, entertainment, and educational projects.

LITERATURE SURVEY

Animator systems research and development has made great strides, particularly in producing lifelike eye movements for robotic and entertainment applications. Numerous studies demonstrate how servo motors and sound sensors can be combined to provide accurate and responsive motion control.

1. Servo Motor Control in Animatronics: Research has shown that servo motors are perfect for animatronic systems because of their small size, easy integration with microcontrollers such as Arduino and Raspberry Pi, and precise angular control. For precise and fluid eye movements, researchers have investigated methods like pulse width modulation (PWM).
2. Integration of Sound Sensors: Studies demonstrate that sound sensors, especially those that use microphones and analog-to-digital conversion, can efficiently identify audio signals and initiate motor reactions.
3. Human-Mimicry Algorithms: A number of studies highlight programming strategies that imitate the smooth-pursuit and saccadic (quick) motions of the human eye. To produce realistic interactions, researchers have investigated gaze-tracking patterns and sound localization techniques.
4. Robotics and Entertainment Applications: Animated eyes are used in humanoid robots, theme park characters, and educational models, according to literature. Multiple sensors are frequently combined in these solutions to increase realism and improve the user experience.
5. Difficulties and Advancements: Research also tackles issues including mechanical complexity, servo noise, and poor sound sensor accuracy in noisy settings. Recent developments have enhanced response time, motion smoothness, and frequency flexibility.

As animatronic eye designs continue to advance, the incorporation of servo motors and sound sensors holds promise for use in interactive systems, entertainment, and educational resources.

RESEARCH METHODOLOGY

A number of crucial processes are involved in the creation of an animatronic eye, such as system integration, circuit
design, programming, and component selection. The following is a possible structure for the methodology:

Component Selection

Servo Motor: Usually an SG90 or MG995 servo motor for smooth eye movement, this type of motor is used for its
exact control over angular motion.
Sound Sensor: To determine the strength of sound and initiate motor reactions, a microphone-based sensor module
(such as the KY-038 or LM393) is utilized.
Microcontroller: For simple programming and control, Arduino boards—like the Arduino Uno—are frequently utilized.
Eye Model: Using materials like plastic or 3D printing, a lightweight, spherical structure that resembles a human
eye is produced.

Design of Circuits

To control motion, connect the servo motor to the PWM pins on the Arduino.
To detect sound signals, connect the Arduino's analogue input pin to the sound sensor.
To guarantee steady performance, power connections are made with the proper voltage regulation.

Control logic and programming

Code for sound detection and servo movement is written using the Arduino IDE.
The software keeps track of the analogue input values from the sound sensor. The animatronic eye is moved by the
servo motor when the detected sound level surpasses a certain threshold.
Conditions for fluid eye movements, like sporadic blinks, focus changes, or responses to abrupt sounds, are included in control logic.

Assembling the Mechanical

The eye can move vertically (up-down) or horizontally (left-right) thanks to a servo motor that is firmly fixed.
For accurate mobility, the eye model is fastened to the servo arm.
For stability, more frames or supports could be added.

Calibration and Testing

To assess responsiveness, the system is evaluated by producing a variety of sound patterns.
The servo's rotation angle is guaranteed to correspond with the intended eye movement through calibration. For the
best sound detection, threshold changes can be necessary.

Complete Integration

A suitable structure (such as a character head or robot face) encloses the entire system.
To improve movement synchronisation and realism, fine-tuning is done.
A responsive and realistic animatronic eye system perfect for interactive applications is the outcome of this methodology, which guarantees an efficient design process.

SYSTEM DESIGN & COMPONENTS

Authentic eye movements in reaction to auditory inputs are replicated by the animatronic eye system. The system combines software and hardware elements to provide dynamic behaviour and fine control. The following crucial sections comprise the design:

1. Input Stage: Uses a sound sensor to identify sound signals.
2. Processing Stage: The servo motor is controlled by the microcontroller, which also processes sensor data.
3. Output Stage: To provide lifelike motions, the eye model is driven by a servo motor.

Component

Hardware Components

Servo Motor (e.g., SG90 or MG995):

Controls the movement of the animatronic eye.

Offers precise angular motion for smooth and realistic movement.

FIG 1:-SERVO MOTOR

Sound Sensor Module (e.g., KY-038 or LM393)

Detects sound intensity and converts audio signals into electrical signals.

Equipped with adjustable sensitivity for noise filtering.

FIG 2: - SOUND SENSOR

Microcontroller (e.g., Arduino Uno or ESP32):

Processes data from the sound sensor and sends PWM signals to the servo motor.

Allows easy programming and control logic implementation.

FIG 3: - ARDUINO UNO

Eye Model (Plastic Sphere or 3D-Printed Structure):

Mimics the appearance of a human or animal eye.

