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Editorial

We, at HMRITM are delighted to announce the release of Volume 8, Issue 1, of HMR Interdisciplinary Journal of Science, Technology & Education Management. HMRIJSTEM publishes articles which present novel research in the areas of engineering, science, technology and management. The Editorial Team encourages interdisciplinary research and the current issue publishes five research papers and the efforts of all authors are significant for the successful operation of the journal.

We take this opportunity to thank all those contributors, reviewers, in making this issue an unforgettable one including all Advisory Board Members for their motivation and support in bringing out this edition of HMRIJSTEM. Suggestions and feedback from our readers are welcome for the overall improvement of quality.

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Editorial Board

"Arduino-Powered Intelligent Vacuum: Bringing Tomorrow's Technology to Today's Floors with IoT and Automation"

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***Abstract*—This research paper presents a novel method for developing an affordable Arduino-based smart vacuum cleaner designed for autonomous cleaning operations. The core components of this smart vacuum cleaner include Arduino UNO, an Arduino Motor Shield, Motor Driver L293D, Servo Motor, Ultra Sonic Distance Sensor, Bluetooth Module, Wheels, DC Motor (6v), Lithium-Ion Battery Cell, Switch, Water Bottle, and Fan Blade. Key functionalities encompass obstacle detection using an ultrasonic distance sensor, dynamic direction changes facilitated by a servo motor, suction through a fan and motor combination, and waste storage in a water bottle. The cleaning process is remotely controlled through a mobile app connected via a Bluetooth module, offering users flexibility and a user-friendly experience.**

This research project addresses challenges in robotic cleaning technology, emphasizing affordability, functionality, and user experience. The primary objective is to create an autonomous robot capable of navigating and cleaning floor surfaces independently. Real-time obstacle detection is crucial for safe operation, achieved through the integration of an ultrasonic distance sensor, providing continuous data on nearby objects and enabling dynamic path adjustments. The servo motor plays a pivotal role in executing course corrections, ensuring smooth maneuvers around detected obstacles. User convenience is prioritized through remote operation via the mobile app, utilizing the Bluetooth module for seamless communication between the user and the robot. Rigorous testing in diverse cleaning scenarios evaluates factors such as dust and debris collection rate, energy consumption, and overall cleaning time, providing valuable insights for future development. The project successfully achieves its objectives, demonstrating efficient obstacle avoidance, navigation, and cleaning capabilities. The mobile app interface ensures intuitive control and real-time feedback on the robot's status. Performance evaluation indicates successful dust and debris collection with minimal energy consumption, contributing to the development of affordable and accessible robotic cleaning solutions for both domestic and commercial applications. Future work will focus on advanced navigation algorithms, improved obstacle detection systems, and further optimization of energy consumption and cleaning efficiency.

***Keywords*— Arduino UNO, Smart Vacuum Cleaner, Autonomous Navigation, Sensor Integration, Home Automation**

INTRODUCTION

In an era characterized by rapid technological advancements and increased automation, daily routines are undergoing a transformation to enhance efficiency and convenience[1]. The integration of smart devices and robotics has revolutionized various aspects of our lives, including household cleaning. Traditional vacuum cleaners, while effective, lack adaptability in navigating intricate environments and require manual operation. To address this challenge, the "Arduino-based Smart Vacuum Cleaner" project proposes an innovative solution that merges state-of-the-art technology with household functionality. Leveraging Arduino's versatile microcontroller capabilities, servo motor control, ultrasonic distance measuring, and Bluetooth connectivity, the project aims to develop an autonomous vacuum cleaner capable of intelligent navigation, obstacle avoidance, and thorough cleaning. This groundbreaking innovation represents the convergence of robotics and domestic needs, ushering in a new era of intelligent and efficient home appliances.

Despite the prevalence of conventional vacuum cleaners in modern households, they exhibit limitations that impede effectiveness and user convenience. The core research problem lies in developing an autonomous vacuum cleaner that surpasses these limitations. Manual control required for vacuuming tasks consumes time and demands continuous supervision to prevent collisions with obstacles. The project's objective is to address these challenges by harnessing Arduino-based technology. Through the intricate integration of ultrasonic sensors, servo motor orientation, and Bluetooth communication, the project aims to create a vacuum cleaner capable of identifying obstacles, autonomously planning alternative routes, and executing effective cleaning maneuvers. This innovative approach streamlines the cleaning process and underscores the potential for household appliances to adapt to their environment through intelligent automation.

The motivation driving the "Arduino-based Smart Vacuum Cleaner" project stems from the overarching goal of enhancing daily living through innovative and

pragmatic solutions. The mundane nature of household chores, coupled with the rapid advancement of technology, creates an opportune space for reimagining these tasks. The project is fueled by the aspiration to make cleaning more efficient, less time-consuming, and ultimately hassle-free. The prospect of a vacuum cleaner that can independently navigate rooms, detect obstacles, and intelligently re-route itself is inherently enticing. This technology not only offers convenience but also empowers users to reclaim valuable time and energy for more meaningful pursuits.

The primary aim of the "Arduino-based Smart Vacuum Cleaner" project is to usher in a new era of intelligent cleaning products that seamlessly integrate robotics, automation, and user-centric design[2]. The project is guided by a set of clearly defined objectives to achieve this overarching goal, including avoiding obstacles through the implementation of sensors and algorithms that enable the robot to navigate its surroundings and sidestep impediments without human assistance. These autonomous robots have versatile applications, ranging from easy-to-manage indoor spaces to challenging outdoor landscapes, making them valuable for transportation, exploration, and surveillance purposes.

I. LITERATURE SURVEY

In the study "Design and implementation of vacuum cleaner robot using Arduino and smartphone" by Saman Mohammdi et al. (2020), the authors introduce a fundamental Arduino-based robot controlled via a smartphone[3]. The incorporation of an ultrasonic sensor for obstacle avoidance establishes a robust foundation for our project. The basic mobile app control framework offers opportunities for future enhancements in user interface and functionality. However, identified limitations, such as the absence of intelligent cleaning patterns and real-time feedback, serve as focal points for our project's improvement. "IOT-Enabled Vacuum Cleaner Using Arduino" by V. Ramya and B.S.N. Prasad (2021) explores enhanced user experience through the integration of an IoT module for remote control and monitoring. This innovative approach opens avenues for potential integration with smart home systems and voice control, elevating cleaning convenience. Yet, the increased complexity and potential security concerns associated with IoT technology require careful consideration in our design[4-6].

Shifting focus to efficiency and adaptability, "Intelligent Floor Cleaning Robot using Arduino" by Ritu Gupta and Rajesh Singh (2017) delves into implementing intelligent cleaning algorithms and optimized dust management strategies[7]. Theoretical concepts presented in this paper offer valuable insights for our future iterations, aiming to develop robots capable of learning and adapting cleaning approaches based on the environment and user preferences. However, the lack of concrete implementation details and potential algorithmic complexity necessitate further research for practical application in our project. In "Smart Vacuum Cleaner using Arduino and Bluetooth" by Guransh, Gurpreet Singh, Udaybir Singh Gill, Lucky Verma, and Disha Sharma (2023), Arduino-based smart vacuum cleaners address challenges faced by conventional smart vacuum cleaners. Utilizing open-source hardware and software ensures affordability, customization, and user-friendly control. These projects integrate ultrasonic sensors for obstacle avoidance, optimize energy consumption for longer cleaning cycles, and present promising alternatives for wider user adoption. Further research on advanced navigation, environmental sensing, and smart home integration holds the potential for more intelligent and efficient cleaning robots[8-10].

The paper "Development of Arduino Programme Code for Autonomous Smart Vacuum Robot" by DC Patel and HS Patil (2017) highlights cost-effective alternatives to commercial robots in Arduino-based smart vacuum cleaners. These systems utilize open-source hardware and software for obstacle avoidance, autonomous navigation, and simultaneous brushing/vacuuming. Integration with ultrasonic and LIDAR sensors, along with AI algorithms like SLAM, holds promise for efficient floor coverage and obstacle detection. Ongoing research on advanced navigation, environmental sensing, and smart home integration could lead to more intelligent and accessible cleaning robots in the future[11-16].

EXPERIMENTAL SET UPS

The experimental setup for the Arduino-based Smart Vacuum Cleaner involves the utilization of various tools and components. These tools include an Arduino Board, Motor Shield, Motor Driver L293D, Ultrasonic Distance Sensor, Geared Motors, DC Motor (6V), Servo Motor, Fan Blade, PVC Pipes, Water Bottle, Lithium-Ion Battery Cells, Switch, Bluetooth Module, Mobile App, Chassis, Wheels, and various electronic components such as resistors, wires, and a breadboard. The model represents an autonomous vacuum cleaner integrating these components for obstacle avoidance, intelligent movement patterns, and mobile app control. The methods employed in the experimental setup encompass the development of obstacle detection and avoidance algorithms using the ultrasonic distance sensor, the design of intelligent movement patterns for efficient cleaning, integration of commands into the mobile app interface for user-friendly remote control via Bluetooth, and implementation of performance evaluation metrics to assess factors like dust collection, energy consumption, and cleaning time. Additionally, the setup involves the utilization of Arduino libraries for servo and motor control, and the design of an intuitive mobile app interface for enhanced user experience[17-54].

Fig. 1: UNO Board

The experimental setup provides various services, including Bluetooth communication, connectivity, autonomous navigation, real-time feedback, remote control, obstacle detection, and cleaning efficiency. These services leverage components such as the Bluetooth Module, ultrasonic distance sensor, servo motor, and DC motor to enable bidirectional data exchange, seamless connection, independent navigation, user feedback, remote command execution, obstacle detection, and optimized cleaning. The architecture of the setup is divided into hardware and software components. The hardware architecture involves the Arduino UNO as the main microcontroller, motor control through the Motor Shield and Motor Driver L293D, sensor orientation via the Servo Motor, obstacle detection with the Ultrasonic Distance Sensor, communication through the Bluetooth Module, cleaning mechanism powered by the DC Motor (6V), and control through a manual switch. The software architecture includes control libraries, obstacle handling algorithms, intelligent movement algorithms, communication protocols, and mobile app command processing. In terms of analysis techniques, the setup undergoes hardware integration testing to validate correct assembly and functionality of motors, servos, and sensors. Software programming is tested for responsiveness to individual commands through Bluetooth and voice control. Obstacle detection and avoidance mechanisms are evaluated in controlled environments, and voice control command accuracy is assessed for reliable execution.

Fig. 2: Ardino Integrated IDE

TOOLS/METHODS/SERVICES/ARCHITECTURE

This research project employs a variety of tools, methods, services, and architecture to develop an affordable Arduino-based smart vacuum cleaner designed for autonomous cleaning operations.

