Natural User Interfaces and Smart Personalization

Lab 58 Technology Research Brief

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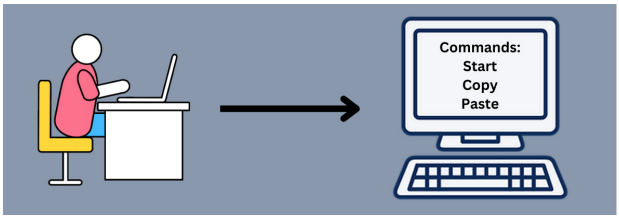
Natural user interfaces, or NUIs, are the interactions, between humans and computing devices, that are guided by various natural human behaviors such as speaking or bodily gestures.[1] Smart personalization refers to the idea that these user interfaces are customized and adapted for each individual user based on their preferences.[2] NUIs are the up-and-coming method for human and computer interaction.

Initially, humans interacted with computers using command-line interfaces or CLIs. CLIs are text-based user interfaces used to operate programs, govern computer files, and interface with the computing system.[3] CLIs utilize a keyboard to accept those input commands; in this case, the use of a mouse is unnecessary. From there, the commands are initiated at the command prompt and then processed by the computing device. The downside to this type of interface was the level of difficulty involved for the user in both learning and using CLIs.[4]



Source: Made in Canva

Figure 1. Command-line user interface.

This figure displays the operation of a command-line user interface. The user types in the commands that they want the computer to fulfill, and the computer acts out the commands that the user inputs.

KEY TAKEAWAYS

1. **NUIs are meant to be more intuitive than CLIs and GUIs, as they make use of natural human behaviors such as pointing, touching, and looking to move computing forward.**
2. **NUIs are great for expert computer users but can be difficult for novices because they require learning and memorizing certain new, preset gestures.**
3. **An NUI should take advantage of the users' existing skills and knowledge, have a clear learning path, and allow both novice and expert users to interact in a natural way.**

[1] Mortensen, D. H. (2022, December 9). *Natural user interfaces – what does it mean & how to design user interfaces that feel naturaly.* The Interaction Design Foundation.

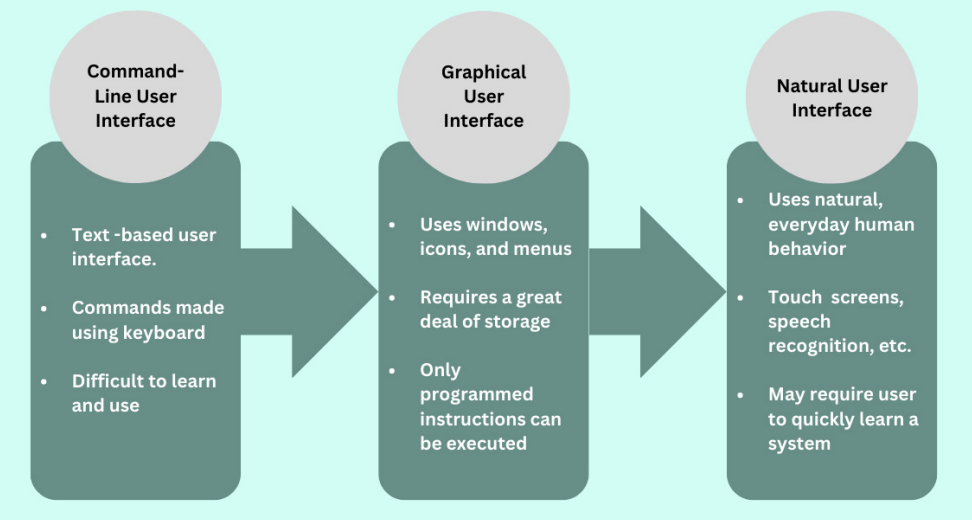
[2] Weld, D. S., Anderson, C., Domingos, P., Etzioni, O., Gajos, K., Lau, T., & Wolfman, S. (n.d.). *Automatically Personalizing User Interfaces.* University of Washington, Department of Computer Science & Engineering.