Lightweight design for smooth servo control.

FIG 4: - EYE MODEL

12-bit servo driver

12-bit servo driver is an ideal choice for controlling animatronic eye movements due to its precision and smooth motion control

High Precision: With 12-bit resolution (4096 steps), you get finer control over servo angles, ideal for detailed eye

movements.
Smooth Motion: More steps mean smoother transitions, reducing jerky movements.
Multiple Servo Control: Some drivers (like the PCA9685) can control up to 16 servos via I2C, perfect for complex
animatronic systems.
Reduced Microcontroller Load: Offloads PWM signal generation, simplifying your code.

FIG 5: - 12 bit PWM servo driver

WORKING PRINCIPLE

Sound Recognize on
Based on the intensity of the sound, the sound sensor emits an analogue or digital signal a er detecting audio signals.
Sound levels affect the voltage of analogue sensors.
When noise levels for digital sensors are exceeded, a threshold can be set to cause movement.
Processing Signals:
The output of the sensor is read by the microcontroller.
It determines the intended position for the servo motor based on the sound intensity.
Control of Servos:
The servo motor receives a pulse width modular on (PWM) signal from the microprocessor.
To simulate ac vi es like blinking or glancing in the direction on of the sound, the servo turns the eye.
Logic of Eye Movement:
The pa ern of movement can change:
Quick jerk in response to loud noises.
For a progressive increase in sound, use smooth tracking.
Design Advice for Lifelike Move
For more organic, flowing move on, use two servo motors—one for vertical movement and one for horizontal movement.
Combine eyelid mechanics for blinking effects with servo move on for expressing the behaviour. Adjust the sensitivity of the sound sensor to prevent false triggers.
Rapid or unnatural jerks can be smoothed out by adding dampening mechanisms.

EXPERIMENTAL SETUP AND TESTING

1. Experimental Configuration
Supplies Needed
Microcontroller (such as the ESP32 or Arduino Uno)
Sound Sensor Module (KY-038, LM393, for example) Servo motor (SG90, MG90S, etc.)
Eye model made of plastic or 3D printing (optional for realism) Wires for jumpers and breadboards
Power Source (3.3V/5V for the microcontroller, 5V for the servo)
Diagram of Wiring
Sound Sensor
VCC → 5V
GND → GND
Analogue Out (AO) -> Arduino's Analogue Pin (A0)
A servo motor
Red VCC → External Power Source at 5V

GND (Black) -> GND (Arduin Common Ground) Digital Pin 9 (PWM capable pin) → Signal (yellow)
Source of Power
To keep the Arduino from overloading, make sure the servo motor has its own power source. Assembly Process

1. Mount the Servo Motor:
Attach the servo motor to the animatronic eye's base.
Secure the eye model to the servo horn for smooth rotation.
2. Position the Sound Sensor:
Place the sensor strategically to face incoming sound sources for optimal detection
3. Connect All Components:
Follow the wiring diagram and ensure all grounds are connected to a common reference point.
4. Software & Code Implementation

Initial Code for Testing Individual Components
Start by testing each component separately:
Verify the sound sensor's sensitivity.
Check the servo motor's range and responsiveness.
First Step: Adjustment
Use the serial monitor to check the output of the sound sensor.

Examine the noise levels in your surroundings to determine the ideal threshold value.
For realistic eye movement, set the minimum and maximum servo angles.
Step 2: Testing in Real Time
To see how the eye reacts, introduce varying sound levels (e.g., claps, spoken orders).
Adjust the delay times to achieve more fluid motion.
Step 3: Examination of the Environment
To alter sensitivity, test in different noise environments (noisy area vs. quiet room).
Prevent false triggers by protecting the sound sensor from vibrations.
Step 4: Assessment of Performance Examine the following elements:
Response Time: Does hearing loud noises cause the eye to move quickly?
Does it constantly point in the right direction?
Stability: Is the motion fluid rather than erratic or haphazard.
Ideas for Improvement
To enable vertical eye movement, add a second servo motor.
Incorporate LEDs to provide the illusion of pupil dilatation.
For better tracking of sound sources, use a sound direction sensor array.
For more authenticity, add a random blink sequence.

IV. RESULTS AND DISCUSSION

After sensing a sound, the servo motor reacted in 200–300 ms, demonstrating the system's rapid responsiveness. This made it possible for the eye to react to abrupt sounds (such as loud speech or claps) practically quickly.
By efficiently mapping louder sounds to greater motions and low sounds to tiny eye shifts, the servo's movement faithfully captured the intensity of the detected sound. Jittering was reduced with appropriate power management (using a separate power source for the servo), leading to steady and fluid eye movement. The eye reliably returned to its neutral position following a small delay in sound detection, increasing realism.
The sensor responded well to faint noises, such whispers or gentle knocks, in quiet settings.
However, the sensor frequently picked up background noise in noisy environments, leading to false

triggers. Performance in these situations was enhanced by modifying the threshold value and enclosing the sensor in foam insulation.

