AR SURGICAL NAVIGATION SYSTEM

AKI SURGICAL NAVIGATION

Abstract

Human-computer interaction is pivotal in healthcare, notably in the development of Augmented Reality (AR) Surgical Navigation Systems. These systems, exemplified by VisAR and ClarifEye, integrate AR technology to provide real-time, contextually relevant information during surgeries. Despite their proven benefits, challenges such as discomfort with AR headsets persist.

This project explores novel approaches to surgical navigation, leveraging existing technology like AR, gloves, glasses and app interaction. Recognizing challenges faced by elderly surgeons and those with disabilities, an AI visual assistant app is proposed. The app boasts a user-friendly interface with voice interaction and comprehensive medical information. While its simplicity may limit functionality, additional features like a chat menu and shortcut buttons enhance versatility.

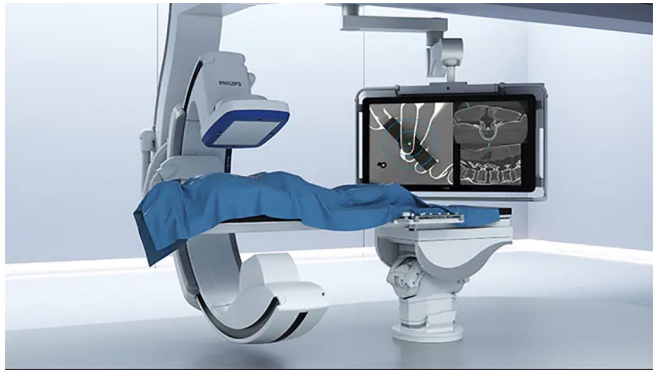
Addressing concerns of a learning curve and dependency on voice recognition, the app includes documentation and a chat menu. It aims to cater to diverse user needs and preferences. Importantly, the app goes beyond conventional functionality, incorporating features to support individuals with dyslexia and autism. A text-to-speech feature aids dyslexic users, while a structured interface and a multi-sensory system cater to those with autism.

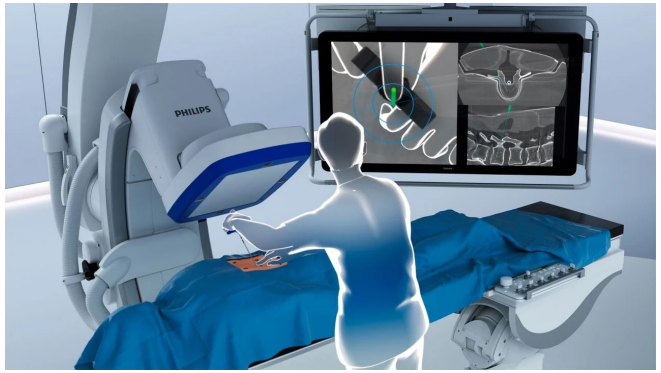
The design prioritizes inclusivity, considering the needs of different generational groups in the medical field. By avoiding unnecessary complexity, the app aims to be accessible to all, contributing to a more efficient and inclusive healthcare environment. The project aligns with the evolving landscape of surgical technology, offering innovative solutions for improved surgical outcomes and enhanced user experiences.

Research context

- Human-computer interaction plays a pivotal role in shaping various domains, with healthcare being one of the areas of focus. A compelling application within healthcare is the advancement of Augmented Reality (AR) Surgical Navigation Systems. These systems epitomize the convergence of cutting-edge technology and medical expertise, aiming to elevate surgical procedures by delivering real-time, contextually relevant information directly within the surgeon's field of view.

- AR Surgical Navigation Systems harness augmented reality to overlay crucial data onto the surgical field, empowering surgeons to make more informed and precise decisions during procedures. The primary objective is to seamlessly integrate medical imaging data and essential patient information into the surgeon's visual perception, thereby fostering a more intuitive and efficient surgical workflow.





AR Surgical Navigation System nowadays

Steve Cvetko, the Chief Innovation Officer at Novarad, has played a crucial role in advancing augmented reality (AR) technology in surgical navigation. He is credited as the creator of VisAR, an AR surgical navigation system that has recently received FDA approval. VisAR stands out for its ability to convert patient imaging data into a 3D hologram visible through an untethered Microsoft HoloLens 2 visor.

AR surgical navigation systems have already demonstrated their effectiveness in various life-saving and life-improving procedures worldwide. Notable applications include revolutionizing neurosurgical procedures by offering precise visualization for tumour resections, spinal surgeries, and deep brain stimulation. Orthopaedic surgery has seen remarkable advancements in joint replacements and spine surgeries, enabling surgeons to precisely align implants and ensure optimal placement.

