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Zero UI : Voice Based, Gesture Based and Brain Computer Interface - Comparative Analysis

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I. Abstract

Zero UI, or Zero User Interface, represents the next frontier in user experience design, aiming to minimize or eliminate the traditional graphical interfaces we're accustomed to. Its scope is vast, encompassing voice commands, gestures, and context-aware automation. The current market for Zero UI is burgeoning, with multiple devices with varied interfaces to choose from. This review paper aims at studying all the prominent Zero UI present in the market and provides a comparative analysis in various aspects.

Keywords : Zero UI, voice commands, gesture, BCIs(Brain Controlled Interfaces)

II. Introduction

Contactless UI is redefining user interactions by eliminating the need for physical touch. It primarily leverages voice commands, allowing users to control devices and applications using their voice alone. Gesture-based interactions utilize natural movements to navigate and operate devices, enhancing user experience with intuitive controls. Brain-Computer Interface (BCI) takes contactless UI a step further, enabling direct communication between the brain and external devices, opening up possibilities for seamless control and interaction without any physical input. Together, these technologies are shaping a future where interfaces are more intuitive, convenient, and accessible.

III. Zero UI

Here is a brief of the Zero UIs explored in this paper :

1. Voice Commands : Voice commands stand at the forefront of Zero UI, offering a hands-free and intuitive way to interact with devices and applications. This technology has seen widespread adoption across various sectors due to its convenience and accessibility. In the home automation sector, voice commands allow users to control smart lights, thermostats, and appliances effortlessly. In the automotive industry, voice-activated systems enable drivers to make calls, set navigation destinations, and control entertainment systems without taking their hands off the wheel. Voice assistants like Alexa, Google Assistant, and Siri have become ubiquitous, assisting users with tasks ranging from setting reminders and searching the web to playing music

and managing schedules. Rabbit R1 is another device that lets users interact with natural language commands with a greater degree of freedom in terms of tasks that it can undertake. Furthermore, voice commands are increasingly being integrated into healthcare, aiding in hands-free documentation and control of medical equipment. Overall, voice commands have permeated many aspects of daily life, simplifying tasks and enhancing user experience across a multitude of applications.

2. Gesture Based : Gesture-based interactions represent a groundbreaking aspect of Zero UI, enabling users to control devices and interfaces through natural movements and gestures. This intuitive approach to interaction has found its way into various sectors, enriching user experience and expanding the possibilities of how we interact with technology. Augmented Reality (AR) has greatly benefited from gesture-based UI, offering immersive experiences where users can manipulate virtual objects with hand gestures. In gaming, gesture controls add a layer of realism and engagement, allowing players to interact with games in new and exciting ways. The healthcare industry utilizes gesture-based systems for touchless control of medical equipment, reducing the risk of contamination. Additionally, gesture-based interfaces are becoming increasingly prevalent in automotive and retail sectors, enhancing user interfaces in vehicles and creating interactive shopping experiences. As technology continues to evolve, gesture-based interactions promise to play a pivotal role in shaping the future of Zero UI, bridging the gap between humans and machines with seamless and intuitive interactions.

3. BCI(Brain Computer Interface) : Brain-Computer Interface (BCI) stands as a revolutionary form of Zero UI, bridging the gap between the human brain and external devices to enable direct communication and control. This innovative technology has garnered significant attention across various fields for its potential to redefine human-computer interaction. In healthcare, BCIs offer new possibilities for assisting individuals with disabilities by allowing them to control prosthetic limbs or wheelchairs through thought alone. Research in the gaming industry explores BCIs to create immersive gaming experiences where players can control characters and actions using brain signals. Moreover, BCIs hold promise in neurology for monitoring brain activity and diagnosing neurological conditions more effectively. In the future, BCIs may also find applications in automotive safety, allowing drivers to control vehicle functions through brain signals without manual input. As advancements continue, BCI technology is poised to unlock new realms of possibilities, transforming how we interact with technology and enhancing the scope of Zero UI.

IV.Parameters and Results

1. **Accuracy :** Here accuracy as a parameter for evaluating Voice Commands, Gesture-Based UI, and Brain-Computer Interfaces (BCI) refers to the system's ability to correctly recognize and interpret user inputs or commands without or with minimum errors.

(i) Voice Command Recognition

- Averaging on 90% accuracy voice commands are fairly recognized well but lack in aspects pertaining to linguistic differences.
- Difference in accents is a primary factor in hampering exactitude of the recognizing systems .
- Degradation in understanding and accuracy of foreign languages which are linguistically and morphologically different from prominent languages such as English is observed .

(ii) Gesture Based Recognition

- Accuracy is observed to be greater than 90% for most systems credited to various hardware and software improvements.
- Usage of IoT devices and external sensors has drastically elevated the accuracy of recognition of hands as it redistributes the load of recognition, also allowing dynamic recognition.
- WiFi based recognition and algorithms with greater scrutiny has enabled precise recognition.

(iii) Brain Computer Interface

- Accuracy averages to a decent 84% with most BCIs being EEG devices.
- Although some research shows improved performance to about 94% accuracy, it is for too simple tasks .

Accuracy	**Voice Commands**	**Gesture Based**	**BCI**
Average Score	9	9.2	8.8

Table 1.0

2. **Error Handling :** Here Error Handling as a parameter for evaluating Voice Commands, Gesture-Based UI, and Brain-Computer Interfaces (BCI) refers to the system's capability to manage and resolve errors or misunderstandings that occur during user interaction.

