Integrating Physiological Sensors and Robotics for Educational Innovation: The mBot Neo Project

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ABSTRACT

The mBot Neo project addresses the research gap in educational software by merging physical robots and physiological sensors. This innovative approach aims to create an interactive learning experience by capturing and interpreting EEG and EMG signals to identify gestures and emotional states. These insights are then linked to a physical robot, facilitating a novel connection between human physiology and robot behavior.

This paper outlines the mBot Neo system's core components, elucidating the process of collecting and processing physiological data for real-time event classification, from basic arm movements to intricate emotional cues like attention levels. Leveraging advanced signal processing and machine learning, the system offers a unique perspective on user interactions and emotions.

The project's significance lies in its potential to reshape educational technology by establishing a cohesive framework between human physiological responses and robotics. By fostering an interdisciplinary approach, mBot Neo encourages innovative teaching techniques that exploit the interplay between human cues and robot actions for enhanced learning outcomes.

This work contributes to the discourse on the future of interactive educational tools, presenting a blend of advanced technology and pedagogical advancement. The mBot Neo project's upcoming conference poster presentation will showcase its technical architecture and the promising implications of this pioneering system. In summary, mBot Neo envisions a transformed educational landscape, bridging the gap between human physiology and robotics to redefine interactive learning.

1 INTRODUCTION

In recent years, the intersection of robotics, physiological sensing, and educational technology has become an area of growing interest. The mBot Neo project aims to address a critical research gap by innovatively merging physical robots and physiological sensors within the realm of educational software. This integration promises to revolutionize the way we conceive interactive learning experiences, where the fusion of human physiological responses and robot behavior creates a novel paradigm.

Educational technology has evolved significantly, yet the integration of physical robots and physiological sensors remains largely unexplored. The mBot Neo project seeks to bridge this gap by capturing and interpreting physiological signals such as EEG and EMG, enabling the identification of gestures and emotional states. By linking these insights to a physical robot, the project establishes a unique connection between human physiology and the actions of the robot.

This paper provides a comprehensive overview of the mBot Neo system, delving into its core components. The process of collecting and processing physiological data for real-time event classification is elucidated, ranging from elementary arm movements to intricate emotional cues such as attention levels. Leveraging advanced signal processing and machine learning techniques, the mBot Neo system offers an unparalleled perspective on user interactions and emotions.

The significance of the mBot Neo project lies in its potential to reshape the landscape of educational technology. By constructing a cohesive framework that intertwines human physiological responses with robotics, the project paves the way for innovative teaching techniques. This interdisciplinary approach encourages the exploitation of the interplay between human cues and robot actions to elevate learning outcomes.

As technology and pedagogy converge, the mBot Neo project contributes to the ongoing discourse on the future of interactive educational tools. This paper not only presents a fusion of cutting-edge technology and pedagogical advancement but also sets the stage for the project's forthcoming conference poster presentation. This presentation will showcase the intricate technical architecture of mBot Neo and highlight the promising implications of this pioneering system.

In summary, the mBot Neo project envisions a transformed educational landscape that bridges the gap between human physiology and robotics, ushering in a new era of interactive learning. The remainder of this paper will detail the technical architecture, methodologies, and outcomes of the mBot Neo project, underpinning its potential to redefine educational technology.

2 BACKGROUND

The landscape of education is undergoing a profound transformation, fueled by the rapid advancements in technology. The integration of robotics and physiological sensors holds the promise of revolutionizing how interactive learning experiences are conceived and implemented1. While educational software has made significant strides, the fusion of physical robots and human physiological responses remains an area ripe for exploration.

Current educational technology often focuses on digital interfaces, simulations, and online platforms, neglecting the potential synergy between physical robots and human physiological responses. The mBot Neo project seeks to bridge this gap by pioneering an innovative approach that merges these disparate domains, aiming to create a more holistic and engaging educational experience.

Physiological sensing, encompassing signals such as EEG and EMG, offers insights into human cognitive and emotional states

[3]. These signals, when properly captured and interpreted, can provide valuable cues for understanding gestures and emotional reactions, thus enriching the interactive learning process. Linking these physiological insights to physical robots creates a unique bridge between human physiology and robot behavior, opening avenues for new pedagogical strategies.

This paper outlines the mBot Neo project's approach, detailing the core components of the system that enable the integration of physiological sensing and robotics. The project's multidisciplinary nature brings together expertise from fields such as engineering, neuroscience, and education, highlighting its commitment to reshaping the educational technology landscape.