Tools:

Arduino UNO: Acts as the central microcontroller, processing sensor inputs and managing the vacuum cleaner's overall logic.Arduino Motor Shield and Motor Driver L293D: Facilitate precise control of multiple motors, allowing efficient movement of the vacuum cleaner. Servo Motor: Responsible for dynamic direction changes, enabling the vacuum cleaner to maneuver around detected obstacles. Ultra Sonic Distance Sensor: Essential for real-time obstacle detection, providing continuous data on nearby objects. Bluetooth Module: Enables seamless communication between the mobile app and the vacuum cleaner for remote control. DC Motor (6v): Powers the fan blade, creating suction for effective cleaning. Lithium-Ion Battery Cell: Serves as the primary power source, providing energy for the entire vacuum cleaner system. Water Bottle: Acts as a waste storage compartment for collected debris. Switch: Offers basic on/off control for the entire system. Wheels: Enable mobility, allowing the vacuum cleaner to move across surfaces.

Methods:

Obstacle Detection and Avoidance Algorithms: Developed to leverage the ultrasonic distance sensor for real-time obstacle detection, allowing the vacuum cleaner to autonomously navigate and adjust its path dynamically. Intelligent Movement Patterns: Algorithms designed to guide the vacuum cleaner efficiently, ensuring thorough cleaning in diverse environments. Mobile App Integration: Commands are integrated into a mobile app interface for user-friendly remote control, with Bluetooth facilitating seamless communication between the app and the vacuum cleaner. Rigorous Testing: Diverse cleaning scenarios are tested, evaluating factors such as dust and debris collection rate, energy consumption, and overall cleaning time.

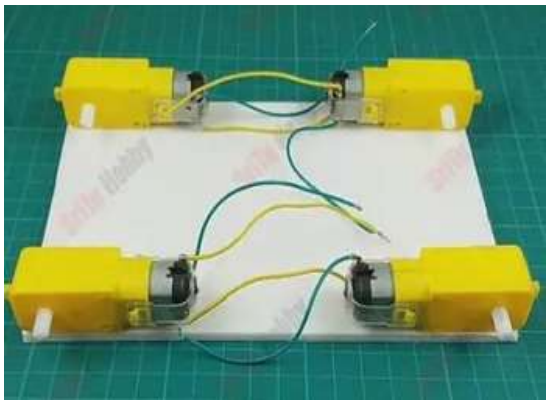

Fig. 3: Connect the motor and wheels

Services:

Bluetooth Communication Service: Establishes bidirectional communication, enabling users to remotely control the vacuum cleaner and receive real-time status updates. Autonomous Navigation Service: Employs advanced algorithms for independent floor cleaning, utilizing obstacle detection and intelligent movement patterns. Real-time Feedback Service: Provides users with continuous updates on the vacuum cleaner's status and performance. Remote Control Service: Enables users to send commands to the vacuum cleaner through the mobile app for convenient control. Obstacle Detection Service: Leverages the ultrasonic distance sensor and servo motor for real-time obstacle assessment and dynamic path adjustments. Cleaning Efficiency Service: Incorporates intelligent movement patterns and optimized algorithms to enhance overall cleaning efficiency.

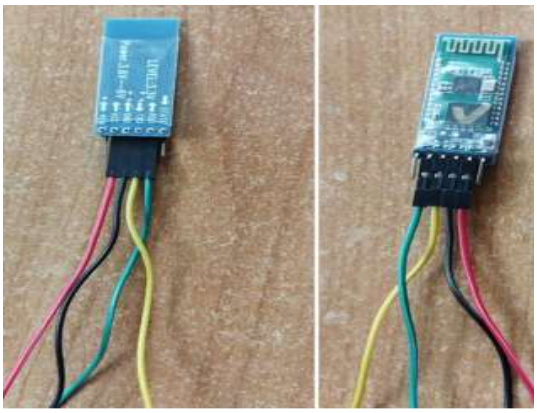

Fig. 4: Connection Blue tooth

Architecture:

Hardware Architecture: Involves the Arduino UNO as the central microcontroller, motor control through the Motor Shield and Motor Driver L293D, sensor orientation via the Servo Motor, obstacle detection using the Ultra Sonic Distance Sensor, communication through the Bluetooth Module, and cleaning mechanism powered by the DC Motor (6V). Software Architecture: Utilizes control libraries, obstacle handling algorithms, intelligent movement algorithms, communication protocols, and mobile app command processing to coordinate various components of the vacuum cleaner efficiently.

RESULTS AND ANALYSIS

The "Arduino-based Smart Vacuum Cleaner" initiative has reached a significant milestone, delivering an innovative and independent cleaning solution. By strategically combining various components and advanced technologies, our project has successfully met its primary goal: the development of a vacuum cleaner capable of autonomously navigating a room, skillfully avoiding obstacles, and executing efficient cleaning operations.

A notable accomplishment of the project lies in the effective integration and utilization of ultrasonic distance measuring sensors. These sensors serve as the smart vacuum cleaner's eyes, providing real-time information about its surroundings. The live perception afforded by these sensors enables the device to promptly identify obstacles in its path, facilitating intelligent decision-making for seamless navigation. The additional implementation of a servo motor to adjust the sensor's direction enhances the cleaner's spatial awareness, enabling it to broaden its field of view and elevate its obstacle detection capabilities.

The introduction of Bluetooth connectivity marks a paradigm shift in the interaction model with the smart vacuum cleaner. By leveraging commonplace devices such as smartphones, users can now remotely control the device. The system supports a diverse range of commands, granting users the ability to dictate the vacuum cleaner's movements—whether it involves moving forward, reversing, turning left or right, or coming to a complete halt. This adaptability ensures the vacuum cleaner's utility across a spectrum of cleaning scenarios, signifying a substantial advancement in user convenience.

The software framework, built upon the foundation of Arduino libraries for servo and motor control, has proven to be robust and dependable. A critical aspect of the project's success is the vacuum cleaner's autonomous behavior, facilitated by a fusion of obstacle-spotting algorithms and intelligent movement patterns. Confronted with obstacles, the vacuum cleaner exhibits the capacity to swiftly assess the situation, determine optimal routes, and dynamically adjust its trajectory to avoid collisions. This underscores the effectiveness of the implemented software algorithms in achieving the desired level of autonomy.

The "Arduino-based Smart Vacuum Cleaner" project serves as a testament to the successful integration of servo motor control, ultrasonic distance sensing, and Bluetooth connectivity. The vacuum cleaner impresses not only with its adept obstacle evasion skills but also with its efficient cleaning prowess. The project's success extends beyond the amalgamation of hardware components; it showcases the sophistication of software algorithms that empower the vacuum cleaner's autonomous conduct. This achievement prompts contemplation of future advancements in home automation and the domain of robot-assisted cleaning.

II. CONCLUSION AND FUTURE WORK

The "Arduino-based Smart Vacuum Cleaner" project marks a significant stride in the domain of intelligent cleaning solutions, leveraging state-of-the-art technologies to create a versatile and autonomous device. As we bring this research venture to a close, key insights and achievements emerge:

The project has successfully realized its primary objectives, resulting in a smart vacuum cleaner demonstrating autonomous navigation, obstacle avoidance, and efficient cleaning. The integration of ultrasonic sensors, servo motor control, and Bluetooth connectivity has given rise to a sophisticated cleaning marvel that adeptly adapts to its surroundings.

The inclusion of ultrasonic sensors has notably enhanced the vacuum cleaner's spatial awareness, enabling real-time obstacle detection and facilitating intelligent decision-making in navigating intricate environments. The incorporation of a servo motor to manipulate the sensor's direction further augments the cleaner's comprehensive perception of its surroundings. Bluetooth connectivity has transformed user interaction, allowing remote control via smartphones. The system's adaptability to diverse commands enhances usability, providing users with a seamless and intuitive means of directing the device to meet varied cleaning scenarios. The software architecture, founded on Arduino libraries, has proven reliable and sophisticated. The vacuum cleaner's autonomous behavior, driven by obstacle-spotting algorithms and intelligent movement patterns, underscores the effectiveness of implemented software algorithms in achieving the desired level of autonomy.

The "Arduino-based Smart Vacuum Cleaner" project, while successful, suggests several areas for future improvement. Advanced obstacle detection using machine learning algorithms could enhance the device's intelligence and adaptive navigation. Energy consumption optimization through smart algorithms would contribute to prolonged operation. Exploring room mapping and cleaning path optimization could enhance efficiency. Integrating the vacuum cleaner into broader smart home ecosystems, ensuring compatibility with home automation platforms, holds promise. User interface enhancements, focusing on intuitive controls and informative feedback, aim to improve the overall user experience, aligning with evolving user expectations in the realm of smart devices.

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"Identification of Emotion from Speech using KAFS"

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ABSTRACT: ***Chatbots are special agents that respond with the user in natural language just as a human woul reply. Specifically, social chatbots are the ones which establish a strong emotional relationship with the user. The main concept behind this chatbot was to provide mental relief to students who undergo different levels of stress and which can be the onset of an inimical depression. In this paper, we proposed an intelligent social therapeutic chatbot which distributes the text into emotion labels namely, Happy, Joy, Shame, Anger, Disgust, Sadness, Guilt, and Fear. Further, based on the emotion label, it identify the users' mental state such as stressed or depressed using users' chat data. For emotion detection, we deployed three popular deep learning classifiers. In particular, the proposed methodology of the chatbot is domain the pessimistic actions and rebuild more constructive thoughts.***

Keywords: Support Vector Machines, Relational Algebra Parsing Tools, Mel Frequency Cepstrum Coefficient , Pulse code modulation, Linear Predictive Cepstral Coefficients

I. INTRODUCTION

Although emotion detection from speech is a relatively new field of research, it has many potential applications. In human-computer or human-human interaction systems, emotion recognition systems could provide users with improved services by being adaptive to their emotions.

The body of work on detecting emotion in speech is quite limited. Currently, researchers are still debating what features influence the recognition of emotion in speech.

In this project, we attempt to address these issues. We use K-Means and Support Vector Machines (SVMs) to classify opposing emotions. We separate the speech by speaker gender to investigate the relationship between gender and emotional content of speech.There are a variety of temporal and spectral features that can be extracted from human speech. We us statistics relating to the pitch, Mel Frequency Cepstral Coefficients (MFCCs) and formats of speech as inputs to classification algorithms. The emotion recognition accuracy of these experiments allow us to explain which features carry the most emotional information and why.

II. CORPUS OF EMOTIONAL SPEECH DATA

The data used for this project comes from the Linguistic Data Consortium's study on Emotional Prosody and Speech Transcripts [1]. The audio recordings and corresponding transcripts were collected over an eight month period in 2000-2001 and are designed to support research in emotional prosody. The recordings consist of professional actors reading a series of semantically neutral utterances (dates and numbers) spanning fourteen distinct emotional categories, selected after Banse & Scherer's study of vocal emotional expression in German [2]. There were 5 female speakers and 3 male speakers, all in their mid-20s. The number of utterances that belong to each emotion category shown in Table 1. The recordings were recorded with a sampling rate of 22050Hz and encoded in two-channel interleaved 16-bit PCM, high-byte-first ("big-endian") format. They were then converted to single channel recordings by take the average of both channels and removing the DC-offset.

