Design and Development of an Interactive AI Toolkit for Engaging Older Adults in AI Discussions

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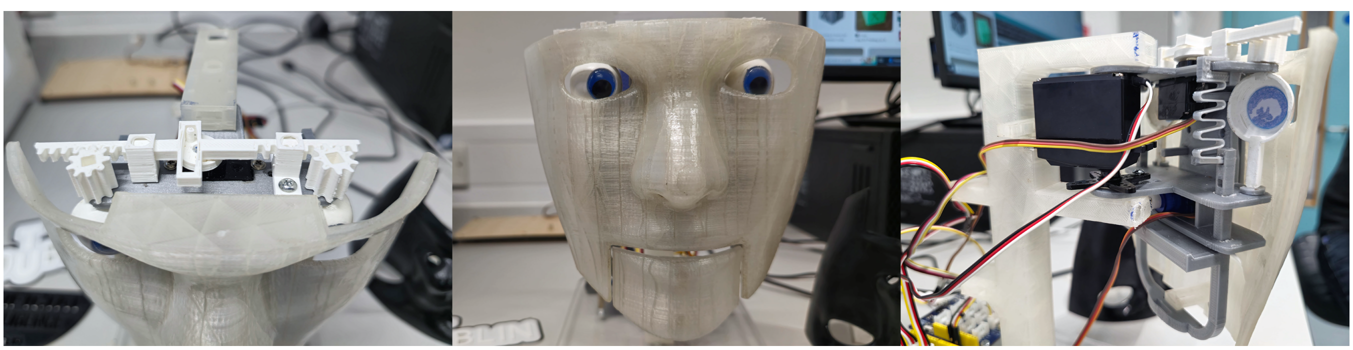

Figure 1: AI talking mask (centre). Eye movement mechanism (left). Jaw mechanism (right).

Abstract

This paper presents the design and development of a low-cost, interactive Artificial Intelligence (AI) toolkit in the form of an animatronic 'talking' mask. The toolkit aims to democratise AI and make it more accessible, particularly for older adults, by facilitating hands-on engagement with AI technologies and engaging them in meaningful discussions about its opportunities and potential drawbacks. The toolkit is built using customisable features such

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as replaceable face, jaws and eyes, and modular software features like face tracking, speech recognition, speech-to-text and text-to-speech engines, and large language model (LLM). The customisable design provides a means to explore perceptions, raise awareness and encourage healthy discussions about different facets of AI, especially amongst technologically-challenged populations. It promotes co-design opportunities by leveraging its customisability to allow for adaption of its features to suit the technical abilities and preferences of the audience. Designed with an open-source approach, the project also encourages collaboration among makers and developers, fostering community-driven enhancements and adaptations. This accessibility empowers others to build upon the design, contributing to its evolution as a versatile tool for education and outreach. Evaluation of the platform with 3 distinct user groups highlights its potential to demystify AI technologies and engage diverse audiences in a conversation about the challenges and opportunities they present. This paper concludes with the identification of future opportunities for this research, including the use of co-creation methodologies with end users to extend the work to suit their needs and provide a public engagement framework for understanding emerging technologies.

Keywords

AI literacy, AI toolkit, Human-computer interaction, Co-creation, Older adults and technology, Digital inclusion, AI-driven public engagement, AI adoption barriers, Experiential learning in AI, Digital divide

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1 Introduction and Problem Statement

Europe is facing a significant demographic shift, with its population ageing rapidly. By 2050, it is projected that around 30% of Europe's population will be aged 65 or older [5]. While many older adults frequently use information and communication technologies (ICTs), many still lack access. Moreover, the pace of digital innovation often fails to account for their needs, resulting in exclusion [8]. As essential services, such as healthcare, communication, and banking increasingly move online, many everyday activities have become more challenging for the less digitally literate, leading to a widening digital divide [10, 13]. This divide creates barriers to accessing essential resources and exacerbates isolation and dependence on others.

