HAKSH-E: An Autonomous Social Robot for Promoting Good Hand Hygiene among Children

Sreejith Sasidharan[1], Devasena Pasupuleti[1], Anand M Das[1],
Chaitanya Kapoor[1], Gayathri Manikutty[1] and Bhavani Rao R[1]

[1]AMMACHI labs, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, India,

1. Abstract

- We present *"Haksh-E"*, a social robot for promoting good hand hygiene among children. This robot can supply valuable objective data to stakeholders and the UN to monitor progress on targets for UN SDGs 3 and 6 (Fig. 1).

Figure: Our UN SDGs of focus: 3 and 6

- We discuss the design parameters of *Haksh-E* and a pilot study conducted with 10 children, between the ages $6-11$ years, hailing from rural and urban locations in Southern India.
- The children provide insights on their perception and acceptance of our robot prototype over various dimensions including likeability, perceived intelligence, anthropomorphism, trustworthiness, age, and gender.
- Our results suggest that *Haksh-E* has the potential to be used in educational and children-centered spaces to promote handwashing behavior change.

2. Motivation and Background

- In the current and post-pandemic COVID-19 era, increased awareness of health has been a key trend. Therefore, a potential application of social robotics is to promote healthy habits such as increased hand hygiene, wearing masks, and maintaining social distancing, especially among children.
- Existing commercial social robot platforms are cost-prohibitive especially when they are to be deployed at scale in developing economies. This necessitates a custom-designed robot with low-cost components which is made with manufacturing technologies accessible in developing countries.
- In 2019, our team carried out a *Wizard of Oz* study in a rural school in India with our previous embodiment of the hand washing robot called *Pepe* (Fig. 2) [1,2]. The results showed significant ($> 40\%$) improvements in terms of change in handwashing habits of young children.

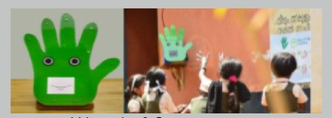

Figure: *Wizard of Oz* study in India with *Pepe*

- *Haksh-E* is an autonomous version of *Pepe*. The name "*Haksh-E*" was given to the robot as a portmanteau of two words from the Sanskrit language that means "hand cleaning". We also chose this name as it was a gender-neutral, uncommon, yet easy for children to recall.

A. Haksh-E Laser-cut and 3D Printed Embodiment Parts

Figure: Parts of the Robot Head and Neck

3. Design Implementation

1. Physical Appearance :

- A human-like appearance can cause unmet expectations of the robot's capability and ultimately lead to the "uncanny valley" effect. Also a social robot's morphology must match its intended purpose and application. Hence, we designed *Haksh-E* as an anthropomorphic soap dispenser (Fig. 4).

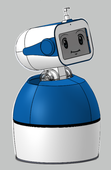

Figure: CAD Model of Haksh-E

2. Robot Speech and Behavior :

- For the robot's speech, we used a pitch corrected female voice to make it gender-neutral and child-like.
- The face of *Haksh-E* was animated and the mouth was programmed to lip-sync to the robot's utterances. Additionally, glowing RGB LEDs were present in the robot's chest.

3. Motion and Degrees of Freedom :

- *Haksh-E* has a stationary torso and a head with two rotational degrees of freedom (DoF) to maintain its gaze at salient objects and faces in its vision (Fig. 5).
- The robot's body is equipped with stepper motors, magnetic rotary encoders, optical limit switches all of which are easily available. This helped in lowering the cost and complexity.

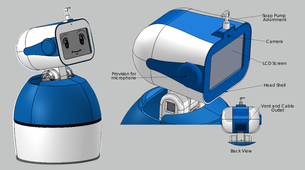

Figure: Robot Model

4. Computation :

- All of *Haksh-E's* high-level functions are controlled by a Jetson Nano™. This also allows the recognition of individual handwashing steps and future addition of autonomous conversational capabilities.
- All low-level functions are performed by an Arduino Mega, which communicates with Jetson Nano via UART.

5. Vision System :

- *Haksh-E's* vision system has two cameras; an overhead camera at the handwashing station for the real-time prediction of handwashing steps, and an on-body camera for face recognition and gaze-control.

6. Speakers and Microphones :

- *Haksh-E* has two speakers and the head of the robot has a provision for adding four microphones.