(i) Voice Command Recognition

- Errors are handled through quick correction through multimodal probabilistic models.
- Strategy follows to not deny the understanding or recognition of the command and instead follow through with similar probable statement in form of question.This prevalent strategy is found to have a positive effect on the user.

(ii) Gesture Based Recognition

- Does not have an explicit error handling mechanism set in place but strives on continuously improving the system based on feedback.
- Use of complex algorithms such as CNN(Convoluted Neural Network) to learn from error through back propagation is persuasive.
- A more novel way to the problem is perhaps the introduction of trainable or personalized gesture recognizers backed by deep learning algorithms.

(iii) Brain Computer Interface

- BCI algorithms use advanced algorithms that most accurately identify errors and what a better suited interaction result would have been.
- ErrP (Error Related Potentials) are neurophysiological signals associated with error processing that allow a more intuitive as well as more accurate assessment of the errors.

Error Handling	**Voice Commands**	**Gesture Based**	**BCI**
Average Score	8	9	10

Table 2.0

3. **Intuitiveness :** Here Intuitiveness as a parameter for evaluating Voice Commands, Gesture-Based UI, and Brain-Computer Interfaces (BCI) refers to the system's ability to be easily understood and operated by users without the need for extensive learning or instructions.

(i) Voice Command Recognition

- NLP (Natural Language Processing) makes such an UI highly intuitive where unlike previously interaction with a computer required computer language.

(ii) Gesture Based Recognition

- Although traditional algorithms and systems did not support much intuitiveness they worked on the same principles of interaction as that of a computer thus making the interaction somewhat familiar to the user.
- Advanced technology ensures that new waves of hardware and software consist of trainable and personalized control thus making it more intuitive.

(iii) Brain Computer Interface

- BCI are known for their highly intuitive interfaces, with the highest degree of intuition involved that too sourced directly from the brain.
- Although some drawbacks persist with major issues in erroneous recognition of intentional and unintentional commands.

Intuitiveness	Voice Commands	Gesture Based	BCI
Average Score	8	10	7

Table 3.0

4. **Consistency :** Here Consistency as a parameter for evaluating Voice Commands, Gesture-Based UI, and Brain-Computer Interfaces (BCI) refers to the system's ability to maintain uniformity and reliability in recognizing, interpreting, and executing user inputs or commands across different interactions, devices, or applications.

(i) Voice Command Recognition

- 70% - 90% of inconsistent and noiseful voices are understood by the recognizer, making it more prone to erroneous understanding and being less viable in particular environments.
- New voices are recognised quite ploddingly.

(ii) Gesture Based Recognition

- It has higher consistency in recognizing and acting on noisy gestures mainly due to training on vast datasets and continuous error back propagation.

(iii) Brain Computer Interface

- Although it provides the highest degree of freedom of method of interaction it is prone to inaccuracy in case of deprived or swinging mental states along with moods erratically changing the landscape criteria of interaction causing continuous inconsistency and ambiguousness on system’s part.

Consistency	Voice Commands	Gesture Based	BCI
Average Score	7	9	7

Table 4.0

5. **Adaptability :** Here Adaptability as a parameter for evaluating Voice Commands, Gesture-Based UI, and Brain-Computer Interfaces (BCI) refers to the system's ability to adjust, modify, or respond to changes in user behavior, preferences, environments, or input methods.

(i) Voice Command Recognition

- Its adaptability to new users is tedious.
- User Adaptability to it is fairly convenient.

(ii) Gesture Based Recognition

- It adapts fast to new users thanks to training on vast datasets and operations of neural networks.
- It has a steep learning curve and variance in method of interaction based on a system which causes unrest among users.

(iii) Brain Computer Interface

- Although it is complex to recognize intuitive methods it does a fairly good job
- It may be hard to get accustomed to and difficult to handle at first.

Adaptability	**Voice Commands**	**Gesture Based**	**BCI**
Average Score	7.5	7	8

Table 5.0

V.Analysis

The scores given to all three Zero UIs are relative in nature and are data driven in nature. They aim to reveal and help assess their capability and extend to which they perform within a particular parameter.

Based on the average score Voice Based UI and BCI (Brain Computer Interface) although perform fairly well on certain parameters particular issues such as Voice Recognition of new users or noisy voice recognition,and limited scope of tasks and BCI's insufficient capabilities to cope with human emotions and being able to differentiate between intentional and unintentional commands.

Zero UI	**Voice Commands**	**Gesture Based**	**BCI**
Average Score	7.90	8.84	8.16

Table 6.0

Based on the average score Gesture Based Zero UI seems the most viable with its high accuracy, great error handling capacity through backpropagation in neural networks and implicit error handling and continuous improvement , its ability to cater to audiences both in traditional and trainable or personalized domains, consistent performance and adaptability to user. Although user adaptability and learning curves being steep bars it.

VI.Conclusion

Voice Based UI and BCI face quite big blockages, correction of which has bleak scope or require more rigorous research in domains such as biology and psychology for further advancements with a complex aggregation with technology for desired results, which for now seem a distant future.

Although Gesture Based UI seems to have the most potential in most all parameters. The issue of steep learning curve can be solved by graduating the user through stages of Zero UI hardware. A proposed solution could be to instead of directly introducing the user to an AR (Augmented Reality) headset such as Apple Vision Pro, one could gradually introduce the user to simple gesture based environments on already comfortable systems such as mobile phones or laptops slowly building and training the user for more complex tasks and then shift to full Gesture Based UI.

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