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Research Article

Social Robot Face Emotion Recognition Using Wavelet Transformation

Ms. R.Gayathri [1], Dr. S. Uma[2]

[1] Ph.D Research Scholar, Department of Computer Science, C.M.S College of Science and Commerce, Coimbatore-49, Tamil Nadu, India.
[2]Associate Professor, Department of Computer Science, Dr. N.G.P. Arts and Science College, Coimbatore-48, Tamil Nadu, India.

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ABSTRACT

Facial emotion recognition plays a pivotal role in enabling social robots to interact with humans effectively, as it allows robots to perceive and respond to human emotional states. Emotions are complex and dynamic, involving various physiological and behavioral cues. This study explores the use of Wavelet Transform as a tool for enhancing emotion recognition in social robots. The Wavelet Transform is a mathematical technique that captures both time and frequency-domain information simultaneously, making it ideal for analyzing physiological signals like EEG and ECG. The findings show that Wavelet Transform-based emotion recognition can significantly improve a social robot's ability to perceive and respond to human emotions in real time. This advancement has the potential to revolutionize human-robot interactions in various domains, such as healthcare, education, and entertainment, by enabling more empathetic and context-aware interactions. This research contributes to the ongoing development of emotionally intelligent social robots, paving the way for more natural and meaningful human-robot interactions.

Keywords: Social Robots, Artificial intelligence, wavelet transform, Emotion Recognition

INTRODUCTION

A social robot is one that is made to interact socially and naturally with people. They can be found everywhere, including public areas, schools, hospitals, and residences. These robots can recognize and react to human emotions, gestures, and voice thanks to their sensors, artificial intelligence, and communication interfaces. They take care of the elderly, treat the autistic, encourage learning in kids, help with customer service in retail settings, and provide entertainment in public areas, among many other functions. Among the many shapes that social robots can take are virtual assistants that resemble humans, animals, or screens. Because social robots may enhance production, efficiency, and human-robot cooperation, they are becoming more and more popular across a range of industries.
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Manufacturing and Assembly: By assisting human workers with precise and repetitive tasks, optimizing the production process, and reducing errors, social robots can enhance manufacturing and assembly operations.
Customer service: Retail, hotel, and service industries utilize social robots to help customers with informational tasks, product or service discovery, and Q&A sessions.
Healthcare: In the medical industry, social robots are used to monitor vital signs, converse with patients, keep them company, and remind them to take their meds.
Education: By providing personalized tutoring, answering questions, and assisting students with their homework, social robots are being employed in educational settings as interactive teaching tools that enhance the learning process.
Warehouse Management: Social robots help human workers with selecting and packing duties while helping to manage inventories and fulfill orders in warehouses.
Agriculture: To perform labor-intensive jobs like planting, harvesting, and crop health monitoring,

autonomous social robots are deployed in fields**.**

Construction: Under human supervision, social robots equipped with advanced sensors and Artificial Intelligence (AI) could assist in construction tasks, inspect buildings, take measurements, and perform particular tasks.

Research and Development: Social robots are vital tools in scientific research labs because they can follow preset protocols and interact with researchers for data collecting and experimentation. **Entertainment and Hospitality:** Social robots are employed as tour guides, greeters, and entertainers at theme parks and resorts to enhance the visitor experience.

Public Spaces: In public places like airports and museums, social robots are used to give guests information, guidance, and security assistance. Emotion recognition is essential for social robots to function well and be accepted in human interactions for a number of reasons.

Enhanced Communication: Since emotions are at the core of human communication, social robots that are trained to recognize and respond to human emotions can help people communicate more effectively. By enhancing the naturalness and reliability of interactions, this enhances the whole experience.

Empathy and Social Bonding: In situations where individuals require emotional assistance, like healthcare or elder care, emotionally intelligent robots that can demonstrate empathy by comprehending and valuing human emotions might promote a sense of social connection between humans and robots.