The benefits of AR navigation systems extend to both surgeons and patients. Surgeons benefit from enhanced spatial awareness, improved accuracy, and reduced cognitive load. Patients experience minimized invasiveness, reduced risk of complications, and shorter recovery times.

However, the integration of AR technology in surgical navigation comes with its set of challenges, including discomfort and wearability issues associated with AR headsets. Efforts are underway to address these challenges through more ergonomic designs. The future outlook for AR in surgical navigation holds immense potential, with advancements expected to offer even greater precision, personalized guidance, and applications in medical education.

Recent advancements in surgical technology have seen the emergence of augmented reality surgical navigation (ARSN) systems, such as the VisAR system by Novarad. This FDA-approved system, featuring the untethered Microsoft HoloLens 2 visor, allows surgeons to focus directly on the surgical objective, promoting efficiency and minimizing distractions.

The workflow of ARSN in a Hybrid OR plays a pivotal role in ensuring seamless transitions between non-navigated and navigated surgery. Navigational software is a key element designed for efficiency and user-friendliness in ARSN systems.

Moreover, Philips' augmented reality surgical navigation solution, ClarifEye, expands the horizon of AR applications in spine surgery. This technology enables surgeons to define and navigate critical trajectories with precision, avoiding damage to neurological and vascular structures.

In conclusion, the fusion of augmented reality with surgical navigation systems represents a ground breaking era in modern surgical technology. Whether through systems like VisAR or ClarifEye, these innovations promise minimally invasive surgery, improved precision, and reduced radiation exposure, ultimately enhancing patient outcomes and advancing the field of surgery.

User Groups

Direct users

Direct users actively manage, utilize, and support the AR Surgical Navigation System in healthcare, contributing to decision-making, collaboration, data optimization, maintenance, troubleshooting, implementation oversight, and training. This highlights their interconnected roles in the system's successful integration and utilization in healthcare.

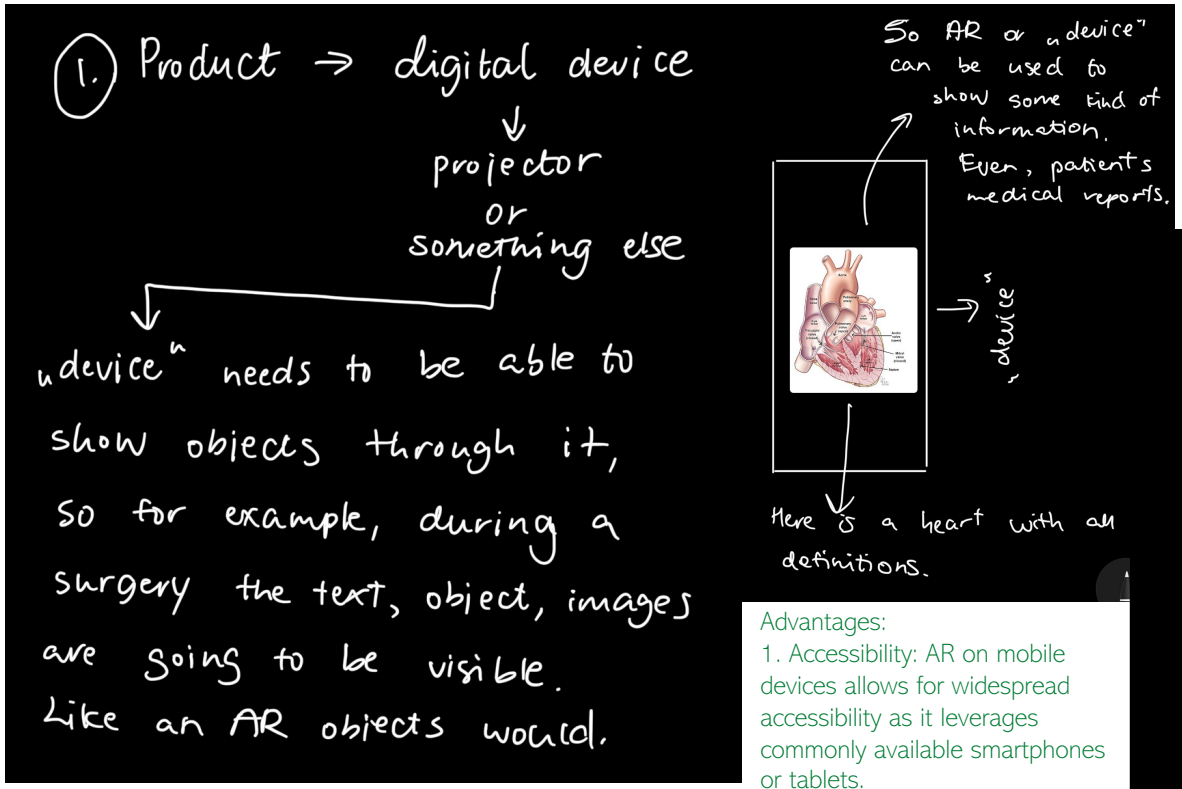
- ❑ Surgeons
- ❑ Surgical assistants
- ❑ Biomedical engineers
- ❑ Healthcare administrators
- ❑ Education Professionals
- ❑ Medical Imaging Professionals