Artificial Intelligence (AI) presents a promising landscape to improve the quality of life for the ageing population. Its application in home automation systems, monitoring and sensing systems, activity tracking, and virtual reality can provide meaningful benefits [3]. However, the exclusion of older populations from the design process of technologies, including AI [1], often leads to outcomes that fail to address their unique needs, resulting in solutions that are less inclusive compared to those designed for other age groups. For instance, while digital voice assistants have the potential to improve interaction with technology for older populations, research and development efforts seldom prioritise their participation [14].

This digital divide faced by older adults is a recognised concern. The European Parliament's special committee on AI in a Digital Age [4] states that "existing digital gaps can only be closed with targeted and inclusive measures towards both women and the elderly", thus, encouraging targeted investments and measures towards enhance digital skills and bridge this divide. Furthermore, factors like lack of confidence emerging from technology-related anxiety [6] and incognizance of the benefits of technology leading to a resistance towards learning and adopting AI [9] and a rejection of modern digital solutions such as AI [12], particularly among older citizens, further widens the digital gap.

Building public trust and engagement with AI is essential to ensure equitable access to AI-driven services, skills, and opportunities that enable everyone, including older adults, to participate fully in society. Addressing barriers identified in a survey involving older people in [15] – such as the inaccessibility of AI, insufficient expertise to independently use AI, and privacy concerns – can significantly improve adoption of the technology among this demographic. Additionally, the same study highlights the willingness of older people to participate in a co-design process, both during the conceptualisation and development processes of products and services.

These factors, while specifically highlighted in relation to AI adoption among older people in [15], resonate with broader findings from the literature on technology adoption [1, 6]. This alignment underscores their significance as crucial determinants to foster empowerment among older citizens. By addressing issues such as accessibility, capability building, and privacy concerns, and by embracing co-design approaches, we can enable older adults to confidently and independently engage with digital tools in an AI-driven society. Pursuing these strategies will not only enhance adoption but also promote equitable participation in the opportunities in this AI-driven digital age.

This work introduces the design and development of an interactive, cost-effective AI toolkit designed to engage older adults in meaningful discussions and experiences with AI. The toolkit centres around the creation of an AI-enabled 'talking' mask, which serves as an accessible and customisable interface to democratise AI interaction for older adults. This work seeks to create a supportive and engaging environment for users to explore AI technologies, understand their implications, and foster a broader dialogue about AI's potential benefits and risks.

2 Objectives

The main objective is to democratise access to AI to catalyse its adoption through an open-source design for a relatively inexpensive, customisable AI interface. This interface is designed for older adults with a practical, accessible, and engaging platform for interaction with a large language model (LLM). However, its customisability and modular features enable it to be employed for engaging with a diverse demographic. A combination of image recognition AI technologies, speech processing, and robotics are further utilised for mimetic representation. The toolkit offers a tangible interface to an LLM with integrated face tracking, and a set of age-friendly 'recipe' prompts to highlight both the positive and negative aspects of generative AI.

In summary, the platform is equipped with the following features of AI:

- Speech-to-text and text-to-speech and associated opportunities for more accessible HCI.
- Object tracking (e.g. face tracking)
- Facial recognition (based on consent)
- Generation and display of creative outputs such as images, using user voice activation commands
- Features to highlight the potential risks with the use of generative AI, such as the phenomenon of AI hallucinations, where the AI produces convincing yet false information

By interacting with these curated prompts as well as creating their own prompts, users will experience first hand the advantages, disadvantages and limitations of generative and other AI tools. This experiential learning will help demystify AI and provide users with a nuanced understanding of its capabilities and challenges.

3 Technical Development

The technical development of this platform is an ongoing process, with some fundamentally necessary features already implemented and operational. These operational features have been tested at various educational and public engagement events and feedback solicited at these events has been used to prioritise further developments of the platform. Other features currently remain in various stages of development. This iterative approach allows for continuous refinement and integration of new capabilities, ensuring that the platform evolves based on user feedback and future objectives. The following subsections provide an overview of implemented features.