- **FEATURE EXTRACTION**

Pitch and related features

Bäzinger et al. argued that statistics to pitch conveys considerable information about emotional status [3]. Yu et al. have shown that some statistics of the pitch carries information about emotion in Mandarin speech [4].For this project, pitch is extracted from the speech waveform using a modified version of the RAPT algorithm for pitch tracking [5] implemented in the VOICEBOX toolbox [6]. Using a frame length of 50cms, the pitch for each frame was calculated and placed in a vector to correspond to that frame. If the speech is unvoiced the corresponding marker in the pitch vector was set to zero.

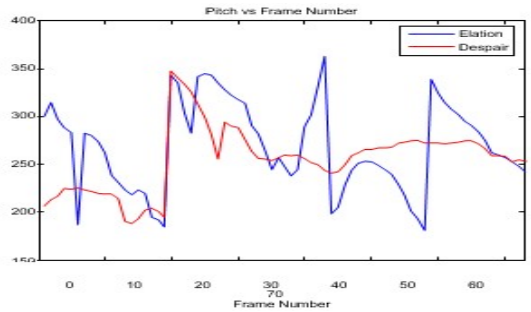

Figure 1: Variation in pitch for 2 emotional states

Figure 1 shows the variation in pitch for a female speaker uttering "Seventy One" in emotional states

of the despair and elation. It is evident from this figure that the mean and variance of the pitch is higher when "Seventy One" is uttered in elation rather than despair. In order to capture these and other characteristics, the following statistics are calculated from the pitch and used in the pitch feature vector:

- Mean, Median, Variance, Maximum, Minimum (for the pitch vector and its derivative)
- Average energies of voiced and unvoiced speech
- Speaking rate (inverse of the average length of the voiced part of the utterance).

Hence, the pitch feature is 13-dimensional.

MFCC and related features

MFCCs are the most widely used spectral representation of speech in many applications, including speech and speaker recognition. Kim et al. argued that statistics relating to MFCCs also carry emotional information [7].

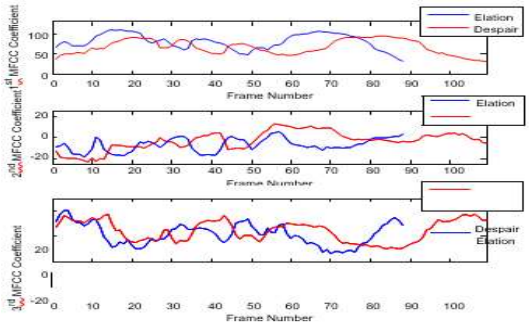

Figure 2: Variation in three MFCCs

For each 25ms frame of speech, thirteen standard MFCC parameters are calculated by taking the absolute value of STFT, warping it to a Mel frequency scale, taking the DCT of the log-Mel-spectrum and returning the first 13 components [8]. Figure 2 shows the variation in three MFCCs for a female speaker uttering "Seventy One" in emotional stated of despair and elation.In sound processing, the mel-frequency cepstrum (MFC) is a representation of the short-term power spectrum of a sound, based on a linear cosine transform of a log power spectrum on a nonlinear mel scale of frequency.Mel-frequency cepstral coefficients (MFCCs) are coefficients that collectively make up an MFC [1]. They are derived from a type of cepstral representation of the audio clip (a nonlinear "spectrum-of-a-spectrum").

MFCCs are commonly derived as follows:

- Take the Fourier transform of (a windowed excerpt of) a signal.
- Map the powers of the spectrum obtained above onto the mel scale, using triangular overlapping windows.
- Take the logs of the powers at each of the mel frequencies.
- Take the discrete cosine transform of the list of mel log powers, as if it were a signal.
- The MFCCs are the amplitudes of the resulting spectrum.

There can be variations on this process, for example: differences in the shape in the shape or spacing of the windows used to map the scale, [3] or addition of dynamics features such as "delta" and "delta-delta" (first- and second-order frame-to-frame difference) coefficients. [4]

MFCC Flowchart is given below:

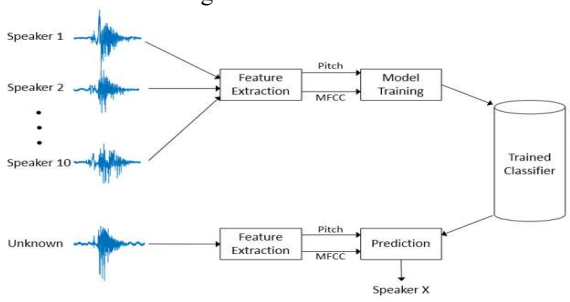

Figure 3: Differences in the shape in the shape

LPCC:

In LPCC before converting into cepstral coefficient, first compute a LPC spectral envelope, linear prediction coefficient used in speech recognition as well as in system identification problem in modern control system, maximum entropy technique, speech coding and synthesis. This process is also known as autoregressive process and applied on the spectrum which capture the vocal tract properties of vowel like sound. First three step of LPCC is same as the MFCC technique. As in the MFCC pre-emphasis is applied to speech waveform in LPCC pre-emphasis.

The flow chart is as follows:

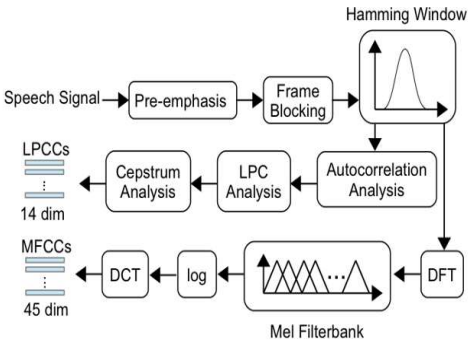

Figure 4: Autoregressive process

Formants and related features

Tracking formants over time used to model the change in the vocal tract shape. The use of Linear Predictive Coding (LPC) to model formants is widely used in speech synthesis [9]. Prior work done by

Petrushin suggests that formants carry information about emotional content [10]. The first three formants and their bandwidths were estimated using LPC on 15ms frames of speech. For each of the three formants, their derivatives and bandwidths, we calculated the mean, variance, maximum and minimum across all frames. We also calculate mean, variance, maximum and minimum of the mean of each formant frequency, its derivative and bandwidth. The formant feature vector is 48-dimensional.

- **LIBROSA AS A FEATURE DETECTION**

The librosa.core submodule includes a range of commonly used functions. Broadly, core functionality falls into four categories: audio and time-series operation, spectrogram calculation, time and frequency conversion, and pitch operations. For convenience, all functions within the core submodule are aliased at the top level of the package hierarchy, for example librosa.core.load is aliased to librosa.load. Audio and time-series operations include function such as: reading audio from disk via the audioread package7 (core.load), resampling a signal at a desire rate (cor.resample), stereo to mono conversion (core.to_mono), time-domain bounded auto-correlation (core.autocorrelate) and zero-crossing detection (core.zero_crossings).

RAVDESS

The RAVDESS is released under a Creative Commons Attribution license, so please cite the RAVDESS if it is used in your work in any form. Published academic papers should use the academic paper citation for our PLoS1 paper, personal works, such as machine learning projects/blog posts, should provide a URL to this Zenodo page, though a reference to our PLoS1 paper would also be appreciated. The Ryerson Audio-Visual Database of Emotional Speech and Song (RAVDESS) contains 7356 files (total size: 24.8 GB). The database contains 24 professional actors (12 male, 12 female), vocalizing two lexically-matched statements in a neutral North American accent. Speech includes calm, happy, sad, angry, fearful, surprise, and disgust expressions, and song contains calm, happy, sad, angry and fearful emotions. Each expression is produced at two levels of emotional intensity (normal, strong) with an additional neutral expression. All conditions are available in three modality formats: Audio-only (16bit, 48 kHz, .wav), Audio-Video (720p H.264, AAC 48 kHz, .mp4) and Video-only (no sound).

FILE NAMING CONVENTION

A file naming convention (FNC) can help you stay organized by making it easy to identify the file(s) that contain the information that you are looking for just from its title and by grouping files that contain similar information close together. A good FNC can also help others understand and navigate better through your work.

Consider the following examples:

a. Files without employing a naming convention:

Test_data_2013
Project_Data
Design for project.doc
Lab_work_Eric
Second_test
Meeting Notes Oct 23

b. Files with a naming convention:

20130503_DOEProject_DesignDocument_Smith_v2-01.docx
20130709_DOEProject_MasterData_Jones_v1-00.xlsx
20130825_DOEProject_Ex1Test1_Data_Gonzalez_v3-03.xlsx
20130825_DOEProject_Ex1Test1_Documentation_Gonzalez_v3-03.xlsx
20131002_DOEProject_Ex1Test2_Data_Gonzalez_v1-01.xlsx
20141023_DOEProject_ProjectMeetingNotes_Kramer_v1-00.docx

The files with a naming convention provide a preview of the content, are organized in a logical way (by date yyyy-mm-dd) identify the responsible party and convey the work history, unlike the files without a naming convention.

SPECTROGRAM

A spectrogram is a visual representation of the spectrum of frequencies of a signal as it varies with time. When applied to an audio signal, spectrograms are sometimes called sonographs, voiceprints, or voicegrams. When the data is represented in a 3D plot they may be called waterfalls. Spectrograms are used extensively in the fields of music, linguistics, sonar, radar, speech processing, [1] seismology, and others. Spectrograms of audio can be used to identify spoken words phonetically, and to analyze the various calls of animals. A spectrogram can be generated by an optical spectrometer, a bank of band-pass filters, by Fourier transform or by a wavelet transform (in which case it is also known as a scaleogram or scalogram).[2]

MAC TERMINAL

The Mac Terminal is a command line interface (CLI) for Mac OS X available in all OS X versions through Lion. It is also a gateway to Unix, or the underlying operating system of OS X.Terminal allows users to modify various characteristics of their Mac desktops, fonts, files and more beyond the standard OS X graphical user interface (GUI).It allows for total customization and command. However, if novice

computer users apply modifications incorrectly, this can harm the system or lead to a loss of data.

CLASSIFICATION

We tried to differentiate between "opposing" emotional states. Six different "opposing" emotion pairs were chosen: despair and elations, happy and sadness, interest and boredom, shame and pride, hot anger and elation, and cold anger and sadness.

For each data set, we formed inputs to our classification algorithm comprising of feature vectors from: Pitch only, MFCCs only, Formants only, Pitch & MFCCs, Pitch & Formants, MFCCs & Formants, and Pitch, MFCCs & Formants. Hence, for each emotion pair, the classification algorithm was run on twenty one different sets of inputs.

K-Means Clustering

For each emotion pair, all input sets were clustered using K-Means clustering (k=2) for all twelve combinations of the parameters listed below: Distance Measure Minimized: Squared Euclidean, L1 norm, Correlation, and Cosine (the Correlation and Cosine distance measures used here are defined as in the MATLAB 'kmeans' function). Initial Cluster Centroids: Random Centroids and User Defined Centroids (UDC). A UDC is the centroid that minimizes the distance measure for the input features of one emotion in the emotion pair. Maximum Number of Iterations: 1 (only when the initial cluster centroid is a UDC) and 100 (for both Random and UDC centroids).