Indirect users

Indirect users share a common interest in the AR Surgical Navigation System. Their collective focus lies in observing improved surgical outcomes, shortened recovery times, and potential cost savings. This shared interest contributes to the overall success and integration of the system in the healthcare ecosystem.

- ❑ Patients and their family members
- ❑ Insurance providers
- ❑ Medical device manufactures
- ❑ Regulatory bodies
- ❑ Policymakers

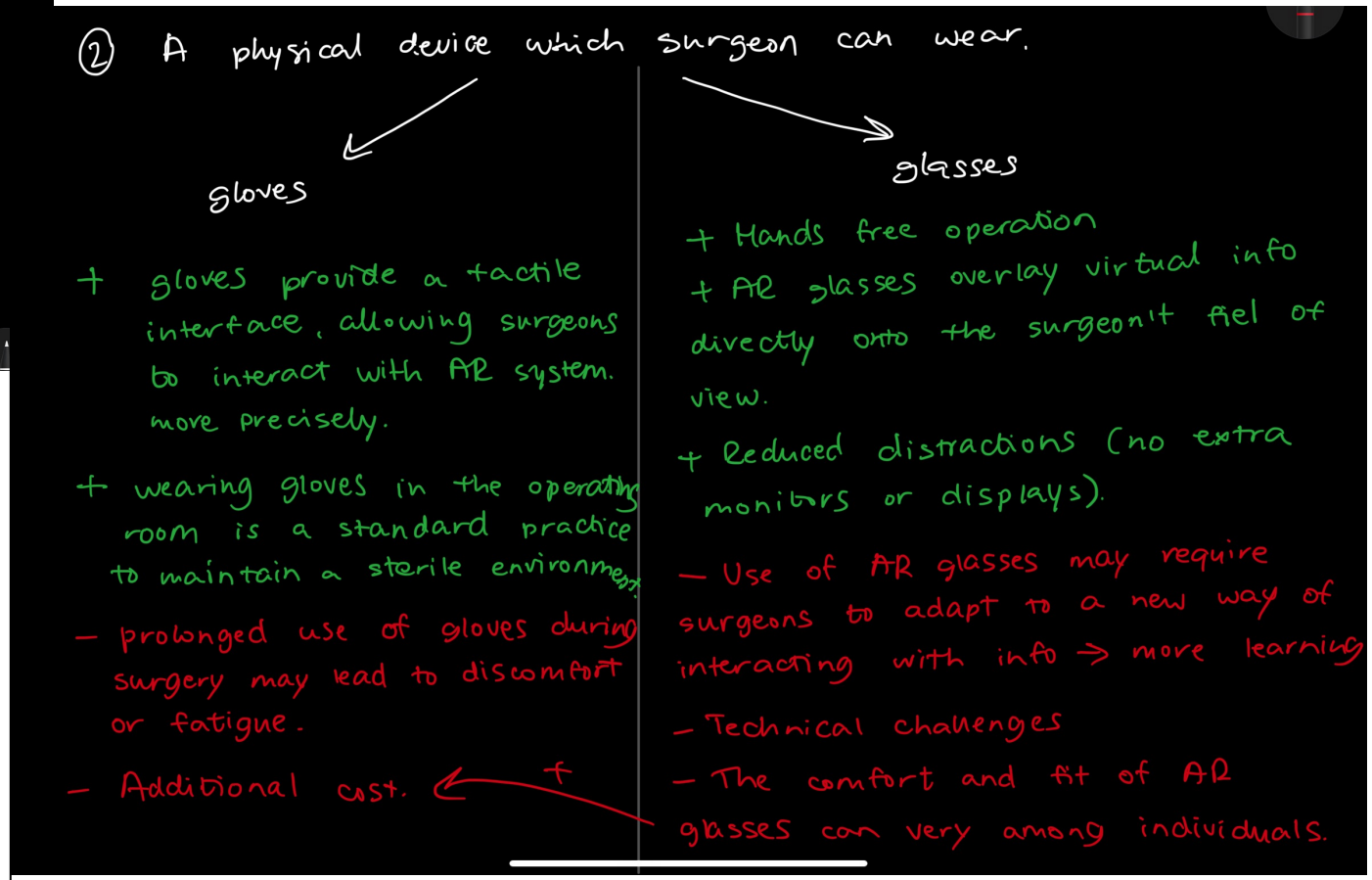
Ideas development



Advantages:
1. Accessibility: AR on mobile devices allows for widespread accessibility as it leverages commonly available smartphones or tablets.

This accessibility can facilitate the adoption of AR technology across various surgical settings without the need for specialized hardware.
1.Cost-Efficiency: Utilizing existing mobile devices for AR surgical navigation can be cost-effective compared to investing in dedicated AR hardware.
3. Flexibility: AR offers flexibility in terms of device choice.
4. Real-Time Updates: AR on mobile devices can provide real-time updates and information, ensuring that surgeons have access to the latest data during procedures. This dynamic feature enhances decision-making and precision during surgery.

Disadvantages:
1.Limited Field of View: For example, mobile devices have smaller screens compared to dedicated AR glasses. This limitation in the field of view may affect the amount of information that can be displayed simultaneously, potentially impacting the surgeon's spatial awareness.
2.Battery Life: Extended use of AR applications on digital devices may drain battery life rapidly. This could be a concern during lengthy surgical procedures, necessitating careful management of device power to ensure uninterrupted functionality.
3.Interference with Sterile Field: Surgeons and medical staff need to ensure that the devices are adequately sanitized and integrated into the surgical workflow without compromising hygiene.
4.Processing Power: Advanced AR applications may require significant processing power, and not all devices may meet the necessary specifications.



According, to VisAR and ClarifEye AR surgical navigation systems that are already in existence, my exploration in these two concepts aimed to innovate new approaches to the utilization of surgical navigation. In both ideas, I leveraged products that are already in existence, such as AR, gloves and glasses. While these items have established applications in various fields, I sought to identify their advantages and disadvantages to discern if I could repurpose them to advance my unique ideas.