3.1 Toolkit Components

(1) Customisable AI 'Talking' Mask: The physical mask has been developed with interchangeable parts such as facial features, eyes, and jawline. These customisable components allow for the personalisation of the mask's appearance based on user preferences. Some users may choose to interact with a more human-like mask, while others might prefer a robotic form, promoting inclusivity and personalisation in AI interactions. Figures 2 and 3 showcase the mechanics to interchange mask face and jaw respectively, whereas, Figure 4 showcases example of two different types of mask.

(2) Face tracking with moving eyes: This feature equip the platform with mimetic capabilities, providing the AI mask with human-like features. A webcam is used to detect face of the user interacting with the mask, subsequently aligning the eyes to look towards the user based on their position in the frame captured by the webcam. The gear mechanism used to animate eyes is depicted in Figure 1 on the left-hand side and in Figure 5.

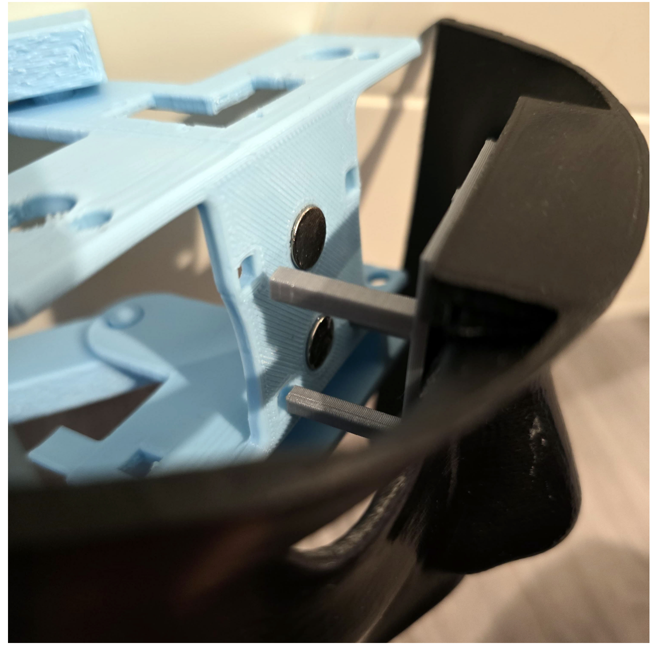

Figure 2: Mask replacement mount.

(3) Speech-to-Text and Text-to-Speech Software: The mask includes customisable speech-to-text and text-to-speech software components that enable users to converse in a natural manner with the AI mask in an accessible, low-barrier way. In a future version of the 'talking' mask the voice used by the AI mask will be customisable (e.g. by language and gender) based on user preferences. These components are key to creating an engaging and interactive experience for older adults, providing a human-like conversational interface that is easy to use and understand.

(4) Generative AI Engine with Prompt Engineering: The core of the mask's functionality is generative AI, capable of producing human-like text responses (which are translated to speech by the text-to-speech component) based on user inputs. Through prompt engineering, the mask is guided to generate responses that are relevant to topics of interest to the user, such as health and wellbeing, history, art, or cooking. The generative AI facilitates discussions and introduces users to both the capabilities and limitations of current AI technologies. The current iteration of the mask uses OpenAI API [11] to generate responses, with the option of local on-board LLM currently under development.

3.2 Open Source Accessibility (All)

All design and development elements of the toolkit will be made available via open-source repositories to encourage community engagement and further development. This includes:

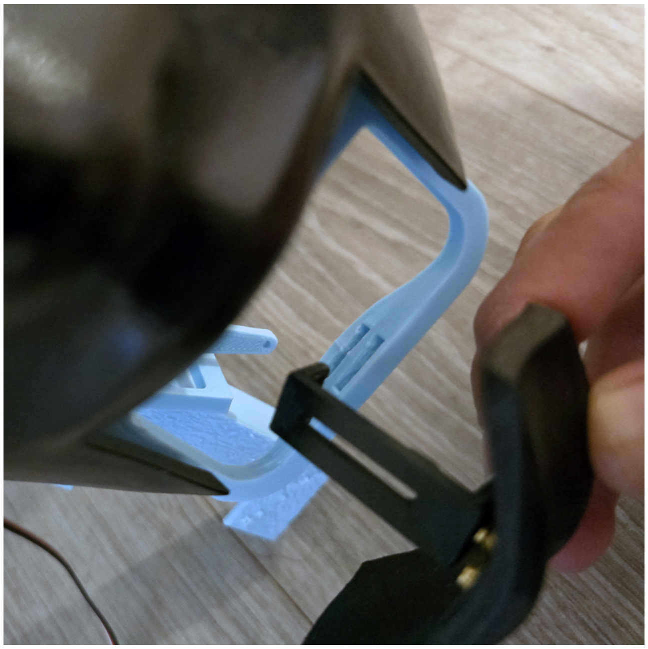

Figure 3: Jaw replacement mount.

Figure 4: Customisable 3D printed mask options.

- 3D models and drawings for the mask's physical components
- Source code for the software components (e.g., speech-to-text, text-to-speech, code to integrate with generative AI libraries)
- Source code for controlling the hardware components
- Technical documentation detailing the off-the-shelf hardware and software components used, including motors, microcontrollers, sensors, and software libraries

This approach will ensure that the toolkit is not only accessible to the immediate user base but can also be adapted, extended and redistributed by developers and educators worldwide.

3.3 System Architecture

The development of the customisable AI-enabled talking mask involved a multi-faceted approach, requiring the integration of electronic, mechanical and software engineering components as well as product design principles. A methodical approach was employed for the development. First, a requirements analysis was carried out during which the expected requirements were identified. The requirements were then decomposed into independent modules, which were finally integrated into the system as a whole. Following are the design requirements identified in the first step:

(1) **Customisability:** The face, jaw, and eyes of the mask were identified as components that were to be hot-swappable to enable the personalisation of the mask, as stated in Section 3.1 and presented in Figures 2, 3, and 4.
(2) **Animatronic Elements:** To foster mimetic features of the mask, it was decided to develop the mask as a relatively simple animatronic exhibit, where only the eyes, jaws, and neck could be actuated. This necessitated the identification and use of mechanisms to move these elements of the mask based on cues from the person interacting with it. While animation of eyes and jaw have been prioritised and implemented using rack and pinion gear and spring retraction mechanisms respectively, as depicted in Figure 5, animating the neck is part of the current development cycle.
(3) **Low-cost, Easy Accessible Electronic Components:** The actuations required for mimetic elements were performed using relatively inexpensive and easily available general-purpose hobby servo motors.
(4) **3D-Printed Interface Components:** The mechanism to actuate animatronic elements required the design of an interface between the actuators (servo motors) and the movable parts of the mask. Such interface components included springs and gears, which were 3D printed. This step provided the opportunity to design the mask around the specification determined by the researchers rather than basing the design of the mask around off-the-shelf interfacing components, thus providing more freedom in the development process.
(5) **Hardware Requirements:** The selection of the hardware components was based on their availability, cost-effectiveness, and community presence in addition to their capability to effectively manage the computational requirements. A Raspberry Pi 3B (RPi) was selected as the processing component for the mask. It also provided several features out of the box, such as HDMI connectivity for the display interface, a 3.5mm audio jack, Bluetooth (BT) connectivity for audio output, and GPIO ports for interfacing additional electronic components. A webcam with an integrated microphone was used to provide a real-time feed of the scene in front of the mask and was used to track the location of users

in its frame to inform the movement of its eyes as well as provide a microphone to capture a user's speech input. This feature of the system will be discussed in Section 3.4.

(6) **Software:** Python was used to develop the necessary software functionality of the mask and will be discussed in detail in Section 3.4. A YAML configuration file was added to store configuration information in a central location. This removes the need to edit python source files to change system settings allowing for system behaviour to be changed on the fly based on user preferences/abilities.