UDC	1	65.89%	14.95% cold anger-sadness		MFCC	L1 norm
UDC	1	88.43%	9[78% **Female Speakers**			
Experiment	Features	Distance Measure	Centroid	Iterations	Recognition Accuracy	Variance
	despair-elation	MFCC	L1 norm	UDC	1	80.42%
	9.66% happy-sadness	MFCC	L1 norm	UDC	1	72.80%
	15.24% interest-boredom	MFCC	L1 norm	UDC	1	70.62%
	18.06% shame-pride	MFCC	L1 norm	UDC	1	81.18%
	19.79% hot anger-elation	MFCC	L1 norm	UDC	1	77.16%
						4.37%
cold anger-sadness	MFCC	Correlation	UDC	1	72.04%	15.00%

Table 2: Highest Recognition Accuracies using K-means Clustering

III. RESULTS & DISCUSSION

The results obtained by the experiments performed allow us to make the following observations:

- Using the formant feature vector as an input to our classification algorithms, always results in sub-optimal recognition accuracy. We can infer that formant features do not carry much emotional information. Since formants are used to model the resonance frequencies (and shape) of the vocal tract, we can postulate that different emotions do not significantly affect the vocal tract shape.
- Using squared Euclidean as a distance measure for K-means always results in sub-optimal recognition accuracy. Using this distance metric effectively places a lot of weight on the magnitude of an element in the feature vector. Hence, an input feature that might vary a lot between the two opposing emotions may be discounted by this distance measure, if the mean of this feature is smaller than that of other features.
- Of all the methods implemented, SVMs with linear kernel give us the best results for single-gender classification, especially in male speakers. This indicates that this feature space is almost linearly separable. The best results using K-means classification are usually obtained when the cluster centroids are UDCs which we think indicated that unsupervised learning algorithms such as K-means cannot pick up on all the information contained in the feature sets, unless we add some bias to the features.

IV. CONCLUSION AND FUTURE WORK

Although it is impossible to accurately compare recognition accuracies from this study to other studies because of the different data sets used, the methods implemented here are extremely promising. The recognition accuracies obtained using SVMs with linear kernels for male speakers are higher than any study. Previous studies have neglected to separate out male and female speakers. This project shows that there is significant benefit in doing so. Our methods are reasonably accurate at recognizing emotions in female and all speakers. Our project shows that features derived from agitated emotions such as happiness, elation and interest have similar properties, as do those from more subdued emotions such as despair and sadness.

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"Exploring the Cosmos: The Arduino Starship Game - A Fusion of Technology, Innovation, and Immersive Entertainment"

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Abstract— Embarking on the frontier of creativity and innovation, this research paper introduces the Arduino Starship game, a dynamic amalgamation of technology and entertainment. The focal point of this project is a 16x2 LCD display, offering players an immersive experience as they navigate their starship using a joystick and computer input through the Serial Monitor. The project unfolds a plethora of learning opportunities, delving into the intricacies of LCD displays. It explores the creation and display of custom characters, enhancing the visual appeal. Further, the extraction of data from the Serial Monitor adds a layer of understanding, while unraveling the joystick's functionality enriches our comprehension of game control dynamics. A key innovation lies in the utilization of EEPROM for storing and updating high scores, ensuring a competitive gaming edge.

As players maneuver their starship through a celestial battlefield filled with adversaries, strategic navigation becomes paramount, armed with a single bullet that demands judicious use. The Arduino Starship game not only encapsulates the excitement of gameplay but also embodies the joy of mastering LCD technology, data management, and creative problem-solving. Situated at the intersection of technology, creativity, and ambition, our efforts to bring the Arduino Starship game to life stand as a testament to our unwavering dedication. Through honing our skills in LCD mechanics, data interpretation, joystick dynamics, and EEPROM manipulation, we aspire to pioneer an immersive gaming experience that captures both the thrill of competition and the joy of innovation.

Keywords—Arduino Starship game,16x2 LCD display, Joystick control, Serial Monitor, Custom characters, Data extraction & Game control dynamics,

I. INTRODUCTION

In the dynamic realm of electronic gaming and interactive entertainment, our research project, titled "Arduino Starship: Innovating Gameplay with LCD and Joystick Integration," marks a pioneering foray into the intersection of cutting-edge technology and imaginative creativity. Fueled by the growing demand for immersive gaming experiences, our ambitious endeavor seeks to redefine gameplay essence by seamlessly combining tactile and digital interactions on the Arduino platform, prominently displayed on a vivid 16x2 LCD[1].

Positioning itself at the crossroads of innovation and user engagement, our project embarks on an interdisciplinary journey to explore uncharted territories beyond conventional gaming interfaces[2]. Our research problem revolves around the perpetual challenge of innovating and enhancing gaming experiences to captivate users on sensory and cognitive fronts. This crystallizes into a critical inquiry, delving into the seamless amalgamation of the precision and responsive control of a joystick with the visually captivating canvas provided by an LCD display. Motivated by a fervent desire to address and bridge this existing gap, our initiative stands as a harbinger of change and a catalyst for innovation in the gaming industry. Beyond entertainment, our project aspires to introduce a compelling blend of tangible and digital interactions, revolutionizing how players engage with the virtual realm and inspiring the inquisitive minds of gamers and electronic enthusiasts. At the core of our motivation lies the eagerness to redefine conventional gaming interfaces, grounded in revitalizing the concept of gaming through a harmonious marriage of mechanical precision and technological innovation. Our goal is not just to create an engaging experience but to contribute to the evolving discourse of interactive entertainment, shaping the trajectory of future developments in the field.

The overarching aim of our research project is to develop the Arduino Starship game, meticulously curated to harness the synergistic potential of an LCD display and a joystick for navigation and control. Guided by a resolute vision, we delve into the intricate mechanics of LCD displays, explore the nuanced dynamics of joystick functionality, and seamlessly integrate these elements into a cohesive and immersive gaming experience.

Our research project seeks to transcend traditional gaming paradigms, aspiring to be more than a technological feat—it aims to be a beacon of ingenuity, forging a path where entertainment and enlightenment converge harmoniously. Through meticulous exploration and innovation, we aim to contribute to the evolving landscape of interactive entertainment, setting a new standard for immersive and educational gaming experiences. As we navigate

this uncharted terrain, our research project stands as a testament to the potential of interdisciplinary collaboration and the transformative power of converging technologies in the realm of gaming.

II. Literature Survey

The intersection of technology and gaming has spurred continuous exploration, pushing the boundaries of conventional gaming paradigms. The symbiotic relationship between tangible interfaces and digital experiences has given rise to a diverse array of projects, each contributing to the evolution of interactive entertainment.

Historically, gaming interfaces have evolved from simple button-based controllers to more intricate systems incorporating motion sensors, touchscreens, and augmented reality[3]. The challenge, as articulated in the "LCD-Based Game with Joystick" project, revolves around innovating to captivate users on multiple sensory and cognitive fronts. The integration of tactile and digital interactions on the Arduino platform reflects a trend in research where hardware components are harnessed to enrich the gaming experience. The concept of using LCD displays as a canvas for gaming interfaces has garnered attention in the literature. Studies have explored the visual appeal, clarity, and flexibility offered by LCD technology. Researchers highlight the potential for creating visually captivating and informative displays that go beyond the constraints of traditional monitors. The 16x2 LCD display in the project not only provides a compact form factor but also aligns with the trend of leveraging limited screen real estate for creative and engaging interfaces[4-6].

Joystick-based controls, another focal point of the project, have a rich history in gaming. The literature acknowledges the importance of precise and responsive control mechanisms in enhancing the user experience. The integration of a joystick into gaming interfaces has been explored extensively, with an emphasis on ergonomics, precision, and the immersive feel it imparts to gameplay. The challenge lies in seamlessly combining these mechanical inputs with digital visuals to create a cohesive and engaging user experience. The motivation behind the "LCD-Based Game with Joystick" project aligns with broader trends in the gaming industry. Researchers recognize the need to transcend the conventional understanding of gaming interfaces and explore innovative ways to captivate audiences. The project's emphasis on education alongside entertainment resonates with a growing interest in gamification for learning purposes, acknowledging the potential to engage and educate inquisitive minds7-9].

As gaming evolves, the literature emphasizes the importance of interdisciplinary collaboration. The marriage of mechanical precision and technological innovation, as envisaged in this project, underscores a broader shift towards converging technologies in gaming. This collaborative approach not only enhances gameplay but also contributes to shaping the trajectory of future developments in the field. The "LCD-Based Game with Joystick" project positions itself within a vibrant landscape of research exploring the confluence of technology and gaming. By addressing the perpetual challenge of innovating gaming experiences, it adds a valuable dimension to the discourse surrounding interactive entertainment, setting a new standard for immersive and educational gaming experiences[12-13]. As the project navigates uncharted terrain, it exemplifies the transformative power of converging technologies in the realm of gaming and serves as a testament to the potential of interdisciplinary collaboration.

III. Experimental Set ups

The realization of the envisioned gaming experience involved a meticulous implementation process, blending hardware integration and software development to bring the "LCD-Based Game with Joystick" project to life. The implementation unfolded in distinct phases, each contributing to the refinement and enhancement of the final product. At the core of the implementation was the assembly of hardware components. The Arduino Uno microcontroller functioned as the central processing unit, orchestrating communication between the 16x2 LCD display and the joystick module. Precise wiring and connection setup were executed to establish a robust interface, ensuring real-time interaction between physical inputs and digital outputs. This phase demanded attention to detail to guarantee the seamless integration of components.

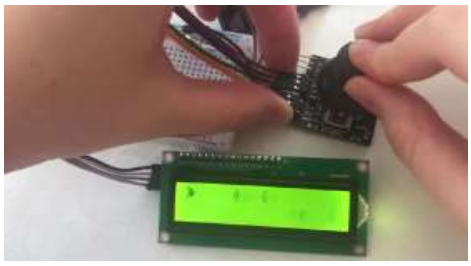

Fig. 1: Combining the Functionalities

The software development phase revolved around coding within the Arduino Integrated Development Environment (IDE). It entailed crafting algorithms to interpret joystick inputs and translate them into responsive actions displayed on the LCD screen. The programming architecture prioritized efficiency, responsiveness, and a captivating user interface. Iterative coding, testing, and debugging were crucial to achieving a harmonious synergy between hardware and software components.

Fig. 2: A functional game scenario

A significant focus of the implementation was on defining and refining game mechanics. The project aimed not only for entertainment but also educational value. Consequently, game logic was developed to engage users in a challenging yet informative experience. This phase required careful consideration of user feedback gathered during testing, leading to adjustments in difficulty levels, scoring mechanisms, and educational content. The implementation process was iterative and user-centered. Multiple testing sessions were conducted to solicit user feedback, identifying areas for improvement in gameplay, visual aesthetics, and overall user experience. This feedback loop informed subsequent iterations, guiding the implementation towards a final version that met the project's objectives and user expectations. The implementation of the "LCD-Based Game with Joystick" project seamlessly blended hardware integration, software development, and user-centered refinement. The result is an innovative Arduino-based game that not only demonstrates technical prowess but also delivers a captivating and educational gaming experience at the intersection of technology and imagination[14-51].