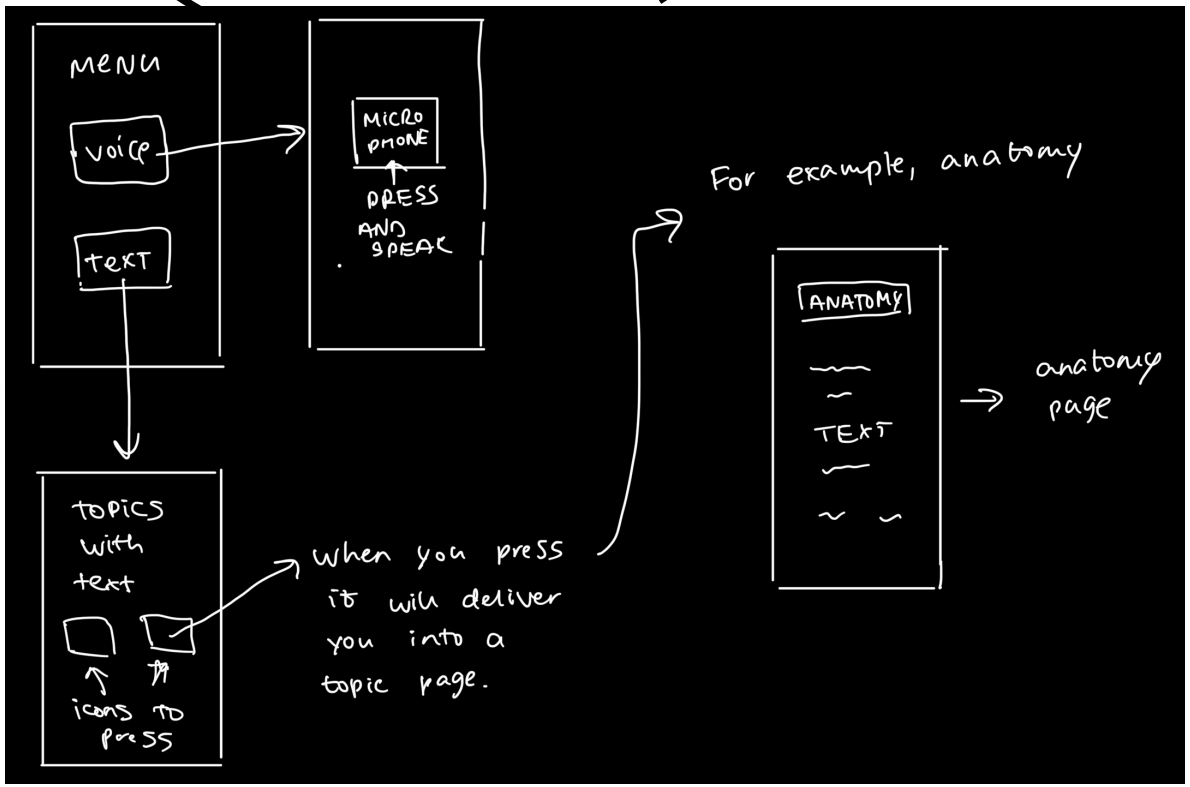
Final idea

voice assistant app

Building upon my two previous ideas, which presented certain challenges, including the persistent issue of high costs and potential difficulties faced by elderly surgeons who continue to work in the medical field, in adopting AR gloves or glasses due to their diverse abilities. Notably, these products may pose challenges related to vision and learning impairments, affecting users, especially those with disabilities like dyslexia. I propose the development of a straightforward solution in the form of an AI visual assistant app. This solution aims to address the previously mentioned issues while accommodating the needs and capabilities of both the elderly surgeons and other users with different disabilities in the medical profession.

What the app will have and how it might work:

My primary objective in creating this AI assistant app was to ensure ease of use for everyone. Consequently, the main menu is designed with simplicity in mind, featuring only two buttons. Users