[3] Loshin, P., & Gillis, A. S. (2021, December 3). *What is a command-line interface (CLI)?* TechTarget.

[4] Loshin & Gillis (2021).

The Evolution of User Interface

Because using CLIs is difficult, humans began to improve the way that they interact with computers by developing the interface most commonly known today, graphical user interfaces, or GUIs. GUIs utilize graphical elements such as symbols, menus, and images to allow humans to interface with computing devices, typically using a mouse and keyboard. Although they are user-friendly, GUIs have the disadvantages of being relatively slow and lacking in flexibility due to the need for preprogrammed instructions.[5] In the 1990s, Steve Mann developed NUIs as an alternative to CLIs and GUIs. NUIs have emerged and appear to be the future of human-computer interaction.



Source: Made in Canva

Figure 2. The evolution of user interfaces.

This figure displays the evolution of the development of user interfaces. Humans began interfacing with computers through command-line interfaces. Today, graphical user interfaces are the main interaction used. Natural user interfaces are the newest iteration of human-computer interaction.

Many companies—including tech giants like Microsoft, Lenovo, and Apple—have begun incorporating NUIs, and the smart personalization of those interfaces, into their devices. The most well-known type of NUI is multi-touch technology, which is common in touch screen tablets and mobile devices.[6] Some other examples of NUIs include voice recognition devices, such as the Siri device created by Apple; eye tracking devices, such as the eye recognition laptop developed by Lenovo; and devices guided by human gestures, such as the Xbox Kinect device developed by Microsoft.

The expansion of NUIs presents a monumental opportunity for RTI to conduct research on ways to make NUIs more intuitive and simpler for novice users to learn to navigate. This brief will outline how NUIs work, as well as how RTI could get involved in the growth of NUIs since NUIs appear to be the next iteration of the way in which humans will utilize computers, tablets, phones, and other computing devices.

How Do Natural User Interfaces Work?

The purpose of NUIs is to create ease and understanding surrounding interaction with computing devices. The development of NUIs essentially removes the need of the user to learn complicated commands and other abstract methods of computing.[7] The user operates NUIs through movements associated with natural, everyday human behaviors, such as pointing, touch, speech, eye movement, and other gestures.[8] An NUI likely can function in many different ways, depending on the primary objective and the individual specifications of a user of a given interface. Some NUIs rely heavily on the use of intermediary devices for interaction, but more advanced NUIs are either invisible to the user or so unobtrusive that they quickly seem invisible.[9]

Ease of use is optimized when the system operates on gestures natural to the user. This is the case with multi-touch technology, which is used in touch screen devices or speech recognition. Multi-touch allows a screen or other surface to enable the operation of a system when a user touches it.[10] Touching an icon to make a selection or speaking a command are both fairly natural gestures. However, gestures like using four fingers to change screen views, as is the case with Apple products, may not be as natural.[11] This is one disadvantage of NUIs; sometimes they require a user to quickly go from novice to expert and learn new gestures to be able to operate the system. Because of this potential disadvantage, NUI developers must keep the abilities and existing skillsets of potential users in mind and refrain from including unintentional human gestures in the design.

[5] Wikimedia Foundation. (2022). *Graphical user interface.* Wikipedia.
[6] Lehrhaupt, M. (2015, October 18). *Multi-touch technology and the museum: An introduction.* Arts Management & Technology Laboratory
[7] Contributor, TechTarget (T. T.). (2011, April 5). *Definition: natural user interface (NUI).* Whatls.com,
[8] Contributor (2011).
[9] Contributor (2011).
[10] Lehrhaupt (2015).
[11] Mortensen (2022).

Use Cases of Natural User Interfaces

Multi-touch technology

The most common of all NUIs is the multi-touch technology used to operate touch screen devices. Multi-touch technology enables users to interface with the controls and applications of a system in a more natural way than cursor-based interfaces, because they are more direct.[12] Multi-touch interfaces, such as touch screen laptops, tablets, and smart phones, allow users to interact with the system using either single touch, multiple touch, touch-and-drag, object manipulation, or a stylus device.