IV. Tools/ Methods/ Services/ Architecture

The approach employed in crafting the "LCD-Based Game with Joystick" project involved a systematic and iterative methodology, harmonizing both hardware and software elements to forge a cohesive and captivating gaming encounter within the Arduino platform. Commencing with an in-depth literature review on LCD displays, joystick functionalities, and Arduino programming, the foundational step aimed at garnering a comprehensive understanding of the essential mechanics and principles pivotal for the successful fusion of these components. On the hardware front, the implementation involved assembling an Arduino Uno microcontroller, a 16x2 LCD display, and a joystick module. This intricate process included precise wiring and connection setups to ensure seamless communication between the Arduino and the peripherals. The selection of the Arduino platform was driven by its versatility and extensive community support, streamlining the overall development process.

Fig. 3: Hardware Integration

The software dimension revolved around coding in the Arduino IDE, concentrating on the formulation of algorithms to interpret joystick inputs and visually render corresponding graphics on the LCD display. An iterative testing and refinement process was undertaken to optimize gameplay mechanics, enhance responsiveness, and troubleshoot potential issues. User feedback emerged as a pivotal factor in refining the gaming experience, with the adoption of a user-centered design approach. Iterative testing sessions were conducted to gather insights on usability, game dynamics, and overall satisfaction. This continuous feedback loop played a crucial role in shaping successive iterations, ensuring that the final product aligned with both functional and experiential expectations. In essence, the methodology adhered to a structured progression, commencing with a literature review and extending through hardware assembly and software development. Emphasizing iterative testing and user feedback, this systematic approach facilitated the creation of a sophisticated Arduino-based game seamlessly integrating an LCD display and joystick for a captivating and educational gaming experience.

V. Results and Analysis

In the culmination of our "LCD-Based Game with Joystick" project, the integration of cutting-edge hardware and sophisticated software has redefined the landscape of interactive entertainment on the Arduino platform. This technological odyssey sought to transcend conventional gaming interfaces, creating an immersive experience that marries mechanical precision with technological innovation. The systematic integration process, marked by meticulous hardware assembly and iterative software development, has successfully yielded a tangible manifestation of our vision. The marriage of a 16x2 LCD display and a joystick module has birthed a gaming experience that surpasses mere entertainment. The introduction of educational elements into the gameplay showcases our commitment to captivating not only the senses but also the inquisitive minds of players and electronic enthusiasts.

Fig. 4 : Iterative testing and refinement

Our user-centered approach, characterized by iterative testing and refinement, emphasizes our commitment to delivering a product resonant with our audience. The incorporation of user feedback has not only enhanced gameplay mechanics but has also significantly shaped the overall user experience. The "LCD-Based Game with Joystick" stands as a testament to the transformative power of interdisciplinary collaboration and converging technologies in gaming. Reflecting on this journey, our project stands not merely as a technological feat but as a beacon of ingenuity. It aspires to contribute to the evolving landscape of interactive entertainment, establishing a new standard for immersive and educational gaming experiences. The lessons learned and insights gained extend beyond the realm of gaming, influencing the broader discourse of innovation and interdisciplinary exploration. In the final analysis, our research project serves as a testament to the potential of human creativity and technical expertise in shaping the future of gaming. As we conclude this chapter, we recognize that our technological odyssey is but a prologue to the ongoing narrative of exploration, discovery, and innovation in the ever-evolving landscape of interactive entertainment.

VI. Conclusion and Future work

In conclusion, the "LCD-Based Game with Joystick" project stands as a remarkable achievement in the realm of interactive entertainment, redefining the landscape on the Arduino platform. The integration of state-of-the-art hardware and sophisticated software has not only transcended conventional gaming interfaces but has also created a captivating and educational gaming experience. The systematic integration process, marked by meticulous hardware assembly and iterative software development, has successfully realized our vision. The synergy between the 16x2 LCD display and the joystick module has given rise to a gaming experience that goes beyond mere entertainment, incorporating educational elements to engage players and electronic enthusiasts. The user-centered approach, with its iterative testing and refinement, underscores our commitment to delivering a product that resonates with our audience. User feedback has played a crucial role in enhancing gameplay mechanics and shaping the overall user experience. The "LCD-Based Game with Joystick" serves as a testament to the transformative power of interdisciplinary collaboration and the convergence of technologies in gaming.

As we reflect on this journey, our project goes beyond being just a technological feat; it stands as a beacon of ingenuity. Its contribution to the evolving landscape of interactive entertainment sets a new standard for immersive and educational gaming experiences. The lessons learned and insights gained extend beyond the gaming domain, influencing the broader discourse of innovation and interdisciplinary exploration. In the final analysis, our research project highlights the potential of human creativity and technical expertise in shaping the future of gaming. While concluding this chapter, we acknowledge that our technological odyssey is a prologue to the ongoing narrative of exploration, discovery, and innovation in the ever-evolving landscape of interactive entertainment.

Future work in this domain could explore further enhancements to gameplay, the incorporation of advanced technologies such as augmented reality, and broader educational applications. Additionally, collaboration with educational institutions and game developers could facilitate the integration of the "LCD-Based Game with Joystick" into formal and informal learning environments. This could open avenues for further research into the impact of gamified educational experiences on learning outcomes and cognitive development.

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"Harnessing Blockchain Technology for Sustainable Waste Management: A Review of Applications and Opportunities"

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Abstract:
Waste management is a global challenge that poses significant environmental, social, and economic impacts. Blockchain technology is a distributed ledger system that enables trustless, transparent, and secure transactions among multiple parties. The present review examines how blockchain technology can be applied to various aspects of waste management, such as supply chain tracking, recycling incentives, waste-to-energy initiatives, and decentralized governance models. It also presents some case studies of blockchain applications in plastic waste management and discusses the challenges and barriers to adopting blockchain technology in waste management. The review concludes with some recommendations for further research, innovation, and collaboration to promote the widespread implementation of blockchain technology in waste management.

Keywords: Blockchain, Waste Management, Supply chain tracking, Circular economy, Waste-to-energy initiatives, Decentralized governance models.

Graphical Abstract:

I. INTRODUCTION

Waste generation is a major issue we face today. Inadequate waste collection systems, poor waste management practices, plastic pollution, electronic waste, and hazardous waste are the main challenges. Improper waste disposal can no longer be tolerated. Let's not forget about plastic pollution, which has become a major environmental threat(Kumar, Smith et al. 2017, Basu 2021). We must take immediate action to address these issues by implementing sustainable waste management practices, such as composting, anaerobic digestion, recycling, and repurposing(Lindwall 2020, Agarwal 2023, Smith 2024).

Strengthening governance structures, promoting policy coherence, and fostering stakeholder collaboration are essential for addressing the current issues in waste management(Namoewaste. 2023). Effective management of hazardous waste remains a critical issue that requires specialized infrastructure, trained personnel, and stringent regulations([EPA] 2007). We cannot afford to cut corners when it comes to hazardous waste management. Therefore, we must take responsibility and act now to ensure that we are not endangering future generations with our current waste management practices.

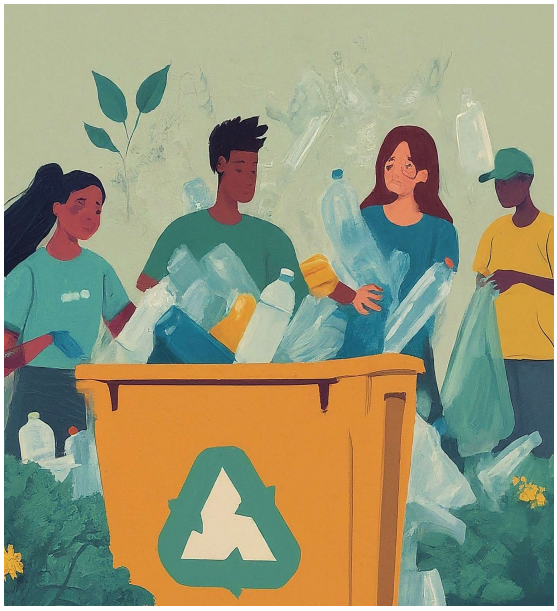

Figure 1: Recycling of Waste

II. OVERVIEW OF BLOCKCHAIN TECHNOLOGY

Blockchain technology is a decentralized, distributed ledger system that securely records transactions across a network of computers. It ensures transparency, immutability, and integrity of data, enabling trustless peer-to-peer transactions. Utilized beyond cryptocurrencies, it revolutionizes industries by enhancing security, efficiency, and reducing intermediaries in various processes(Jha 2024).

1. Definition and Principles of Blockchain

Blockchain is a distributed ledger technology (DLT) that records transactions across a network of computers, creating an immutable and verifiable record of events. Instead of relying on a single central authority, each computer on the network maintains a copy of the ledger, ensuring transparency and security. New transactions are bundled into "blocks" and added to the existing chain, chronologically linking them and making them tamper-proof(Nick Barney 2023).

The fundamental principles include decentralization, immutability, transparency, security, and consensus mechanisms. Decentralization ensures no single entity controls the network. Immutability guarantees that once a transaction is recorded, it cannot be altered. Transparency enables all participants to view transactions, enhancing trust. Security is maintained through cryptographic hashing, and consensus mechanisms ensure agreement on the validity of transactions without relying on a central authority(Artasanchez 2023).

2. Key Components

The key components of a blockchain system(Jha 2024) include:

1. **Distributed Ledger:** A decentralized database that records all transactions across a network of computers.
2. **Blocks:** Data batches containing transactions that are cryptographically linked to form a chain.
3. **Cryptography:** Encryption techniques ensure the security and integrity of transactions, including digital signatures and hash functions.
4. **Consensus Mechanism:** Protocols determining how network participants agree on the validity of transactions, ensuring consensus without a central authority.
5. **Smart Contracts:** Self-executing contracts with predefined rules encoded into the blockchain, automating transactions when conditions are met.
6. **Network Nodes:** Computers or devices participating in the blockchain network, storing a copy of the ledger and validating transactions.
7. **Network Protocol:** Rules governing communication between nodes, ensuring consistency and reliability in data transmission.

III. BLOCKCHAIN APPLICATIONS IN WASTE MANAGEMENT

Blockchain technology presents innovative solutions to address challenges in waste management by offering transparency, traceability, and efficiency throughout the waste lifecycle. One significant application is supply chain tracking, where blockchain ensures transparent and immutable records of waste movement from generation to disposal. This helps prevent illegal dumping and enhances accountability among stakeholders(Bułkowska, Zielińska et al. 2023). Additionally, blockchain facilitates recycling incentives through token-based reward systems, incentivizing individuals and businesses to participate in recycling programs and promote a circular economy. Waste-to-energy initiatives benefit from blockchain by optimizing waste-to-energy processes and enabling peer-to-peer energy trading, thus promoting renewable energy generation from waste. Moreover, blockchain supports decentralized governance models, empowering communities to make transparent and democratic decisions in waste management(Taylor, Steenmans et al. 2020). Despite its potential, challenges such as regulatory hurdles, interoperability issues, and scalability concerns need to be addressed for widespread adoption of blockchain in waste management. Overall, blockchain technology holds promise in transforming waste management practices, promoting sustainability, and mitigating environmental impacts. Collaborative efforts among stakeholders are essential to harness the full potential of blockchain in revolutionizing waste management for a cleaner and more sustainable future.