can choose to access the AI voice assistant, enabling voice interaction through their voice or a dedicated microphone button. Alternatively, selecting the second button labelled "text" will lead users to a comprehensive menu containing all relevant topics within the medical field.



Advantages:

1.User-Friendly Interface: The app boasts a simple and intuitive design with only two main buttons, enhancing accessibility for any users.

2.Voice Interaction: The inclusion of an AI voice assistant allows users to engage with the app seamlessly through verbal commands, providing a hands-free option for increased convenience.

3.Comprehensive Medical Information: The "text" option in the menu ensures users have access to a wide array of medical topics, promoting knowledge and information retrieval within the medical field.

4.Versatile Use: The app accommodates diverse user needs, whether they prefer voice interaction or text-based exploration, catering to different preferences and abilities.

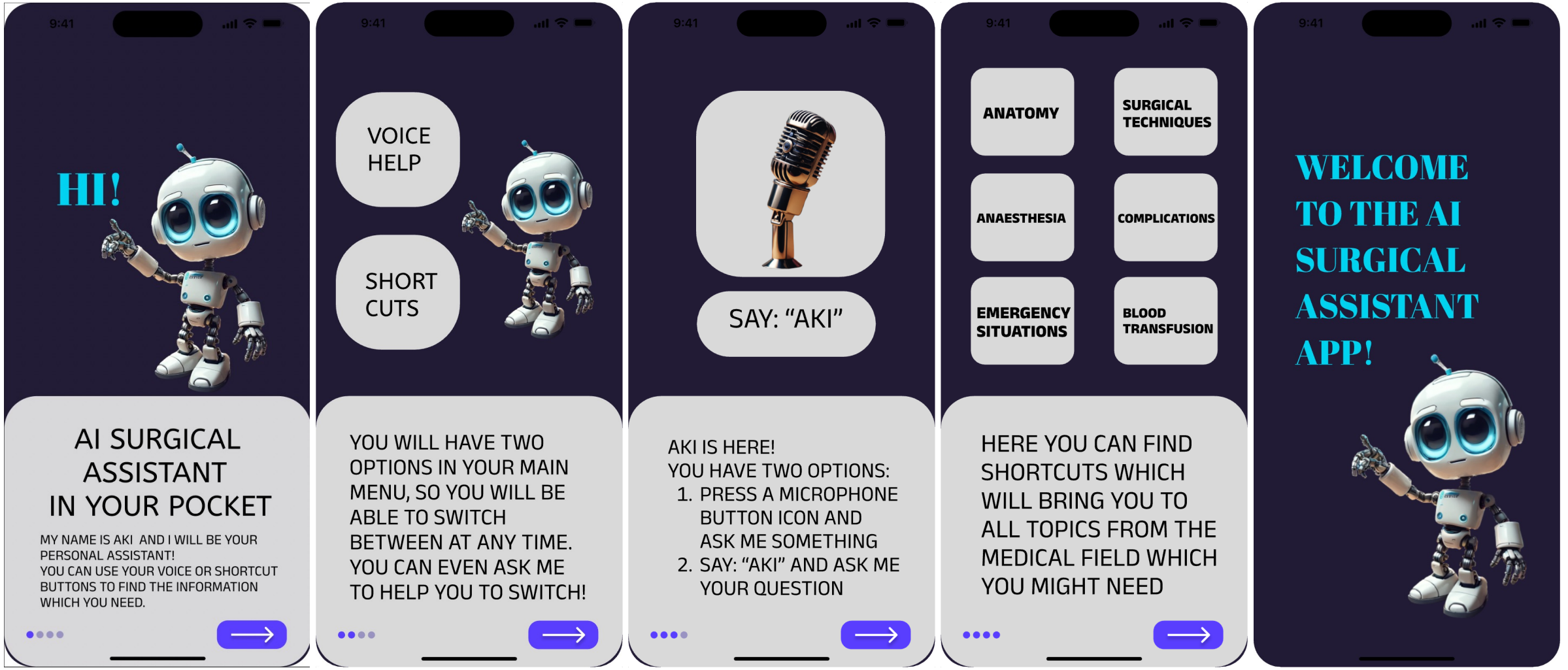
Disadvantages:

1.Limited Functionality: The simplicity of the app may result in a lack of advanced features that could be beneficial for users seeking more specialized or complex functionalities.

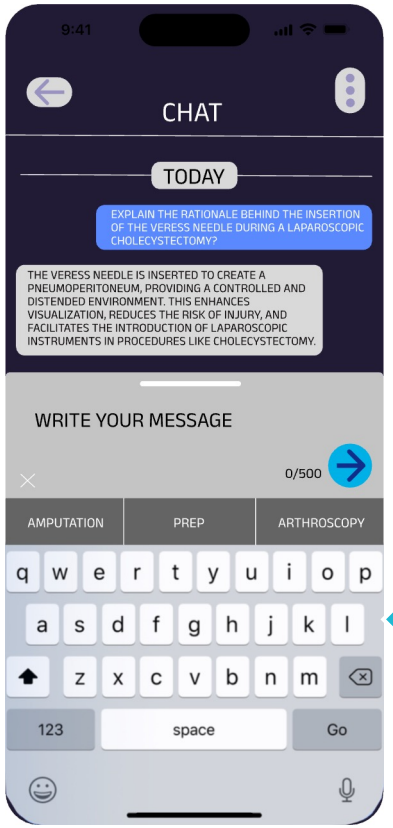
2.Dependency on Voice Recognition: The effectiveness of the voice assistant is contingent on accurate voice recognition, which may pose challenges in noisy environments or for users with distinct accents.

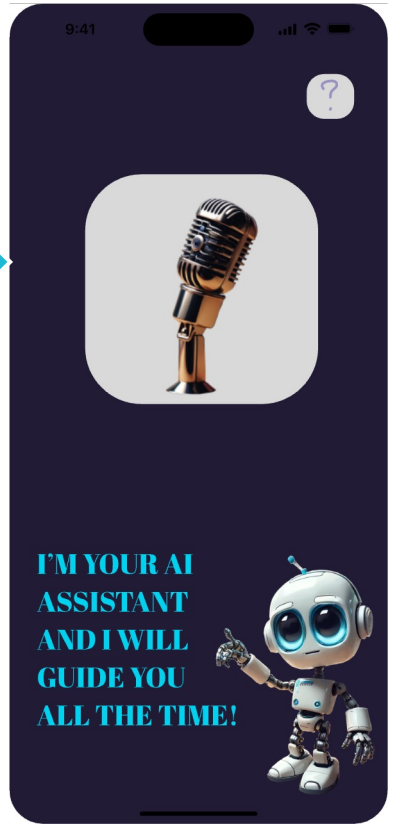
3.Initial Learning Curve: Users may require some time to adapt to the app's interface and functionalities, especially if they are not familiar with voice-controlled or AI-driven applications.