(7) **Tailored hat for the RPi:** The mimesis in the jaw movement of the mask with speech signal was identified as a necessity for creating human-like jaw movement. Therefore, the amplitude of the real-time audio signal was utilised to control the range of jaw movement, determining the extent of its opening and closing. Thus, supplementary hardware in the form of a purpose-built Raspberry Pi hat was designed and developed to act as an envelope detector to which, audio signals were fed from the RPi through the 3.5 mm jack. The hat also controlled the servo motors for the actuation of the neck and eyes.

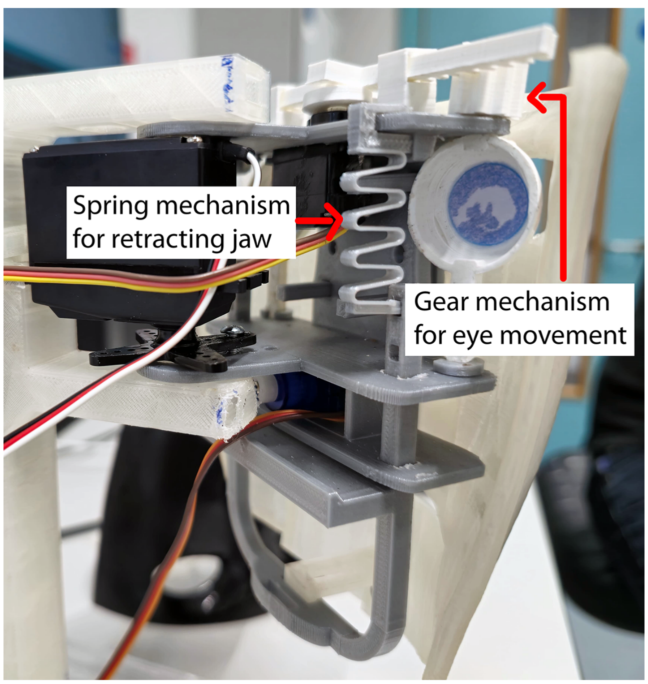

Figure 5: 3D printed rack and pinion and spring retraction mechanisms for eyes and jaw respectively.

3.4 Software

Python was employed to develop scripts to implement other key functionalities of the mask. A multi-threaded system was designed to control the mask by integrating several software components – voice interaction, face detection, and real-time movement control. Pulse-width modulation (PWM) was used to manage jaw movement based on the amplitude of the audio signal and the eyes. The movement of eyes was determined based on a person's face position in the frames streaming from a webcam. The face detection used the Haar Cascade classifier [2, 7] and the location of the face in the frame was communicated to dynamically adjust the mask's eye positioning.

Another module was integrated into the software to listen to user input via a microphone that was integrated into the webcam device. Speech was synthesised for the user's voice input, converted into text, and was appended to an engineered AI prompt. The engineered prompt was intended to limit the scope of GPT's and subsequently, the mask's response. This also enabled customisation of the mask's usage where the engineered prompt could be modified to provide the details of the context (e.g. location, event type) where the mask is being used. This module that listens to the user's input and processes it, was designed to run alongside other modules that controlled actuation. Text output from GPT was converted to speech and was sent to a speaker device through 3.5 mm jack. This audio signal was split and was also fed to the custom RPi hat. These speech-to-text and text-to-speech components will be referred in this paper as the *voice interaction module*. The entire system was designed to operate in real-time and run indefinitely, handling concurrent tasks, until manually interrupted by the user. The flowchart of the system is presented in Figure 6.

