International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 12 | Dec 2025 www.irjet.net p-ISSN: 2395-0072

EchoPaw: A Mini Robotic Dog

P Yashwanth[1], Y Deepika[2], Shivakumara S[3], Dr. Mohamed Saleem[4]

[123]UG Student, Dept. of Robotics and Artificial Intelligence, Bangalore Technological Institute, Karnataka, India
[4]Professor and Head of department, Dept. of Robotics and Artificial Intelligence, Bangalore Technological Institute, Karnataka, India

---

Abstract – *EchoPaw is a design of quadruped robotic system developed to connect human-robot interaction using offline voice commands, servo driven locomotion and AI based communication. The design is integrated with esp32 microcontroller, PCA9685 servo driver, sg90 continuous rotation servos, ultrasonic sensor and DFRobot offline voice recognition module to perform actions. A Bluetooth speaker is integrated in design where it can communicate with humans using LLM's live voice chat. it performs basic actions like sitting, walking, standing and waving hand. The design is developed in low cost, modular hardware and smooth locomotion. The developed design results reliable voice recognition, smooth locomotion and obstacles detection. This work highlights the potential of EchoPaw as an educational and research-oriented mini quadruped robot.*

Key Words: **Quadruped Robot, Voice Recognition, ESP32, Obstacle Detection, PCA9685, Servo Control, Human Robot Interaction.**

1. INTRODUCTION

Robots are also being used to serve as assistance, learning and interactions. Among the various robots the most commonly used robots are quadruped robots where the design we developed similarly looks like dog. Most of the robotic dogs available now requires controls via the internet or voice assistance. The EchoPaw includes the functionality to respond to verbal commands, carry out the dog like action and communicate with the user by give human like voice. The design developed in low cost components responds to human voice as response.

1.1 Relevance Of The Study

This project is relevant because it is centered on developing an interactive robot that is low cost with offline control. In recent years, there has been a rising need for robotic companions and intelligent assistants. The problem with most modern robots is that they are costly to implement. The use of EchoPaw robot is a sensible alternative because it employs components that are readily available, such as ESP32, servos and sensors.

The implementation of offline voice recognition means that the robot is reliable even when there is no internet connection. This is particularly useful in a classroom setting, a laboratory or even indoors. The project is useful for educating students on the concept of embedded systems, robotics as well as interactions with a robot.

1.2 Feasibility study

1. **Technical feasibility:** its uses commonly available components ESP32, SG90 servos, ultrasonic sensors and servo driver. All these modules are easy to program and integrate in the system we opt.

2. **Economic feasibility:** all the components used in the design is low cost and affordable for student projects.

3. **Operational feasibility:** the design is used in indoor only.it gives a stable performance due to offline recognition module and safely operated due to obstacle detection

2. LITERATURE SURVEY

1. **Paper Title: Speech Interaction with an Emotional Robotic Dog**

Author: Christian M. Jones, Andrew Deeming

Abstract and relevance: In the future, consumer electronics will be aware of how people feel in order to create experiences that will be more natural, engaging, entertaining, and productive. This paper describes a emotionally responsive robotic dog. The dog can tell how its user feels by listening to sounds and then acts in response. It explains how the acoustic emotion recognition works and how it is used inside the robotic dog.

2. **Paper Title: On the Robustness of Speech Emotion Recognition for Human-Robot Interaction with Deep Neural Networks**

Author: Egor Lakomkin, M.A. Zamani, Cornelius Weber, Sven Magg, Stefan Wermter

Abstract and relevance: The area of Speech Emotion Recognition (SER) is critical in human-robot collaboration. Furthermore, SER has attracted a lot of research interest. This paper investigates how noise from different real-world environments affects advanced neural networks used for SER, specifically through use of the iCub Robot. The study concluded that both robot ego noise and room acoustics had a negative effect on the accuracy of SER models. In addition, the study showed that the application of data augmentation

methods, including adding background noise and loudness variation to the input data, increased both model performance and its ability to adapt to real-world situations.

3. Paper Title: Emotion Detection for Social Robots Based on NLP Transformers and an Emotion Ontology

Author: Wilfredo Graterol, Jose Diaz-Amado, Edmundo Lopes-Silva, Yudith Cardinale, Cleia Santos-Libarino, Irvin Dongo

Abstract and relevance: To create robots that can socially interact with humans, these robots must recognize the user's emotional state. This requires gathering various types of data from the user, including text, speech, images, and video. By doing this, the robots can perform emotional state recognition and identification. The robots use machine-learning or NLP techniques to determine the user's emotional state and evaluate it.