Adaptability: Emotionally aware social robots may change how they behave and respond to people according on how they are feeling. This enables them to provide individuals in need with appropriate and targeted help.

Personalization: By comprehending people's emotions and preferences, social robots equipped with emotion recognition capabilities can tailor their interactions with them. By personalizing their responses, ideas, and activities, they may do this and boost customer satisfaction and engagement. People and robots can develop a sense of social connection, especially in situations where emotional support is required, such healthcare or elder care, when emotionally in need of in effect.

Human-Autonomous Coordination: Understanding human emotions is crucial for effective human-robot collaboration in industrial or research environments, as it allows robots to read intents and mood, ensuring appropriate reactions to human cues and instructions. The roles of therapy and assistance: In therapeutic contexts such as autism therapy and mental health support, social robots with emotional recognition skills can be very beneficial by providing emotional signals and feedback, supporting therapeutic activities, and assisting individuals in managing their emotions.

Acceptance in the Market: Because people feel more at ease interacting with robots that are capable of sensing and responding to emotions, there has been a rise in the use of robotic technology**.**

Ethical Considerations: In order for robots to act properly, prevent discomfort, and respect boundaries, they must be able to identify emotions. For moral human-robot relationships, this is crucial. Emotions are crucial for human-robot interaction because robots may model and exhibit emotions in a number of ways that encourage social engagement. The capacity for social robots to identify emotions enhances their interpersonal communication skills and strengthens their emotional relationships.

Emotion plays a crucial role in human-robot interaction by both igniting and strengthening the emotional bonds that exist between humans and robots. Emotion is essential for fostering social interaction in robots because it allows them to behave in ways that are similar to those of humans. Emotion recognition is crucial for robots, especially social robots, to interact with humans. Traditional techniques have limitations in terms of precision and speed, which impede intuitive and responsive interactions. This study aims to address these problems by examining wavelet transformation techniques for emotion recognition in social robots. Wavelet transformation, which is widely known for its effectiveness in signal processing and feature extraction, has showed promise in enhancing emotion identification systems. However, its application to social robots has not yet received enough attention.

The research will employ wavelet transformation to develop a trustworthy and efficient system for recognizing emotions. The study uses a mathematical technique to simultaneously collect time-domain and frequency-domain data in order to examine how the Wavelet Transform can be used to improve social robots' ability to identify and respond to human emotions. It seeks to demonstrate the wavelet transform method's promising statistical analysis of automated emotion recognition.

LITERATURE SURVEY

Emotions in HRI remain challenging to integrate due to the need for reliable interactions, precise results, and time constraints for incorporating observed emotions into robot behavior adaptation [2]. This survey, which runs from 2000 to 2020, looks at how people perceive and respond to artificially manufactured emotions by social robots. It highlights advances in robotic psychology that have led to the formation of these emotions as well as how people perceive and respond to them [3]. The analysis of 232 publications on emotional intelligence, emotional models, and their application in robotics [4] highlights the importance of emotion detection in improving human-robot interaction (HRI) and robot performance. Social robotics research aims to improve human-robot interaction and navigation by identifying face expressions.

Accuracy in real-world circumstances is lower than in controlled laboratory conditions, highlighting the need

for additional research [5]. For robot navigation algorithms, Ginés et.al [6] propose a mood detector component that builds a list of emotions present in the image and tags them with positive, neutral, or negative moods over time. The study, which also proposes a multimodal emotion identification system that takes into account vocal tones and facial expressions, highlights the significance of emotion detection in human-robot interaction in this publication [7]. The technology aims to improve human-robot interaction by promoting emotional relationships and communication between the two species by analyzing speech and facial expressions to discern emotions.