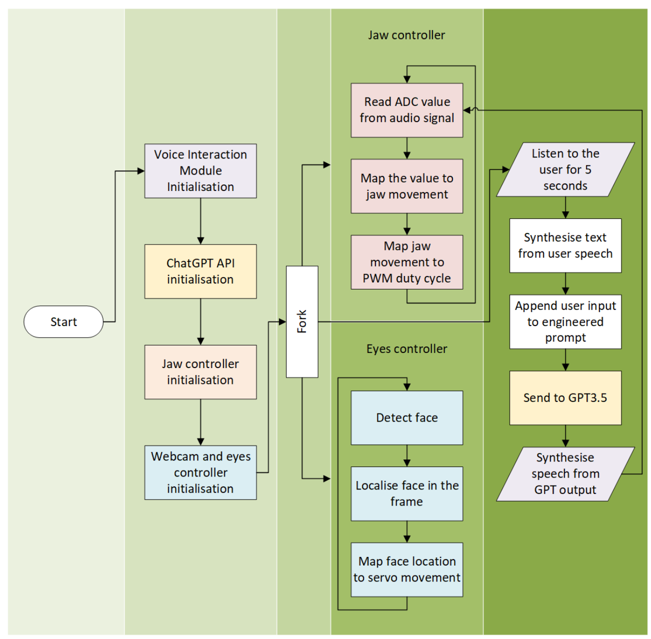

Figure 6: Architecture of the software system.

3.5 Evaluation through Case Studies

Evaluation of the platform was conducted using case studies to assess the AI Mask's effectiveness in democratising AI literacy by introducing the general public, older adults, and the art community to contemporary AI technologies. Importantly, the goal of these workshops was not to promote AI as inherently positive or acceptable, but to initiate and facilitate critical conversations about AI's benefits and challenges with the participants. A series of public showcase events and workshops were tailored to each audience type depending on their prior experience with technology and/or AI, to present key concepts effectively.

Figure 7: Using AI talking mask to foster discussion with an elderly person.

Case Study 1: General Public at Dublin Maker
At Dublin Maker, the AI Mask was showcased to a broad audience, including families with children as well as fellow makers/technologists. This allowed us to observe its accessibility and engagement potential for a diverse, multi-generational crowd. Research-supported engagement strategies such as providing experiential learning opportunities and opportunities for customisation of the AI mask features were used to introduce fundamental AI concepts, helping participants interact with generative AI in practical terms. Hands-on guidance was provided for creating prompts, enabling participants to witness generative AI phenomena such as fact-based responses, non-deterministic responses, and instances of hallucination where the LLM generated plausible but incorrect answers. These interactions sparked curiosity and critical thinking among attendees, leading to active discussions about the ethical implications of AI's limitations and possible applications.

Case Study 2: Older Adults from University of the Third Age
With two University of the Third Age (U3A) groups, our focus was on enabling older adults to gain first hand experience with AI in a supportive and tailored environment. Using age-appropriate, research-informed support, we introduced participants to foundational AI concepts, particularly focusing on large language models (LLMs) and speech recognition. Facilitators worked closely with participants to create prompts that illustrated AI's varying response accuracy and the ethical issues surrounding "hallucinations" in generated outputs. This hands-on experience fostered an informed discussion on how AI technologies impact their daily lives and society. Discussions with participants showed that many participants valued the transparency in discussing AI's strengths and shortcomings, appreciating that the sessions were designed to inform rather than persuade. The results of pre and post surveys with these groups will be published in a later work.

Case Study 3: Art Community at Beta Festival
The AI Mask's presence at the Beta Festival, Dublin, a gathering focused on the intersection of art and technology, offered a unique opportunity to engage members of the creative community in a dialogue about the expressive and ethical dimensions of AI. Here, the AI mask demonstration emphasised the open-source, extensible nature of the AI Mask, appealing to artists and technologists interested in exploring AI as both a medium and a subject of critique. Attendees participated in generating various AI responses and were shown examples of non-deterministic and fact-based responses, as well as hallucinations, prompting discussions on AI's role in art, ethics, and society. This dialogue encouraged participants to view the AI Mask as both a technological artifact and a catalyst for examining AI's aesthetic and ethical implications in creative fields.

The AI Mask's engagement with these three distinct audiences provided insights into how the mask's accessibility and open-source design can effectively promote AI literacy for diverse audiences while fostering a critical dialogue about AI's broader societal implications. By employing targeted dissemination approaches that suited the AI literacy levels of each audience type, we demonstrated that the AI Mask could be an adaptable tool for inclusive, thought-provoking engagement with AI.