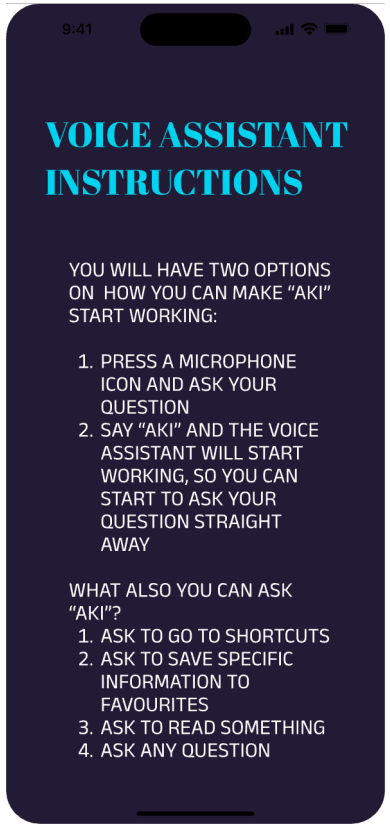
High-fidelity wireframing prototype



According to one of the disadvantages identified in my final paper prototype idea - the initial learning curve, I have opted to incorporate several pages of documentation help at the initial stages of the app prototype. Upon downloading the app, users will be presented with instructions to guide them through the functionalities. This approach ensures that users have access to guidance from the outset, allowing them to familiarize themselves with the app before fully engaging with its features.







The envisioned app goes beyond conventional functionality, aiming to serve individuals with dyslexia and autism through thoughtful design and inclusive features. For those with dyslexia, a text-to-speech feature is integrated, offering a transformative experience by converting written content into spoken words. This addresses challenges associated with traditional text comprehension. Simultaneously, the app caters to individuals with autism by prioritizing clarity in both visual and auditory elements. The user interface is crafted to be visually clear, and voice prompts are articulated with precision, fostering an environment conducive to easy navigation and understanding.

To further support users with autism, information presentation follows a structured and organized approach, minimizing cognitive load and enhancing predictability.

The design of interface is conscientiously crafted with sensory considerations in mind, acknowledging and minimizing potential stimuli that may overwhelm individuals with autism.

In response to two identified disadvantages in my final paper prototype idea – Limited Functionality and Dependency on Voice Recognition – I've taken steps to enhance the app's capabilities and provide users with more options. An additional chat menu has been introduced, allowing users to interact with the AI assistant by typing questions. This feature accommodates situations where voice usage may be impractical due to noise or other constraints. Furthermore, I've incorporated shortcut buttons, enabling users to quickly access comprehensive information on specific topics. For instance, pressing the "anatomy" button swiftly directs the user to relevant content. This multi-faceted approach ensures a faster and more versatile interaction with the app, combining AI voice interaction, chat functionality, and shortcut buttons for a comprehensive user experience.

MENU

VOICE HELP

SHORTCUTS

CHAT

SHORTCUTS

ANATOMY

SURGICAL TECHNIQUES

ANAESTHESIA

COMPLICATIONS

EMERGENCY SITUATIONS

BLOOD TRANSFUSION

FAVOURITES

FAVOURITES

HERE ARE GOING TO BE USER SAVED FAVOURITES

FAVOURITES

INSTRUCTIONS:

PRESS A STAR (IT NEEDS TO BECOME RED) TO SAVE THE INFORMATION HERE. YOU WILL HAVE ACCESS ALL THE TIME.

IF YOU WANT TO REMOVE IT FROM HERE, JUST PRESS A STAR AGAIN (IT WILL TURN BACK TO GREY COLOUR)

FOR EXAMPLE: RIGHT NOW BLOOD TRANSFUSION SHORTCUT IS SAVED, SO IT CAN BE ACCESSED AT ANY TIME

ANATOMY

ANATOMY IS THE STUDY OF THE STRUCTURE AND ORGANIZATION OF THE BODY'S TISSUES, ORGANS, AND SYSTEMS. SURGEONS RELY ON A THOROUGH UNDERSTANDING OF ANATOMY TO NAVIGATE AND MANIPULATE TISSUES DURING SURGICAL PROCEDURES. PRECISE KNOWLEDGE OF ANATOMICAL STRUCTURES IS CRUCIAL FOR ACCURATE INCISIONS, DISSECTIONS, AND OVERALL SURGICAL SUCCESS.