Speech Emotion Recognition (SER) is a critical component that is examined by Alluhaidanet.al [8]. It uses machine learning and neural network technology to investigate speech emotion recognition (SER), an essential part of advanced human-computer interaction. It discusses SER techniques found in the literature, both historical and modern. Cardosoet.al [9] investigates the development of an Emotion Multi-modal Aggregator (EMmA) for AI systems. They used open-source, single-source emotion categorization methods, and the EmMaggregator forecasts emotions. The approach separates the audio and frames of a video clip, and then each source is sent through primary classifiers. The results are combined with machine learning aggregator techniques to build a final classifier. With an accuracy of 80% on the selected dataset, Random Forest and k-Nearest Neighbors outperformed expectations The technique shown in the paper uses a robotic arm to deliver an object in response to a human's facial expression, illuminating real-time emotion recognition for physical human-robot communication. A convolutional neural network-based algorithm was developed to identify emotions in real time. The system was built using an embedded Nvidia Jetson Nano computer, a webcam, the ROS and TensorFlow frameworks, and OpenCV. The developed model produced an accuracy of 93.5% and an error of 6.5% during training and validation. The final prototype's testing accuracy was 94%, with a 6% error [10]. For social robots to change their behavior and associate emotions with other objects, they must comprehend human emotional states.

To identify emotions, they gather information from a variety of sources, including text, audio, images, and videos, and analyze it. Machine learning and Natural Language Processing (NLP) techniques can be used for the analysis of faces and postures in images and videos, as well as for the transcription of speech into text for the purpose of emotion recognition. To enable social robots to identify emotions and preserve this information in a semantic repository, a system built on top of EMONTO (an Emotion Ontology) is proposed. The proof-of-concept version of this system focuses on text emotion recognition via speech-to-text conversion sources or directly text-based sources. Robot tour guides for museums were employed to evaluate the implementation utilizing a speech-to-text converter, a neural network to categorize emotions in texts, and EMONTO combined with ontology. The classification model evaluation by Graterol et.al**.** yielded results similar to a state-of-the-art transformer-based model and provided a roadmap for further development [11]. Emotion recognition is a key tactic used by social robots to improve human-robot interaction and mimic human social behavior. There are a number of limitations with the current studies on multimodal emotion detection, including a decrease in performance when one or more modalities are absent or have different characteristics. This is caused by the vast array of sensory capacities that robots have.

An adaptive and flexible architecture for emotion recognition is offered by Heredia et.al [1] in order to address this. This architecture can handle different levels of data quality and missing data while working with a variety of information sources and modalities. The architecture combines partial results from independent analyses conducted by each modality using an earlier fusion technique called EmbraceNet+. In studies to see how well the suggested design operates, four categories of emotions—happiness, neutral, sorrow, and anger are utilized to detect emotions.

METHODOLOGY

The proposed work's block diagram is displayed in Figure 1. This architecture enables social robots to recognize and respond to human emotions, hence enhancing social interactions. It also comprises sensors to record facial expressions, wavelet transform and statistical analysis for processing face data, and emotion recognition algorithms.

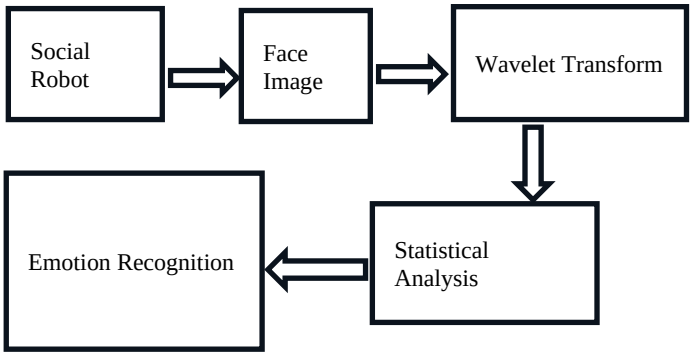

Figure 1: Block Diagram

RESULTS AND DISCUSSION

Social robots are robots designed to interact with humans; they often mimic human emotions and behaviors to encourage dialogue. Faces equipped with sensors and technology is able to recognize and interpret human facial expressions, which are crucial markers of emotional states. Wavelet Transform: Signals or data can be analyzed mathematically using the wavelet transform, which is particularly useful when recognizing emotions. It assists in deciphering complex signals like facial expressions, so that valuable traits or patterns can be identified. Data from social robot sensors, such as facial expressions, are analyzed statistically to find trends, correlations, and patterns that are crucial for accurately identifying emotions.

