Innovative Uses of Social Educational Robotics in K-12 Education

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Abstract

Educational robotics is a popular tool for introducing programming to novices. Although research on educational robotics is growing, most of studies used a version of LEGO robotics, which limits our understanding of how other types of robots can be used in education. This presentation will share several prototypes of custom-built social robots that were developed in Advanced Telerobotics Research Lab and how these robots can be integrated into Science, Technology, Engineering, Art and Mathematics (STEAM).

Introduction

According to the 2019 Bureau of Labor Statistics, the demand for jobs in STEM fields is projected to grow faster than the mean for all other occupations in the U.S. However, the current STEM workforce is characterized by demographic disparities and a lack of diversity. For example, the proportion of undergraduate degrees awarded to women in Computer Science (CS) declined from 25.1% to 18.1% from 2004 to 2014 (NSF & NCSES, 2017). Over the past decade, an increased effort has been invested into broadening participation in STEM and CS through

various interventions in curriculum and instruction that aim to make the CS content more personally relevant and accessible in order increase students' knowledge of the field. Nevertheless, research continues to report barriers to participation including early exposure to CS in schools, access to computers at home, public's narrow perception of the field, stereotypes about CS, and a lack of role models who are women and minorities (Sax et al., 2017). Additionally, research on STEM pathways shows that U.S. students lack basic interest in pursuing STEM careers, which creates a barrier to exploring and engaging in STEM fields among youth.

This presentation will share several prototypes of custom-built, affordable social robots that were developed in Advanced Telerobotics Research Lab and how these robots can be integrated into STEAM. The robots can be used as both teaching aids and learning tools. As teaching aids, the robots can be used by teachers/instructors for teaching content knowledge in a variety of subject areas. As learning tools, the robots can be used for engaging students in CS education. All robots are built with off-the-shelf components, so they are affordable. The computing components can be added incrementally to provide the desired level of a learning challenge, thus allowing students with various levels of CS knowledge and skills to build and program the robots.

Educational robotics is popular for introducing programming to novices because of their ability to reify algorithms and programs (Armoni et al., 2015). Although research on educational robotics is growing, studies integrating robotics in formal education are scarce (Anwar et al., 2019; Poh et al., 2016). Moreover, most of the studies used a version of LEGO robotics, which limits our understanding of how other types of robots can be used as learning tools (Anwar et al., 2019).

Smart Robotic Puppet Theatre

The Smart Robotic Puppet Theatre System was created to engage performing art students in Computational Thinking, Acting, and Making Education (CTAM). CTAM is grounded in maker education, integrating the principles of STEAM with theater and acting. It is a miniature robotic theater, made of customizable stages and puppet pieces, that may be used to create and present various puppet shows. The theater stage has a pan and tilt lighting system, audio integration through an external device, controlled curtains with stepper motors, props, and a grid stage. The light system's camera tracking module recognizes the presence of a robot and communicates with the light fixtures to angle the spotlight. The mBlock IDE is used to edit the story in the theater software, allowing for a straightforward method of scene programming. The puppet plays produced by the Smart Robotic Theater engage performing arts students in robotics and programming to build their own shows.

GerminatorBot-19

GerminatorBot-19 robot was developed for fostering cooperation with COVID-19 health measures in college students and K-12 students. The robot can proactively interact with students in public areas such as school gates and cafeterias to provide sanitizing foam, check temperature, encourage students to wear a face mask, and conduct health check-ups upon demand. GerminatorBot-19 has five key features:

(1) Intelligent human-robot interaction: A smart interaction engine (SIE) enables natural conversation by using natural language processing, computer vision, and machine learning technology.

(2) Virtual based Block Coding: A special virtual coding SIE module can be developed, so that the robot's interactions can be programmed and customized by users.

(3) Mask wearing detection: The mask wearing detection algorithm can be integrated into the robot (Snyder et al., 2021).

(4) Body temperature measuring: Low-cost, non-contact temperature detector can be designed and integrated with the robot (Alves et al., 2020).

(5) Smart reward: An intelligent reward system can be designed for contactless reward points to-be-used as a promotional gift. This feature facilitates data collection of human-robot interactions.

Smart Trashcan

Smart Trashcan Series was designed for teaching recycling to young children in an engaging way while introducing them to a range of CS standards (2016). Its applications can be also extended for teaching a variety of middle and elementary science topics. It integrates programming components that allow students to take control over a robot's behavior (Arnett et al., 2020; 2021). Open-source hardware was used to build a group of low-cost, yet functional and interactive mobile robots, the "Smart Trashcan Brothers." The robot motions and gestures can be controlled via a visual programming interface that allows various programming methods.

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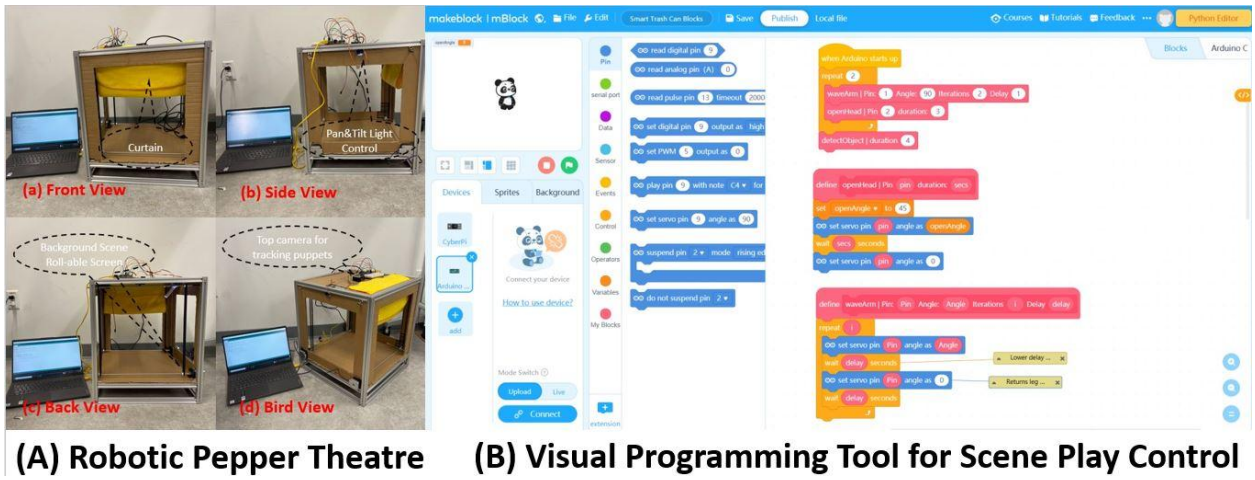