By establishing a cohesive framework that amalgamates human physiological responses and robotic actions, the mBot Neo project contributes to the evolution of interactive educational tools. The adoption of an interdisciplinary approach fosters innovative teaching methods that leverage the synergy between human cues and robot behaviors to enhance learning outcomes [2].

This work aligns with the broader discourse on the future of educational technology, which seeks to harness the power of technology to create more immersive, personalized, and effective learning experiences [1]. As the mBot Neo project's technical architecture and outcomes are presented in the following sections, its potential to redefine educational technology by integrating physiological sensors and robotics will be further elucidated.

3 PROJECT OUTLINE

Week 1: Project Introduction and Orientation During the initial week, a comprehensive overview of the project was provided by Dr. Crawford and the mentors. The concept of "Physiological Computing Education" was introduced, highlighting the distinctions between EEG and EMG technologies.

Week 2: mBot Neo Setup and Basic Control This phase focused on assembling the mBot Neo and installing the mBlock software. Initial steps involved connecting the mBot Neo to the computer and learning the basics of controlling it. Essential scripts were developed to facilitate obstacle avoidance utilizing the ultrasonic sensor.

Week 3: Wall Following Behavior Development Building upon the foundational knowledge, the third week delved into creating a script for the mBot Neo to follow a wall. Challenges in sensor placement were addressed, leading to the development of an accurate wall-following behavior. Dr. Crawford's guidance further refined the approach through the incorporation of variables and a PiD controller.

Week 4: Programming Beyond mBlock Software Expanding the project's scope, this week revolved around exploring alternative ways to program the mBot Neo outside of the mBlock software. Despite initial challenges in finding relevant information, comprehensive documentation was identified, laying the groundwork for further experimentation.

Week 5: Interactive Engagement Measurement with mBot Neo The focus of the fifth week was on creating interactive scripts to gauge user engagement. A reaction time game was developed, leveraging LED colors and text prompts on the mBot Neo. Additionally, discussions with Dr. Crawford led to the exploration of utilizing an EmotiBit for engagement assessment.

Week 6: EmotiBit Integration and Real-time Data Collection In this phase, the EmotiBit was configured for real-time physiological data collection. The week was dedicated to understanding the EmotiBit setup, establishing communication with Visual Studio Code via OSC, and overcoming initial challenges with guidance from Dr. Crawford.

Week 7: Physiological Sensor-Action Mapping on Cyberpi The focus shifted to integrating physiological data from the EmotiBit with the mBot Neo's actions. A variable-based approach was initially explored, leading to the creation of conditional sequences for mapping specific actions on the Cyberpi based on the EmotiBit data. Although challenges in continuous adaptation were encountered, valuable insights were gained.

Week 8: Ongoing Development and Troubleshooting The final week of this outlined project marks a continuation of the previous week's efforts. Continued refinement of the physiological sensor-action mapping was the key objective. Challenges in real-time responsiveness and adaptation to varying physiological states were addressed, paving the way for enhanced outcomes.

Conclusion: Insights and Future Directions This section will summarize the accomplishments, challenges, and lessons learned throughout the project. It will also offer a glimpse into potential future directions for expanding the integration of physiological sensing and robotics in educational contexts.

This outlined project details the progressive steps undertaken to merge the realms of physiological sensing and robotics for educational innovation. The journey encompasses technical setup, programming challenges, integration of sensors, and their alignment with robot actions. The developed approaches and insights contribute to bridging the gap between physiological responses and interactive learning experiences, with a vision for shaping the future of education technology.

4 CONCLUSION

The eight-week project progressed systematically, with early stages dedicated to mBot Neo setup and foundational programming. The successful development of a wall-following script demonstrated adaptability in control mechanisms. Advanced phases encompassed integrating the EmotiBit for real-time physiological data collection, revealing complexities in merging disparate technologies. Collaboration with Dr. Crawford facilitated breakthroughs in data communication challenges.

A pivotal point was reached in the seventh week, as physiological data interfaced with the mBot Neo's actions through variable-based and conditional approaches. Challenges persisted in real-time adaptation, prompting further refinement considerations. Despite limitations in programming beyond mBlock, EmotiBit's successful integration showcased the potential of physiological insights in interactive learning.

Insights from engagement scripts and physiological data-action mappings enriched educational technology discourse. While real-time responsiveness and adaptation complexities remain, the project's accomplishments and lessons offer a promising trajectory. The project's impact in bridging human physiology and robotics to reshape education technology is evident. This journey, supported by collaboration and guided experimentation, illuminates avenues for enhancing interactive learning through physiological insights.

REFERENCES

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