7. Fabrication and Assembly :

- In this paper we present the first design iteration of *Haksh-E* named a s *Haksh-E* version 0.5 which was entirely 3D printed using PLA plastic. Few body parts were laser-cut from acrylic sheets.
- After assembly, final cost of *Haksh-E* version 0.5 totaled to $550.

B. Detailed View of the Neck Mechanism of Haksh-E

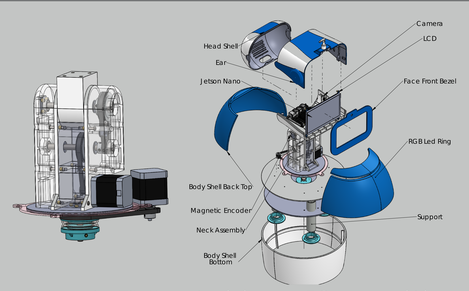

Figure: Pan-Tilt Mechanism (L.); *Haksh-E* Components (R.)

C. System Block Diagram

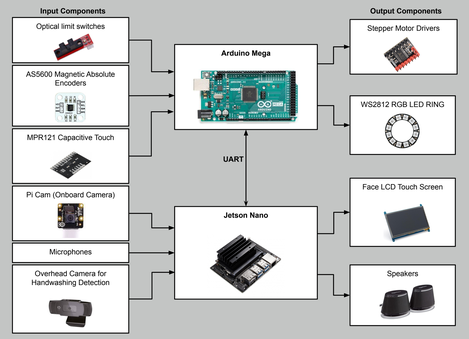

Figure: Block diagram of all the components comprising *Haksh-E*

D. Physical Prototype of Haksh-E Version 0.5

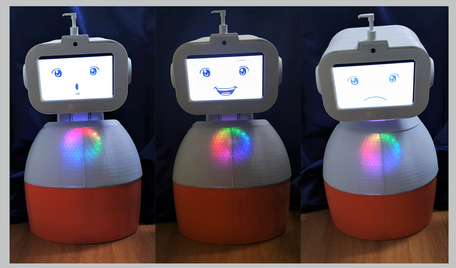

Figure: Various facial expressions displayed by *Haksh-E* version 0.5

4. Acceptance Study

- We conducted a pilot study online to get initial feedback from children and evaluate their perception and acceptance of our robot prototype.
- The study was conducted with ten children between the ages of 6-11 years, where *Haksh-E* was teleoperated by one of the researchers while the children interacted with the robot.

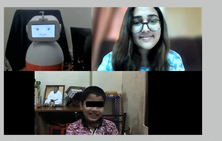

Figure: The study being conducted in online mode with the children

- The questionnaire used in our study was based on the study by Kalegina *et al.* [3]. It has three questions from the Godspeed questionnaire based on the "Likeability (Unfriendly-Friendly)", "Perceived Intelligence (Unintelligent-Intelligent)" and "Anthropomorphism (Machinelike-Humanlike)" scales and three questions based on the "Trustworthiness (Untrustworthy-Trustworthy)", "Age (Childlike-Mature)" and "Gender (Male-Female)" of the robot.
- In addition, we added the question - "Do you like the name *Haksh-E*? If not, why? and what would you like to name the robot?".

5. Results and Future Work

- Results from the online pilot study suggest that children perceived *Haksh-E* to be friendly, intelligent, human-like, and trustworthy.

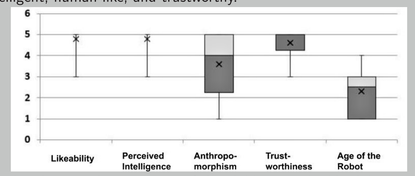

Figure: Box plot showing the responses of the children on the likeability, perceived intelligence, anthropomorphism, trustworthiness and age of Haksh-E

- Several children mentioned that they were not sure as to whether *Haksh-E* was a male or female, or if it was a child-like or mature robot.
- In the future, we will incorporate a conversational AI agent into *Haksh-E* to help the robot interact with children.
- We also plan on incorporating an AI-driven hand gesture recognition system to determine the handwashing quality.

References

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[3] A. Kalegina, G. Schroeder, A. Allchin, K. Berlin, and M. Cakmak, "Characterizing the Design Space of Rendered Robot Faces," in *2018, ACM/IEEE International Conference on Human-Robot Interaction*.