This research will build a framework using EMONTO, an existing emotional ontology. EMONTO includes conceptual models for recognizing emotional states and semantic storage for identified emotional states. A prototype framework has been created as a guide for museum tour robots. It determines the user's emotional state through voice recognition of text, then applies NLP models and stores that information in ontology. This approach can achieve performance levels that meet or exceed those of the best models currently available.

4. Paper Title: Multimodal Emotion Recognition using Transfer Learning from Speaker Recognition and BERT-based models

Author: Sarala Padi, Seyed O. Sadjadi, Dinesh Manocha, Ram D. Sriram

Abstract and relevance: Automatic Emotion Recognition (AER) enhances Human-Computer Interaction (HCI) by enabling AI systems to have an "emotional intelligence" component. We present a multimodal AER framework that applies late fusion to combine a speech-based Res Net model and a text-based BERT model. The results of this work demonstrate the use of transfer learning and data augmentation techniques to optimize the performance of AER systems and maximize their ability to generalize to new datasets. The study also used the IEMOCAP dataset to evaluate the performance of the multimodal approach for AER.

3. EXISTING AND PROPOSED SYSTEM

3.1 Existing System

Typically, the devices use remote control or Internet based voice assistance applications to control robots. Most of the robots are limited in their movement and are not capable of intelligent interaction. Most often, robots do not include anti-collision/safety features, and as such, robots can crash or sustain damage.

3.1.1 Disadvantages of Existing System

- Dependence on internet or smartphone applications
- Limited interaction and intelligence
- Lack of autonomous safety features
- High cost for advanced robotic pets

3.2 Proposed System

EchoPaw is a mini robot dog that can perform different tasks such as walking, turning, sitting, and standing based on voice commands. It uses ultrasonic sensors to detect obstacles and stop on its own. It can also interact with its user by responding through a Bluetooth speaker. This system is valuable for education because it teaches in an interactive and safe way.

4. OBJECTIVE AND METHODOLOGY

4.1 Objective

- To design a mini quadruped robotic dog
- To implement offline voice-based control
- To ensure safe operation using obstacle detection
- To provide interactive communication through voice responses
- To build a low-cost and easy-to-use robotic system

4.2 Methodology

The project starts by choosing the right hardware components, including ESP32, servo motors, and sensors. First, the robot's mechanical structure is put together. Then, the servo motors are programmed to do basic movements. We train voice commands and link them to robot actions with an offline voice recognition module. We add ultrasonic sensing for obstacle detection. Finally, we test and validate Bluetooth-based conversation interaction.

5. DESIGN CONSIDERATION

The design of EchoPaw emphasizes simplicity, balance, and safety. Four servo motors control the legs, enabling stable quadruped movement. An ultrasonic sensor is located at the front to detect obstacles early. Power comes from a Li-ion battery with a buck converter that keeps a stable voltage. The system is set to stop immediately when it detects an obstacle or receives a stop command.

6. MATERIAL IDENTIFICATION AND SPECIFICATION

Table -1: Components and Specification

Component	Specification	Purpose
ESP32	Dual-core MCU with Bluetooth	Main controller
PCA9685	16-channel PWM driver	Servo control
SG90 Servo	360° continuous rotation	Leg movement
Ultrasonic Sensor	2–200 cm range	Obstacle detection
Voice Module	Offline voice recognition	Command input
Battery	Li-ion with buck converter	Power supply

7. WORKING PRINCIPLE

EchoPaw mainly operates through voice commands. When a user gives a command, the offline voice recognition module picks it up and sends it to the ESP32. The controller activates the servo motors to carry out the necessary movement. While the robot is in motion, the ultrasonic sensor constantly checks for obstacles. If it detects an object within a safe distance, the robot stops right away. At the same time, a Bluetooth speaker delivers voice responses using ChatGPT Live, making the robot interactive. Safety monitoring is active in all operating modes.

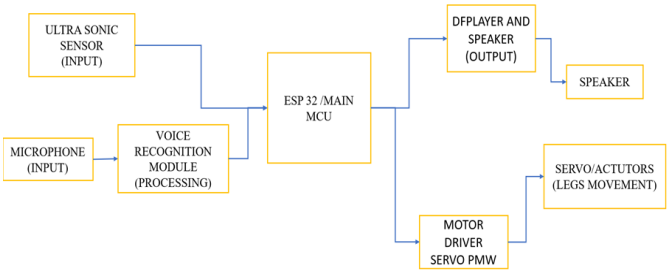


Fig -1: Block Diagram

8. RESULTS AND DISCUSSION

The robot responded successfully to all trained voice commands. Its movements, including walking, turning, sitting, and waving, were smooth and stable. Obstacle detection was effective, which helped prevent collisions. The interactive voice responses increased user engagement. Overall, the performance was reliable in indoor settings. And few supported commands are

Supported commands are:

- Hello Robot
- Move forward
- Move backward
- Sit down
- Stand up
- Turn left
- Turn right
- Wave hand
- Stop

9. CONCLUSIONS

EchoPaw is a small robotic dog that uses voice control, moves on four legs, detects obstacles, and allows for interactive communication. The system works well with offline voice commands and keeps safety in mind while moving. Although the robot is still being developed, it successfully meets the project goals and offers a solid foundation for future improvements.