SURGICAL TECHNIQUES

SURGICAL TECHNIQUES ENCOMPASS A VARIETY OF SKILLS AND METHODS EMPLOYED BY SURGEONS DURING PROCEDURES. THESE TECHNIQUES INCLUDE INCISION-MAKING, TISSUE DISSECTION, SUTURING, AND HEMOSTASIS. SURGEONS CHOOSE SPECIFIC TECHNIQUES BASED ON THE NATURE OF THE SURGERY, AIMING FOR PRECISION, MINIMAL TISSUE DAMAGE, AND OPTIMAL PATIENT OUTCOMES.

ANAESTHESIA

ANESTHESIA INVOLVES THE ADMINISTRATION OF MEDICATIONS TO INDUCE A REVERSIBLE LOSS OF SENSATION. IN SURGERY, ANESTHESIA ENSURES PATIENTS ARE PAIN-FREE AND UNCONSCIOUS DURING THE PROCEDURE. ANESTHESIOLOGISTS CAREFULLY TAILOR THE TYPE AND DOSAGE OF ANESTHESIA TO THE PATIENT AND THE SURGICAL REQUIREMENTS, BALANCING THE NEED FOR PAIN CONTROL WITH THE MAINTENANCE OF PHYSIOLOGICAL STABILITY.

COMPLICATIONS

SURGICAL COMPLICATIONS ARE UNINTENDED AND OFTEN UNDESIRABLE OUTCOMES THAT CAN OCCUR DURING OR AFTER A SURGICAL PROCEDURE. THESE MAY INCLUDE HEMORRHAGE, INFECTION, ORGAN DAMAGE, OR ADVERSE REACTIONS TO ANESTHESIA. SURGEONS MUST BE VIGILANT TO IDENTIFY AND ADDRESS COMPLICATIONS PROMPTLY, EMPHASIZING THE IMPORTANCE OF PREOPERATIVE ASSESSMENT AND METICULOUS SURGICAL TECHNIQUE.

EMERGENCY SITUATIONS

IN THE OPERATING ROOM, EMERGENCY SITUATIONS MAY ARISE, SUCH AS CARDIAC ARREST, MASSIVE BLEEDING, OR ANAPHYLAXIS. SURGEONS AND THE SURGICAL TEAM MUST BE TRAINED TO RESPOND QUICKLY AND EFFECTIVELY TO THESE EMERGENCIES. WELL-ESTABLISHED PROTOCOLS, COMMUNICATION STRATEGIES, AND THE AVAILABILITY OF EMERGENCY EQUIPMENT ARE CRITICAL COMPONENTS OF EMERGENCY PREPAREDNESS IN THE SURGICAL SETTING.

BLOOD TRANSFUSION

BLOOD TRANSFUSION INVOLVES THE ADMINISTRATION OF BLOOD OR BLOOD PRODUCTS TO A PATIENT. IN SURGERY, BLOOD TRANSFUSIONS MAY BE NECESSARY TO REPLACE BLOOD LOST DURING THE PROCEDURE, MAINTAIN ADEQUATE OXYGEN DELIVERY, OR TREAT SPECIFIC MEDICAL CONDITIONS. BLOOD TYPING, CROSSMATCHING, AND MONITORING FOR TRANSFUSION REACTIONS ARE INTEGRAL ASPECTS OF ENSURING THE SAFETY AND EFFICACY OF BLOOD TRANSFUSIONS IN SURGERY.

Moreover, it's important to note that the app will now feature a multi-sensory system incorporating both auditory (voice) and text interaction. This enhancement is particularly beneficial for users with special needs. During the design of the app interface, my focus was on creating a platform that is accessible and user-friendly for everyone. Considering the diverse generational groups within the medical field, especially the potential challenges faced by the older generation in comprehension, I opted not to overload the app with additional functions. This decision was made to ensure simplicity and ease of use across different user demographics.

Possible improvements and discarded ideas

Throughout the development process, I endeavoured to address and rectify the identified disadvantages from the initial paper prototype. However, two additional aspects caught my attention, prompting further enhancements:

1.Customization: To refine the user experience, I aim to introduce a minimalist customization feature in the app. This involves offering customizable settings, empowering users to personalize their interaction. Elements such as font styles, text sizes, and speech speeds can be tailored to provide a comfortable and personalized experience.

2.Reducing Dependency on Internet Connection: Recognizing the potential challenges posed by internet connectivity, I am working to mitigate the app's dependency on online resources. In instances of poor or no internet connectivity, heavy reliance on online resources could hinder the functionality of the AI assistant. To address this, the app will still maintain a text repository covering various topics, ensuring a more robust user experience even in conditions of limited internet access. While the AI assistant's voice and chat functionalities may be affected, the app aims to provide valuable information through its text content.

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