1. Supply Chain Tracking

Blockchain technology offers an innovative solution for traceability of waste from generation to disposal. By creating transparent and immutable records, blockchain enables stakeholders to track the movement of waste throughout its lifecycle. Each transaction, from waste collection to processing and disposal, is securely recorded on the blockchain, providing a verifiable and tamper-proof audit trail. This ensures accountability and helps prevent illegal dumping or improper disposal practices(Salehi 2023). With blockchain-based traceability systems, authorities, businesses, and communities can gain insights into waste management processes, identify inefficiencies, and make informed decisions to optimize resource allocation and promote environmental sustainability(Dindarian and Chakravarthy 2019).

Figure 2: *Scope of Blockchain in waste management.*

Moreover, blockchain technology serves as a potent tool in preventing illegal dumping and fraud within waste management systems(Ahmad, Salah et al. 2021). By establishing transparent and immutable records of waste transactions, blockchain creates a traceable digital ledger that verifies the origin and movement of waste(Salehi 2023). This transparency reduces the risk of fraudulent activities such as falsifying waste disposal records or bypassing regulatory requirements. Through blockchain, authorities can enforce compliance, deter illegal dumping, and uphold environmental regulations, fostering a more accountable and sustainable waste management ecosystem.

2. Recycling Incentives

Blockchain technology has the potential to revolutionize the waste management industry by implementing token-based reward systems for recycling(Adebayo 2023). Using blockchain, transparent and auditable records of recycling activities can be created, allowing for the issuance of digital tokens as incentives for proper waste disposal and recycling. Individuals and businesses can receive tokens for participating in recycling programs, which can be exchanged for rewards or monetary benefits. This approach not only incentivizes increased recycling rates but also promotes environmental consciousness and fosters a circular economy. By ensuring the integrity and transparency of incentive programs, blockchain provides a reliable mechanism for rewarding sustainable behaviours in waste management(Baralla, Pinna et al. 2023).

Encouraging participation and incentivizing proper waste disposal can be significantly improved by implementing a token-based reward system. By utilizing blockchain technology, transparent and auditable records of waste disposal activities are created, allowing individuals and businesses to earn digital tokens to participate in proper waste management practices. These tokens serve as tangible rewards that can be exchanged for various incentives, such as discounts, vouchers, or even cashback rewards. This approach not only motivates individuals to engage in recycling and waste reduction efforts actively but also fosters a sense of environmental responsibility and stewardship. With the transparency and security provided by blockchain, token-based reward systems offer a reliable and effective means of encouraging sustainable behaviors and promoting a cleaner, greener future(Wankmüller, Pulsfort et al. 2023).

3. Waste-to-Energy Initiatives

Waste-to-energy initiatives represent a sustainable solution to both waste management and energy production challenges(Malav, Yadav et al. 2020). These initiatives can be optimized for efficiency and transparency by leveraging blockchain technology. Blockchain enables the secure and transparent tracking of waste-to-energy processes, from waste collection to energy generation(Ahmad, Salah et al. 2021). This ensures that waste materials are properly managed and converted into renewable energy sources, reducing reliance on fossil fuels and mitigating environmental pollution. Additionally, blockchain facilitates peer-to-peer energy trading, allowing surplus energy generated from waste to be distributed efficiently within communities. Furthermore, blockchain-based smart contracts can automate and streamline transactions, ensuring fair compensation for energy producers and consumers alike(Zafar and Ben Slama 2022). By integrating blockchain technology into waste-to-energy initiatives, stakeholders can enhance operational efficiency, promote renewable energy adoption, and contribute to the transition towards a more sustainable and decentralized energy landscape.

3.1 Utilization of blockchain to optimize waste-to-energy processes

Transforming waste into valuable energy requires efficient tracking and processing. Blockchain can optimize waste-to-energy (WtE) processes by streamlining feedstock management(Sun, Liu et al. 2020), enabling traceability and accountability, facilitating smart contracts, fostering transparency and trust, and optimizing resource allocation. Each waste item can be tagged with a unique digital identity, providing transparency on its origin, composition, and calorific value. This allows for precise sorting and optimization of WtE feedstock, maximizing energy output. WtE facilities are complex, involving multiple stakeholders. Blockchain enables secure, trackable records of waste movement, ensuring efficient processing and compliance with regulations. Automated contracts can trigger pre-defined actions based on waste properties, automating tasks like payments to waste

suppliers and energy distributors based on verified weight and energy produced. Citizens can access a transparent record of how their waste contributes to energy generation, promoting public trust and engagement in WtE systems. Real-time data on waste composition and energy production helps WtE facilities optimize resource allocation, ensuring efficient combustion and minimizing emissions(Salehi 2023).

3.2 Transparent allocation of resources and energy outputs

Blockchain technology can revolutionize waste-to-energy (WtE) systems by improving resource allocation, energy distribution, and transparency. Each waste item can carry a unique digital identity on the blockchain, revealing its exact composition and energy potential, allowing for precise sorting and allocation of waste to the most suitable WtE facility. Blockchain can link energy generated from each waste type back to its source, ensuring accurate attribution and transparent distribution of energy credits or profits, and pre-defined rules within smart contracts can automatically allocate resources based on real-time energy needs and waste availability, optimizing resource allocation and preventing overconsumption. By making key data points like waste composition and energy outputs accessible through secure platforms, blockchain technology fosters transparency, encourages responsible waste management practices, and allows for informed discussion on resource allocation and energy distribution(Adebayo 2023). Sensors integrated with WtE facilities and linked to the blockchain can provide real-time data on energy production and resource utilization, enabling continuous optimization of WtE processes, ensuring maximum efficiency and minimal environmental impact. Its benefits extend beyond traditional stakeholders and create opportunities for communities and citizens to participate in waste management practices, fostering responsible and sustainable waste management practices(One 2023).

Figure 3: Model of decentralized governence

4. Decentralized Governance Models

Decentralized governance models, enabled by blockchain technology, are transforming waste management practices(Steenmans, Taylor et al. 2021). Blockchain's decentralized nature allows for democratized governance structures, community-driven decision-making, and increased transparency. By creating transparent and immutable records, blockchain ensures accountability and trust in governance decisions. Smart contracts automate and enforce governance rules, streamlining administrative processes and reducing the risk of human error or corruption. Decentralized platforms empower local communities to actively participate in decision-making processes, ensuring transparency, accountability, and inclusivity in governance structures(Ahmad, Abu Talib et al. 2015).

Blockchain technology plays a crucial role in enhancing trust in waste management systems through its decentralized and transparent nature. Stakeholders in waste management gain access to a secure and immutable ledger that records every transaction and action related to waste management processes. This transparency ensures accountability and fosters trust among stakeholders, leading to increased collaboration, cooperation, and collective action towards achieving sustainability goals(Reed 2008). Decentralized governance models, facilitated by blockchain technology, offer a promising framework for promoting sustainability, equity, and accountability in waste management practices, leading to cleaner and healthier environments for present and future generations.

IV. CASE STUDIES: BLOCKCHAIN APPLICATIONS IN PLASTIC WASTE MANAGEMENT

The global plastic pollution crisis requires innovative solutions, and blockchain technology offers immense potential to address it. By integrating blockchain into plastic waste management, we can incentivize responsible practices, promote a circular economy, and mitigate the environmental impacts of plastic pollution.

Transparent and secure tracking of the supply chain, implementing blockchain-based reward systems to incentivize plastic recycling, providing transparency and traceability, and creating a decentralized marketplace for plastic recycling are some of the potential applications of blockchain technology. With these solutions, we can encourage responsible practices among all stakeholders, foster community engagement and environmental awareness, and work towards a more sustainable future(Khadke, Gupta et al. 2021).

V. CHALLENGES AND BARRIERS TO ADOPTION

Blockchain technology faces challenges in waste management due to lack of awareness among stakeholders, high upfront costs, compatibility issues, regulatory uncertainties, and sustainability concerns(Jiang, Zhang et al. 2023). Collaboration is needed to address these challenges and develop tailored solutions that maximize the benefits of blockchain while mitigating its limitations(Toufaily, Zalan et al. 2021).

1. Regulatory hurdles and legal considerations

The adoption of blockchain for waste management is hindered by regulatory and legal challenges. Standardized regulations, compliance with data protection laws, varying regulatory frameworks across jurisdictions, and legal questions surrounding smart contracts are some of the key hurdles. Collaboration among technology developers, legal experts, policymakers, and industry stakeholders is crucial to develop regulatory frameworks that address these challenges and facilitate the adoption of blockchain solutions in waste management(Chen and Ogunseitan 2021).

2. Technical limitations and scalability issues

Blockchain technology faces significant technical limitations and scalability issues when it comes to waste management(Toufaily, Zalan et al. 2021). Public blockchains such as Ethereum may struggle to handle large volumes of transactions efficiently, and the energy-intensive consensus mechanisms used in many blockchain networks raise sustainability concerns. Interoperability issues between different blockchain platforms and existing systems can also complicate integration efforts. Ongoing research and development efforts are focused on improving blockchain scalability through solutions such as sharding, layer 2 protocols, and alternative consensus mechanisms like proof-of-stake. Collaborative initiatives are essential to overcome these technical hurdles and unlock the full potential of blockchain technology in transforming waste management processes.

3. Integration challenges with existing waste management infrastructure

Integrating blockchain into waste management infrastructure presents several challenges such as compatibility with legacy systems, establishing standardized protocols and formats, interoperability, scalability, cost, regulatory compliance, privacy, and security. Addressing these issues requires efforts from technology providers, waste management entities, regulatory bodies, and other stakeholders to develop standardized protocols, best practices, and infrastructure upgrades. Blockchain can improve transparency, traceability, and efficiency throughout the waste management supply chain(Joshi, Sharma et al.).

VI. FUTURE DIRECTIONS AND RECOMMENDATIONS

Blockchain technology holds significant promise for revolutionizing waste management. To ensure successful implementation, we need continued research to optimize blockchain protocols for scalability, energy efficiency, and interoperability. Collaboration between technology providers, waste management companies, policymakers, and regulatory bodies is essential to develop robust regulatory frameworks(Zhang, Sheng et al. 2024). Stakeholders should prioritize education and awareness initiatives to increase understanding of blockchain technology and its potential applications in waste management. Lastly, fostering a culture of innovation and entrepreneurship in the waste management sector can spur the development of new blockchain-based solutions and drive continuous improvement in waste management processes.

Figure 4: *Blockchain Technology in Life Cycle assessment*

1. Opportunities for further research and innovation

Blockchain technology can provide transformative solutions to address environmental challenges in waste management. One promising area is the development of blockchain-based systems for tracking and tracing plastic waste throughout its lifecycle(Zhang, Zhong et al. 2020). Additionally, innovative approaches to incentivize waste reduction and recycling behaviors using blockchain-based reward systems can be explored. Decentralized waste-to-resource conversion processes also present exciting opportunities for innovation. Interdisciplinary research collaborations between blockchain experts, waste management professionals, environmental scientists, policymakers, and other stakeholders can unlock new opportunities for a more sustainable future.