Figure -1. A Prototype of the Smart Robotic Puppet Theater System

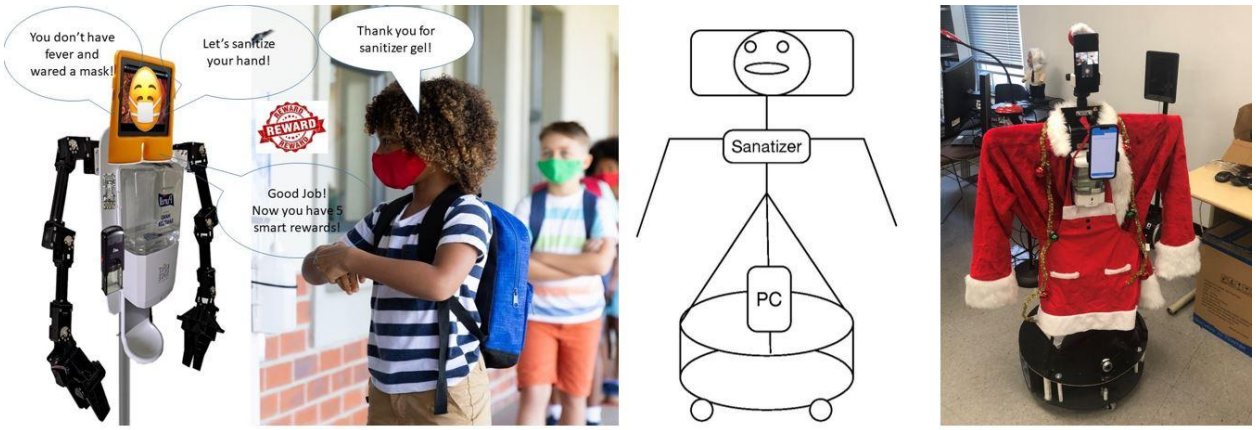

Figure-2. A prototype of GerminatorBot-19 for hygiene education

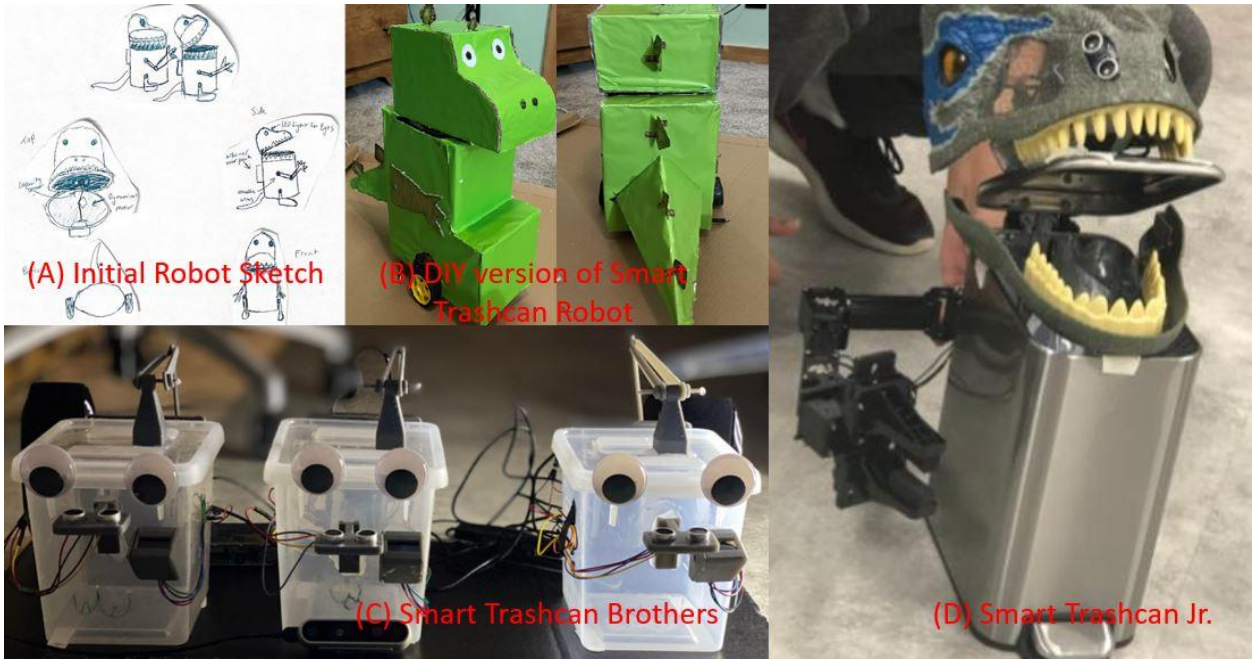

Figure -3. Green-Education Project with Prototypes of Smart Trashcan robot series