In evaluating the feasibility of the AI Mask as a standalone exhibit not requiring technical support, we identified some hardware challenges that will be addressed for its sustainable, long-term use. Issues such as motor burnout, SD card failure, and power supply overload – stemming from running multiple devices (such as RPi, screen, hat, and motors) from a single power source – highlighted the need for a more robust hardware setup to support reliable, independent operation. Resolving these technical limitations is essential for maintaining the mask's usability as a standalone exhibit that can continuously function without frequent maintenance or technical intervention. Suggestions for improvements and extensions were gathered from many insightful conversations with workshop participants and they are discussed in the next section.

3.6 Conclusions and Future Work

The AI mask introduces a low-cost, open-source AI platform to facilitate hands-on experience with contemporary AI technologies and to evaluate its effectiveness in expanding AI literacy among the general public, in particular for the less digitally literate, and encourage a broader dialogue about AI's potential benefits and risks. It is also designed for further adaption and contribution by makers and developers, encouraging makers to engage in co-design sessions to expand the platform's capabilities.

In the shorter term, the next steps in the development of the AI platform are to resolve some technical limitations with the current system configuration such as :

- SD card robustness / failure
- Sufficient power supply for all components
- Servo motor longevity/lifespan
- Automatic launch of AI Mask application on startup
- Dependence on the third-party OpenAI API

Resolving these issues will ensure that the system is more sustainable as a stand-alone exhibit in public spaces (such as libraries) for the general public to experience while requiring minimal technical support. The project is currently being evolved to address the aforementioned challenges. For the upcoming iteration of the AI mask, refinement through the use of NVMe (non-volatile memory express) SSD (solid state drives) in lieu of SD card has already been incorporated. Further planned investigations include examination of using local LLM (to remove the dependence on OpenAI API) in conjunction with AI acceleration module (to boost RPi's AI processing capacity), assessing capabilities of currently available LLMs and their performance on RPi with AI acceleration module, identification and acquisition of industry-grade servo motors, and sourcing a reliable power supply. To support the stand-alone exhibit a monitoring component will also be added to the system to automatically launch, raise alerts, and facilitate the diagnosis and resolution of technical issues remotely as they arise. This could be used to also provide basic logging information regarding usage which is planned to be utilised for gathering empirical evidence of the AI Mask's long-term efficacy through quantitative and longitudinal analysis. Finally, an integral part of the current development is the inclusion of a comparative analysis of our approach with similar platforms in the literature. The outcome will be published in a follow-up publication. In the longer term, the co-creation methodology will be adopted to:

- **Co-Create Desirable Features:** Through a further series of co-creation workshops with members of the public, identify and co-create additional desirable features of the platform that will help foster meaningful dialogues about AI's societal and ethical impacts, particularly for individuals with limited AI experience. Examples of such features might include 1) providing the agency to users to select the voice/language/ used by the system based on their mask selection and should provoke discussion around potential biases as a result of skin/voice tones; 2) adding facial recognition/tracking features to provoke a discussion around the opportunities but also the shorter and longer-term implications/potential risks associated with the use of these technologies.
- **Develop Public Engagement Framework**: Co-create a structured approach for using the platform to facilitate discussions on AI's ethical, social, and economic implications, especially tailored for members of the general public.

In conclusion, the AI Mask initiative represents a significant step toward democratising access to AI technologies by providing a hands-on engagement artefact to foster meaningful dialogue around AI's societal and ethical implications. Addressing the immediate technical challenges by enhancing the system's robustness and integrating a remote monitoring component, the platform will be more sustainable and accessible as a public exhibit. The AI Mask was showcased in three distinct engagement events as presented in Section 3.5, however, no surveys or interviews were conducted during these events due to delays in the ethics approval. The future studies will aim to collect user responses and assess the impact and shortcomings of our work. Furthermore, through co-creation with diverse community stakeholders, the project seeks to expand its features and develop a robust public engagement framework, ensuring it remains an evolving, inclusive, and impactful tool for AI literacy and discussion. This approach underscores the commitment to making AI not just a technological innovation but a medium for inclusive and critical conversations about its role in shaping our collective future.

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