1. Strategies for overcoming barriers to adoption and promoting widespread implementation

To promote the use of blockchain technology in waste management, we can adopt strategies such as awareness campaigns, collaborations with stakeholders, pilot projects, incentivization mechanisms and fostering innovation. These approaches can help overcome barriers to adoption and drive widespread implementation, leading to a more sustainable waste management ecosystem(Tillemann, Price et al. 2019).

VII. CONCLUSION

In conclusion, this document has explored the potential of blockchain technology to transform the waste management sector. Blockchain technology offers a novel way to address waste management challenges, such as inefficiency, fraud, corruption, and environmental impact. By leveraging blockchain technology, various stakeholders in the waste management ecosystem can benefit from improved transparency, accountability, security, and efficiency. Moreover, blockchain technology can enable innovative solutions to incentivize waste reduction, recycling, and recovery and create value from waste-to-energy initiatives. However, there are also significant challenges and barriers to adopting blockchain technology in waste management, such as regulatory uncertainty, technical complexity, scalability limitations, and integration difficulties. Therefore, it is essential to foster further research, innovation, and collaboration among various actors, such as governments, businesses, NGOs, and communities, to overcome these obstacles and realize the full potential of blockchain technology in waste management.

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"Highlands Reserve Natural Wealth: Interrogating Ethics and Environmental Consciousness through Resistance Against the Face of Imperialism in J.R.R. Tolkien's *The Hobbit*"

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Abstract- The paper aims to focus on the importance of the highlands amidst the metaphoric anthropocentric but literally non-anthropocentric imaginary world of Middle-earth as portrayed by J.R.R. Tolkien in his work The Hobbit (1937). It probes into the ethics of possession of land and aims to look at climate change as a cultural problem. The highlands serve as the protector of the environment against the various imperialistic threats possessed by both anthropocentric and non-anthropocentric worlds. It also symbolically acts as the preserver of a vast reservoir of wealth. It shows how the hobbit, Bilbo Baggins, in the so-called non-anthropocentric world, acts as the upholder of great values and attaches importance to the sustainability of the ecology. His inner self develops closer to nature and it reaches its culmination when he begins his adventure to the highlands. Unlike the imperialistic endeavours of the dragon or the dwarfs who aim to capture the wealth, so long under the protection of the highlands, Bilbo believes in the principle of giving and, thus, decides to leave the possession under the protection of the highlands.

Using a postcolonial ecocritical lens, the paper attempts to bring to the fore how Bilbo as the marginalized being in the group grows and develops his consciousness in the proximity of nature where the mountain serves as his alter-ego in preserving its sustainability amidst the greater threat of imperialism and globalisation. The paper analyses Edward Said's idea of the 'exotic' in the context of the Orient and investigates how the imperialist tendency of the creatures in the novel is related to the exoticism associated with the highlands. It simultaneously hints towards the destruction of an ecosystem due to unethical authority and a division based on classes. Drawing from Chinua Achebe's criticism of Joseph Conrad's The Heart of Darkness as a racist attempt of Conrad in portraying Africa and its natives, the paper elaborates on how the highlands are a world of its own and it becomes an anthropocentric and a non-anthropocentric endeavour in winning the battle and preserving its sustainability in the era of modern invasion.

Keywords- Highlands, ethics, imperialist, ecology, wealth, resistance.

I. INTRODUCTION

J.R.R. Tolkien's *The Hobbit* (1937) focuses on the significance of the highlands within nature in the imaginary non-anthropocentric world of Middle-earth. It presents nature as a preserver of wealth and showcases the nature-conscious hobbit's resistance to the imperialistic tendencies imposed by the anthropocentric world. It attempts to bring the non-anthropocentric world to the forefront through the exotic creatures and attempts to deconstruct imperialistic tendencies portrayed in the text. The hobbit, Bilbo Baggins who is generally marginalised by the other creatures due to his unadventurous attitude towards life, later becomes one of the primary reasons for the successful adventures of the dwarfs due to his respectful attitude towards nature. Being born and brought up amidst nature and highlands, the paper shows how an entirely different world devoid of humans and anthropocentric notions of worldview can participate in upholding the natural world from the imperialistic tendencies of the characters allegorised as humans seeking the destruction of the world.

The Hobbit has been critically acclaimed majorly as a fantasy fiction but scholars have equally appreciated it as a mythological, historical, or allegorical narrative. This paper aims to use a postcolonial lens to negotiate the alterities of Middle-earth created by Tolkien. Tolkien's invention of fictional places and a new language just before the wake of the Second World War can be coincidental, but the potential of a postcolonial reading of the text cannot be ignored. Molly Brown-Fuller (2013) in her thesis "The Uncanny and the Potential in J.R.R Tolkien's Middle-Earth" argues that some of Tolkien's characters are temporarily otherised. Still, they get back to the mainstream when Tolkien explores a wide range of places. Fuller (2013) thinks that the fictional locations in Middle-earth help Tolkien to problematize the relationships among the coloniser, colonised and fetishism where "the colonizer(s) disavow their own fears of these places by fetishizing the pathways they colonize for their safe passage" (p. ii).

Using a post-colonial eco-critical lens, the paper aims to show how a deviation from the

Anthropocene can help the marginalised to create a world of their own amidst highlands which in itself tries and preserve its sustainability amidst the external threats that haunt their sustenance. Eco-feminist critic Vandana Shiva (1988) also highlights how the Anthropocene became the primary reason for the destruction of the motherland and how the marginalized connected with the highland territory play an important role in serving the nation. Bilbo Baggins in the novel plays a similar role in resisting imperialism and raising the consciousness of preserving the highland culture. Bilbo Baggins who becomes the epitome of saving highland culture is generally viewed as an 'exotic' in the words of Edward Said (1977) and he rejects the 'gaze' that he receives from various other races through his self-development and building consciousness among other creatures that the wealth that technically belonged to the dwarfs were the possession of the nature and the capturing of the wealth might lead to the destruction of the world.

II. QUESTION OF THE HIGHLANDS

Through the character of Baggins, the author wants to raise the question of who could be considered the rightful heir to the wealth of the highlands. He brings in the concept of ethics as associated with environmental possession. Being a child of nature, he is seen to resist the master-slave dialectic that emerges from the unethical looting of wealth from nature. The dwarfs as colonialists attempt to plunder and drain the wealth of nature where Bilbo breaks the hierarchy of dominance and saves the land from the mouth of destruction. The ethical consciousness and the self-awareness of what constitutes right and wrong bring about a major change in the dynamics of global change. Both natives and colonialists tend to destroy the original wealth of nature for the benefit of their own territories. The dwarfs wanted to retrieve their wealth while the head of the men, the leader of the lake-men, Bard also believed that they had an equal share of the wealth for supporting the dwarfs and helping them destroy the goblins. Destruction of the highlands and the landmass signifies the destruction of the womb, production, and fertility of the land due to which the highlands fail to prosper. Bilbo's entry as a hobbit in the group serves as an intervention to break the imperialistic tendencies and raise the environmental consciousness among the dwarfs that allegorically implies why the mass of the wealth accumulated could not be carried back to their homeland and they decided to leave the acquired treasure in the womb of the highland itself. Mount Erebor which in itself was under the colonization of the dragon, Smaug, received its freedom in the hands of the 'other', the marginalized hobbit who fights back to regain his land, the nature which he calls 'home'.

While Mount Erebor used to be a space of livelihood and protection for the dwarfs, it became a desolate and barren land after its capture by the dragon Smaug. The environmental changes associated with the hands of the Anthropocene are also highlighted through the battle of Five Armies at the end of the story which signifies the ultimate decay of society amid greed and power associated with the changes brought about by the industrial revolution. The scientific revolution poses a threat to the lands that had its peace and beauty amidst the greenery of nature. Here Bilbo's intervention brings about an ethical inquiry and a rise towards environmental consciousness amidst greed, power, possession, and decay.

The Highland is the most important mark of Tolkien's geographic landscape. *The Hobbit* revolves around an expedition to the Lonely Mountain or Mount Erebor, and the mountain is one of the central characters of the novel as well as the film series of the same title. Smaug displaced the 'King under the mountain', Thror and was protecting the wealth of the highland. Thorin Oakenshield, the dwarf king pledged to retrieve the homeland, the 'lonely mountain', and all the wealth which the dwarfs left there including the most precious Arkenstone. Thereafter, the dwarfs initiated the expedition to the mountain to colonize nature. Tolkien does not make it clear in the novel how the huge wealth was stored in the highlands but the dwarfs' claim on it is quite clear. The dwarfs not only wanted to retrieve the lost wealth but they also wanted to recapture the mountain from Smaug's control. The paper tries to evaluate if the dwarfs' right on the mountain and its wealth is justified or not and it will also investigate the literal and metaphorical interpretation of the wealth reserved in the highlands.

III. IMPERIALISTIC TURN

Tolkien creates imaginary creatures to knit a story that can be allegorical. Hobbits are happy within their hobbit holes and do not aspire to imperialise the highlands or nature. The dwarfs, on the other hand, are keen to retrieve the wealth of the highlands. Tolkien allegorizes the wealth of the mountain as almost all the creatures aim to imperialise it. Tolkien adds a map in the novel, the majority of which is covered by mountains and forests. The highlands are the reservoir of natural wealth and the mountains are invaded. *The Hobbit* gives rise to many pertinent questions in the postcolonial world like who should be the inheritor of the natural wealth or if wealth should be accumulated for satisfying one's need or greed.

A new narrative for the children in the form of a folktale might be considered as a part of the narrative of resistance where Bilbo as a part of nature aims to prevent the exploitation of the Highlands. The use of a new linguistic pattern can be considered as a shift from the age of the Holocene to the age of the Anthropocene where the increasing carbon footprints reduce the lifespan of biodiversity. Tolkien carries the linguistic system forward in *The Lord of the Rings*

(1954) and the publication dates for both novels are significant because of the shift in the power dynamics in pre and post Second World War. The clear shift of power in the novel indicates an upcoming revolution which the readers find at the end with the death of Smaug, the dragon, and with the transformation of Bilbo from a timid hobbit to an expert burglar. Bilbo's attempt to restore power equilibrium is an effort to conserve the Highlands which had to be protected from the exploitation of multiple species.

IV. RESISTANCE

The hobbit as a species can be contrasted against the goblins or the dwarfs who are more war-like. The paper argues that the pre-Second World War time has been reflected in the novel. Scholars have compared the goblins with the Nazis who are experts in production but only produce the things of torture. The dwarfs are aggressive in nature and their sole motive is to retrieve their fatherland. The elves are dwellers of the forest- they possess the natural wealth but they also aim to capture parts of the wealth of the highlands. The highlands which do not specifically belong to anyone, are colonized by all. Smaug, the dragon takes it away from the dwarfs but all the creatures have their turn in colonizing the highlands. The imperialistic tendency is prominent within the goblins or the dwarfs but the other creatures like the elves or the hobbit also play their part in colonizing nature. The paper considers all the creatures of the novel including the lake-men as inhibitors of the anthropocentric world who willingly or unwillingly colonise the natural world, and this imperialistic tendency is quite similar to the history of European colonialism. Joesph Conrad in *Heart of Darkness* (1899) portrays a graphic picture of such imperialism where the chief aim of European colonizers is to exploit the unexplored territory of Africa, the 'heart of darkness'. Similarly, all the creatures in Tolkien's novel try to retrieve the wealth from the highlands, the 'lonely mountain' which is majorly unexplored due to Smaug's domination and has become a 'heart of darkness' due to the unresolved mystery.