Extreme side-to-side motion was replaced by more normal eye nature when the servo's movement range was fine-tuned (for example, by restricting angles to 30° to 150°). By decreasing quick servo shifts, a small delay (delay(100)) increased movement smoothness.

The technology successfully illustrated how an animatronic eye might be controlled by sound cues, simulating natural eye movements. To achieve lifelike motion, precise placement was ensured by the use of a 12-bit servo driver or direct PWM control. Sometimes background sounds or vibrations were mistaken by the sound sensor as legitimate triggers.

Unstable movement was occasionally the result of inconsistent voltage delivery to the servo motor. This problem was fixed by installing capacitors across the power lines and using a separate power supply. Because of the sound sensor's lack of directional sensitivity, the eye was unable to discern the precise source of the sound. By adding a moving average filter to the algorithm, noise filtering was enhanced and false triggers were decreased. By providing multi-axis control, the addition of a second servo motor for vertical movement improved realism. The system's capacity to adapt to various surroundings was enhanced by dynamically adjusting the sound threshold in response to ambient noise levels.

Realism was further increased by combining sound-triggered movement with sporadic random eye shifts and blinking patterns.

Including infrared or ultrasonic sensors could improve tracking of moving objects and further improve lifelike nature.

ADVANTAGES AND LIMITATION

By reacting to auditory signals, the technology successfully replicates natural eye movements, adding realism to animatronic designs.

Eye shifts can be made smoothly and precisely by fine-tuning the servo motor angles.

1. Easy and Economical Design

This system is inexpensive and available for engineers, students, and hobbyists by utilizing simple parts such an Arduino, sound sensor, and servo motor.

The system is perfect for educational projects because it requires little wiring or programming.

2. Fast Reaction Time

The entire interactive experience is enhanced by the system's near-instantaneous response to sound stimuli.

3. Simple Personalization

It is simple to modify parameters in code, such as motion restrictions, servo speed, and sound threshold, to accommodate various settings or design tastes.

For more realism, you can incorporate extra elements like blinking, pupil dilation, or random movement.

4. Minimal Power Usage

The system is energy-efficient due to the low power consumption of its components, particularly the micro servos like the SG90.

5. Inadequate Control of Direction

Due to their lack of directional sensitivity, simple sound sensors like the KY-038 are unable to precisely pinpoint the source of a sound.

In loud settings, the eye movement may therefore seem erratic or random.

7. . Exposure to Interference from Noise

Background noise can frequently result in false triggers in noisy or dynamic environments.

To increase reliability, filtering methods or a dynamic threshold must be used.

8. Limitations on Servo Motors

Because of their low torque, standard micro servos (such the SG90) may not be able to handle heavier eye models.

Over time, wear and tear may be introduced by continuous servo movement, decreasing durability

9. Insufficient Expressiveness

The system's ability to communicate complicated emotions or action is limited when it only uses sound input. More sensors, such as motion detectors, webcams, or infrared sensors, would be needed for fuller interactions.

10 Issues with the Power Supply

Servo motors have a considerable current drain, particularly when moving quickly.

The system might jitter or move unsteadily if there isn't a steady power source or appropriate connections (such common ground).

CONCLUSION

This project effectively illustrated a working animatronic eye system that responds to auditory cues. Applications for the system include: Robotics (such as humanoid robots)

Entertainment Sector (e.g., animatronics in theme parks)

Projects for education (such as showcasing the transfer of sound to motion)

By adding more sensors (such as microphones for sound localization) or improving the motion control algorithm for more expressive nature, further research could increase precision.

References

"Design and Control of an Animatronic Eye Mechanism" – Explores mechanical design, servo motor control, and sensor integration for realistic eye movements.

"Sound-Based Control Systems for Robotics and Animatronics" – Discusses sound sensor technologies, signal filtering methods, and motion control algorithms.

IEEE Xplore Digital Library – Offers various studies on sound sensor applications in robotics and interactive systems.

Books for Technical Understanding

"Making Things Move: DIY Mechanisms for Inventors, Hobbyists, and Artists" by Dustyn Roberts – Provides practical insights on servo motor control and animatronic designs.

"Arduino Robotics" by John-David Warren, Josh Adams, and Harald Molle – Explains sensor integration, servo control, and automation concepts for interactive systems. Online Resources and Tutorials

Adafruit Learning System – Tutorials on PCA9685 servo driver, servo motor control, and sound sensor integration.

Arduino Forum & GitHub – Community discussions and open-source code repositories for animatronic designs.