Using data from facial expressions, this architecture aims to comprehend human emotions. Emotion identification algorithm is capable of classifying facial expressions into a wide range of emotional states, such as anger, sadness, and happiness. By being able to identify and react to human emotions, this enhances social robots' ability to engage in meaningful and compassionate human-to-human interaction. The social robot face image examined by the DWT algorithm is displayed in Figure 2. The statistical analysis of the original social robot image is displayed in Figure 3. The statistical analysis of the level synthesized image of the social robot is displayed in Figure 4.

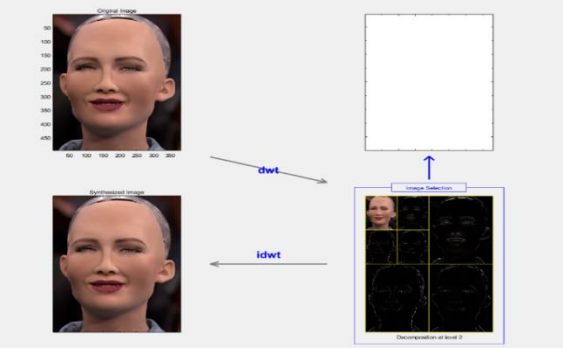

Figure 2: Social robot face analyzed with wavelet Transform

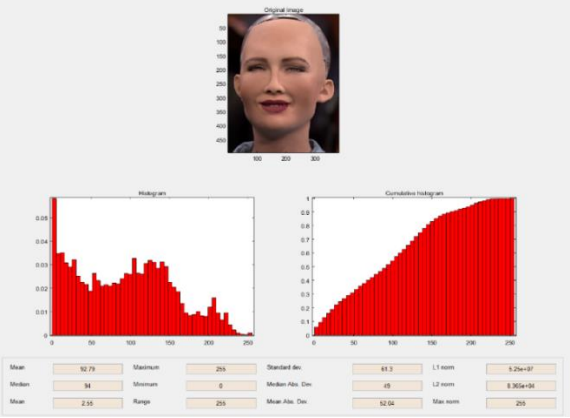

Figure 3: Statistical analyzed in Original Image with haar→X+1:381-Y+1:495

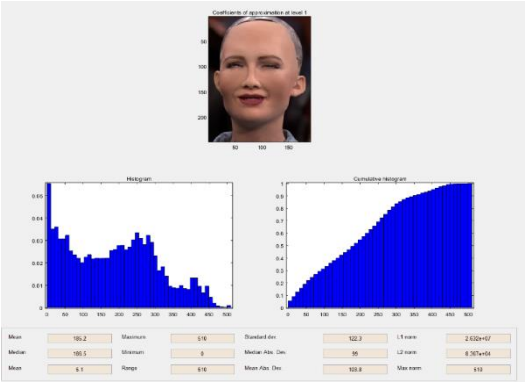

Figure 4: Statistical analyzed in Synthesized Image at level 2 with haar→X+1:381-Y+1:495

CONCLUSION

The development of empathy in social robots and improving human-robot interactions are the main goals of this research. It uses the mathematical method of wavelet transformation to evaluate non-stationary data and identifies emotions based on inputs including voice, body language, facial expressions, and physiological markers. In order to precisely identify emotions, the research integrates statistical analysis, wavelet transform methods, and emotion recognition algorithms into the robot design. With sophisticated algorithms allowing them to comprehend complex emotions including facial expressions, speech tones, body language, and physiological signs, the future of emotion identification in social robots seems bright. The accuracy of emotion detection in intricate real-life circumstances can be improved by integrating numerous sensors, including microphones, cameras, and biosensors, to achieve multimodal emotion recognition. Humanization will lead relationships between humans and machines to shift, becoming more genuine and organic in nature.

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