10. FUTURE ENHANCEMENT

- Adding camera-based vision
- Improving walking patterns
- Introducing emotional expressions
- Enabling autonomous navigation
- Enhancing power management

REFERENCES

[1] C. M. Jones and A. Deeming, "Speech Interaction with an Emotional Robotic Dog," Proc. *Interspeech Conference*, vol. 1, no. 1, pp. 1757–1760, 2008.

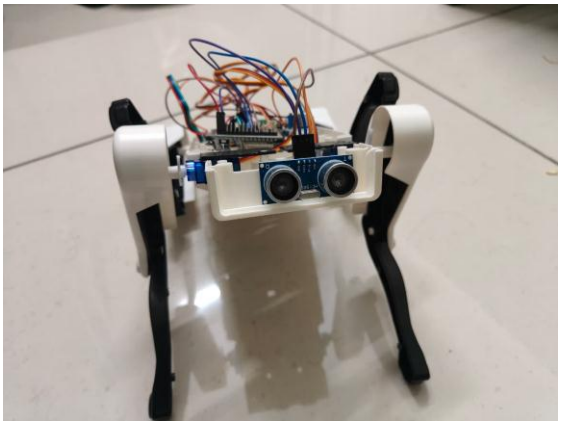
[2] E. Lakomkin, M. A. Zamani, C. Weber, S. Magg, and S. Wermter, "On the Robustness of Speech Emotion Recognition for Human–Robot Interaction with Deep Neural Networks," *Proc. ACM/IEEE Int. Conf. on Human–Robot Interaction*, vol. 3, no. 1, pp. 27–35, 2018.

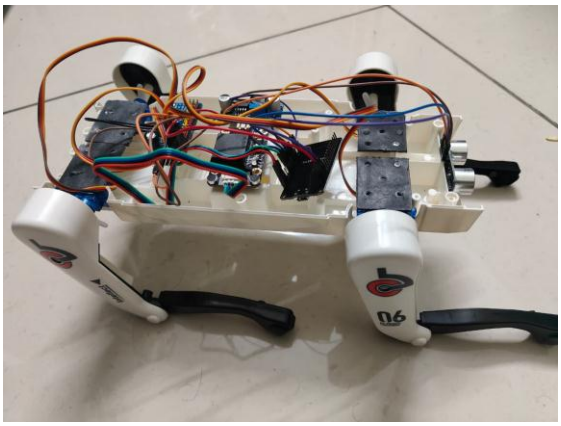
[3] A. Chakravarty, J. K. Tripathy, S. Chakkaravarthy, and A. K. Cherukuri, "e-Inu: Simulating a Quadruped Robot with Emotional Sentience," *International Journal of Robotics and Intelligent Systems*, vol. 10, no. 2, pp. 145–158, 2023.

[4] S. Padi, S. O. Sadjadi, D. Manocha, and R. D. Sriram, "Multimodal Emotion Recognition Using Transfer Learning from Speaker Recognition and BERT-Based Models," *IEEE Access*, vol. 10, no. 1, pp. 118450–118462, 2022.

[5] W. Graterol, J. Diaz-Amado, E. Lopes-Silva, Y. Cardinale, C. Santos-Libarino, and I. Dongo, "Emotion Detection for Social Robots Based on NLP Transformers and an Emotion Ontology," *Sensors (MDPI)*, vol. 21, no. 18, pp. 1–22, 2021.

Appendix- photographs of prototype





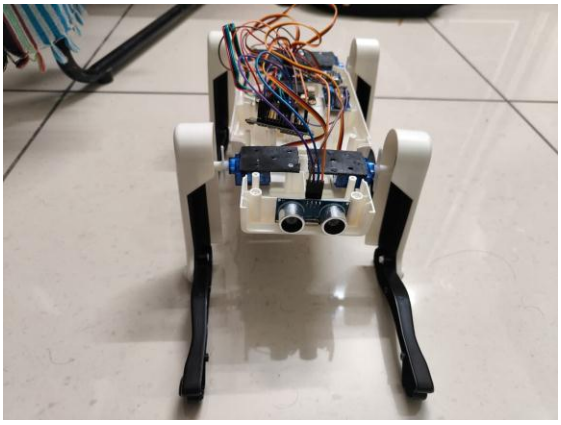


Fig-2: prototype