Chinua Achebe has brutally criticized Conrad's approach towards Africa as he thinks that the colonizers have a much restricted and very limited viewpoint of the continent. For Conrad, Achebe is a representative of European imperialism whose sole motive is to humiliate Africa and Africans as he comments, "*Heart of Darkness* projects the image of Africa as 'the other land', the antithesis of Europe and therefore of civilization, a place where man's vaunted intelligence and refinement are finally mocked by triumphant bestiality" (Achebe, 1977, p. 2). Similarly, the highlands have been otherised in the novel and the sole motive of the creatures is to exploit the forest and the mountain. The highlands have been exoticized and Tolkien deliberately draws the map in such a way that carries a deep undertone of mystery. The dwarfs always consider the forest dwellers as strange and mysterious as they have their reasons to do so. Edward Said considers exoticism as an inseparable element of colonisation and while discussing the word 'orient', Said (1977) comments, "This is not to deny that for artists like Nerval and Segalen the word 'Orient" was wonderfully, ingeniously connected to exoticism, glamour, mystery and promise" (p. 341). The highland in Tolkien's novel is exotic, mysterious, and glamorous, and brings a lot of promises to the creatures. The highlands are mostly uninhabited and unexplored, so it is mysterious and exotic. The 'lonely mountain' is associated with the glorious past of the dwarfs when the 'King under the mountain' ruled there with his great wealth and possession. Finally, the highlands come with the promises of immense wealth, literal or metaphorical, and of a grand future when Thorin Oakenshield, the rightful 'king under the mountain' will be restored to his throne.

The imperialistic tendencies reach their culmination when the dwarfs reach the dragon's cave to retrieve their fatherland and wealth. Smaug, the dragon attacks the lake-men and is killed by Bard. The creatures gather in the highlands to fight in the battle of five armies and all the five armies aim towards collecting the wealth of the mountain. Though they know that the huge amount of wealth of the highlands cannot be displaced still they fight for it. Bilbo strategically wants to prevent the battle but he is unable to prevent it because of the greed of the creatures. A few years after the publication of the novel, the Second World War observed similar battles among multiple nations divided into two sides. Though the dwarfs won the battle, they could not win the Arkenstone as Thorin understood that all these endeavours to gather wealth are futile. Previously, Thorin had an imperialistic mindset and he accused Bilbo of treachery when he tried to prevent the war by exchanging the Arkenstone with the elves. But on his deathbed, injured Thorin agreed that the battle to accumulate wealth was useless and he told Bilbo, "If more of us valued food and cheer and song above hoarded gold, it would be a merrier world" (Tolkien, 1937, p. 271). Thorin here becomes the spokesperson of Tolkien who vouches for peace over war. But the Second World War again chose war over peace and at the end of the war, even the winners understood that the entire effort was futile as imperialism would not help in the betterment of mankind. Like the non-anthropocentric world of the novel, the anthropocentric real world also understood that natural wealth cannot be displaced and the entire war becomes futile at a certain point.

V. QUESTION OF ETHICS

Bilbo as a nature-conscious hobbit is seen to come out of the womb of nature where he used to belong due to the sheer adventurous fits of the dwarfs and the proposal by the wizard, Gandalf to accompany them

on a rugged adventurous journey and help the dwarfs retrieve their possession which had unlawfully captured by Smaug. Bilbo possessed non-adventurous skills like any other hobbit who is "shy of the Big People… are little people, about half of our height, and smaller than the bearded dwarfs" (Tolkien, 1937, p. 14). Yet Gandalf believed that Bilbo had inherited his mother Belladonna Took's adventurous skills, the Tooks, head of the hobbits who had the urge to go out and seek adventures. Moving out from his natural world, Bilbo had to face a lot of challenges in saving his life as well as the life of nature. Bilbo's initiation began the moment he accompanied Thorin and his company to help them recover their lost wealth. Though he was an exotic, an 'other' in the group who had no particular interest in the adventure, his contribution to the adventure spoke of the great knowledge that a person can develop in the lap of nature. His resourcefulness at the time of the journey amounts to the consciousness building that Mother Earth had imbibed in him. He resists the oriental gaze coming from the dwarfs and initiates a process of friendship by developing his adventurous skills. Unlike all the characters in the novel, including the dwarfs, dragons, or goblins who are race-conscious creatures and believed in the destruction or capturing of Mother Earth, Bilbo Baggins as the hobbit believes in the preservation of nature and raising the consciousness that the wealth of nature cannot be taken away by any means by anyone.

If the dwarfs were seen to possess nationalistic tendencies and in the mission of saving their land by retrieving their lost wealth, Bilbo also can be seen to preserve the utility of the land to which he belongs. He highlights how the attempt to colonise the wealth belongs to nature and leads to the destruction of the self as well as the land at large as Vandana Shiva (1988) comments, "The existence of feminine principle is linked with diversity and sharing. Its destruction through homogenization and privatisation leads to the destruction of diversity and of the commons" (p. 43). The deliberate exclusion of any female characters in the novel also highlights that nature as a woman is plundered and looted amidst the imperialistic and expansionist tendencies of humans. The goblins as the maker of weapons were essentially interested in ruling the world and destroying the territories of others. Elves and the lake-men believed in individualistic policies and never allowed the intrusion of their territories by other races. Thorin, the leader of the dwarfs had particularly fallen prey to the hand of greed and power and denied the share of wealth promised to Bard for accompanying them in the killing of Smaug. The conflict raised between the dwarfs and Smaug led to the mass destruction of the men of lake-town and though Bard had killed Smaug before the dwarfs could find ways of doing the same, the dragon's fall destroyed the entire landmass which could have taken years to be recovered. This highlights the condition of nature amidst the greed and territorialisation of the anthropocentric world. The recovery of this destruction is led by Bilbo by resolving the conflict between the men and the dwarfs by handing over the precious Arkenstone to the men and helping them rebuild their land. The exclusion suffered by the environment in the hands of humanistic tendencies is rebuilt and reconstructed through Bilbo's consciousness of saving Nature. The patriarchal endeavour of amassing wealth and increasing the territorial land leads to the destruction of the natural reservoir and the marginalised then come to the forefront to protect the dues of nature as Shiva (1988) also notes, "Marginalisation become a source for healing the diseased mainstream of patriarchal development" (p. 45). Bilbo's leaving of the hobbit hole amidst the natural environment and joining in the adventure symbolically brings him to the forefront where he comes out of the marginalised position, resists his exoticness and plays a dominant role in saving the highlands and the natural wealth from devastation.

Considering Bilbo as the other or the Orient and his place i.e., the hobbit hole, as inferior, stagnant, and degenerate the other creatures had tried to justify their imperialistic tendencies and exploitation of his highland. It is the discourse of power and knowledge that the goblins and the dwarfs inculcate to otherize the hobbit and its highlands. The destruction of the land amidst the conflict between humans and their destructive tendencies led Bilbo to come out of his comfort zone and serve as the savior of the land which had been attacked, looted and tortured in the hands of the imperial power as Said notes that orientalism created a space in which justifications of Occidental's political and cultural domination could be imposed on the Orient. The resistance to surrender while the crisis comes his way signifies the desire to fight back and uphold the natural reservoir of the earth by giving back its wealth and sustaining its vast reservoir. Bilbo's action in the journey and saving the possession of the highlands can be seen as resistance from the marginalised community and turning the gaze back by writing back to the empire. Bilbo being the most inconvenient member of the group both physically and symbolically as an 'other' and a marginalised being turns out to be the most daring of all. In Bakhtin's (1965) words, this 'carnivalesque' atmosphere of breaking the hierarchy of the dominant and the dominated and reversing the power hierarchy is represented by Bilbo's encounter with Smaug, Gollum, trolls and the spiders. His presence of mind, daringness and power of riddles enabled him not only to save himself but his entire group of imperialist friends from falling prey to these creatures who were preventing their territory, and thus, were anti-imperialist in nature.

No one in the group had enough courage to encounter Smaug despite the interest to retrieve the

wealth. Bilbo in this instance showed unparallel bravery in entering the cave and recovering the wealth from the danger of the dragon proving Bilbo's resistance against the face of imperialism and his enduring efforts in saving the highlands despite being othered and marginalised. The other marginalised creature like Gollum being cursed and turned into a creature still continued to resist imperialism by protecting his own territory just like the elves and Breon, the skin-changer who never allowed intrusion in their owned territories from the imperialists. Breon protecting his territory on the hillside never allowed any external threats to surpass the highlands. Rather his dominance over protecting nature disallowed anyone to show enough courage to attack the highlands. Breon like the hobbit also embraced nature and its resources and Breon's skin-changing characteristics became his added advantage to scare any threats away. Hobbit, Breon, Gollum and the spiders protected their own territory from any random invasions by the imperialists and showed their resistance against the face of intrusion by the colonialists. Being marginalised and oppressed just like the highland itself they resist the suppression and break the hierarchy of the ruler and the ruled. It raises pertinent questions on the rightful possession of wealth and concludes that the natural wealth, productivity and fertility of highlands cannot be snatched away from nature which resists the domination produced on them and takes its stand in the wake of destruction and devastation of landmass. The paper concludes that highlands being the vast natural preserver of wealth cannot be displaced either by natives or imperialists and nature in itself creates a space for themselves to resist snatching of wealth from their womb which in turn is embraced by the so-called marginalised beings of nature and amalgamating their selves with that of nature they resist oriental gaze and emerge victorious. In this context, Shiva (1988) notes, "Modern science was consciously a gendered, patriarchal activity. As nature came to be seen more like a woman to be raped, gender too was recreated… the ideology of science sanctioned the denudation of nature" (p. 17).

VI. CONCLUSION

The creatures take resort to violence in order to protect their own territory which justifies Franz Fanon's view of decolonisation. Tolkien shows that the vast ecological reserve of the highlands does not need any anthropocentric protection as that is well protected by the highland itself. Natural wealth or the hoarded gold is not owned by any creature as there remains a constant fight between the imperialists and the natural landscape. The dwarfs or Smaug might think that they own the mountain and thus, deserve the wealth or the elves or the spiders might think that they own the forest, but using so many conflicts throughout the novel Tolkien shows that the hoarded gold or the highlands does not belong to anyone. The creatures might seem like the natives or the subalterns, but they are not entitled to displace the hoarded gold. Though the death of nature is the beginning of their marginalisation, devaluation and displacement, Bilbo's encounter with the imperialist and resisting the disruption of nature's productivity justifies Chinua Achebe's statement, "Let them come and see men and women and children who know how to live, whose joy of life has not yet been killed by those who claimed to teach other nations to bow" (Shiva,1988, p. xii).

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