The term "multi-touch" rose in popularity in 2007. At this time, technology giant Apple expanded basic touch functions to include more complex capabilities. Some of these capabilities include "pinch-to-zoom" and the ability to initiate various functions through the use of predefined touch combinations.[13] Aside from devices such as iPads, tablets, and smart phones, other applications of multi-touch technology include the Perceptive Pixel. Microsoft acquired this application in July 2012; it essentially takes the place of the traditional dry-erase white board by enabling individuals to interact with a large, touch screen board. The user is able to draw and write on the large screen using either their hands or a stylus device. PixelSense is another touch-screen application that Microsoft also owns and operates. The PixelSense application is similar to Perceptive Pixel in that it allows users to operate the device using their hands or a stylus.[14] The major difference is that the device is able to optically recognize when objects are placed on the top of it. An example of this feature is if a beer bottle were placed on a table by the user, the computer would recognize this object as a bottle and display content that is associated with that beer.[15]

Figure 3. Multi-touch technology.

This figure illustrates how multi-touch technology works. A user operates a system by touching the screen of the phone.

Source: Pexels

Voice recognition

Voice user interface is speech recognition technology that allows people to interact with a computer, smartphone, or other device through voice commands. This type of system allows users to initiate automated services and execute their day-to-day tasks in a faster, more intuitive manner. Some popular voice recognition devices currently on the market include Apple's "Siri" personal assistant mechanism, Amazon's "Alexa," Google Assistant, and Microsoft's "Cortana." Other voice command applications include call routing, speech-to-text functions, the hands-free function found on various computing devices, mobile phone voice operations, as well as voice-operated interaction with embedded systems.[16]

Gesture detection

Gesture or motion detection user interfaces allow the user to interact with a system utilizing natural, everyday movements and behaviors. This type of interface works by interpreting human gestures via mathematical algorithms. Gestures can originate from any bodily motion or state but commonly originate from the face or hand. Some examples of gesture detection user interfaces include game controllers such as Microsoft Kinect, Kai, Leap Motion, and the Wii. Other gesture detection devices include depth-aware cameras, stereo cameras, and wired gloves.[17]

Smart Personalization

The concept of personalization centers around the idea of tailoring products, services, and information for each individual. Some methods include link, content, and humanized personalization. Smart personalization essentially customizes the user experience based on the preferences, common gestures, behaviors, and capabilities of the individual user. This personalization occurs through the use of various software tools that collect, store, and manage user information. Some common customizations that can be made through smart personalization include selecting the menus that are visible in a system and other aspects of system appearance, adding buttons to various toolbars, defining the devices macros, and even adding custom functionality via scripting languages.[18]

There are some challenges to personalizing a system for a user. So far, the only two ways to personalize a system are by the user programming their own customizations, or the system automatically adapting to the user. Customizing a system often requires the user to have advanced knowledge regarding the functionality of the device being used, which makes it difficult for many users to take advantage of smart personalization. On the other hand, systems can also be programmed to adapt to a user's regular use habits. The disadvantage to adaptability is that it can threaten the user's level of control. An example of this is the autoedit feature in Microsoft Word. Automatically correcting capitalization or spelling can be extremely useful unless the user did not actually need for the change to be made. In that case, adaptability inconveniences the user.

[12] Lehrhaupt (2015).

[13] Lehrhaupt (2015).

[14] *What is Perceptive Pixel (PPI) and what are the benefits?* (2014, January 13). Business Productivity blog.

[15] Lehrhaupt (2015).

[16] Contributor (2011).

[17] Wu, C.-J., Lin, K.-H., Hsieh, M.-L., & Chang, J.-Y. (2019, June). *Realization of natural user interface for computer control with KNN Classifier Enhanced Smart Glove.* [Proceedings paper]. American Society of Mechanical Engineers (ASME) 28th Conference on Information Storage and Processing Systems, San Diego CA.

[18] Weld et al. (n.d.).

The key to the wide-spread deployment of smart personalization of NUIs is innovating systems that use a combination of customization and adaptation. The best example of this is "SmartEdit" implementation. SmartEdit allows a user to press a button to record themselves when they notice that they are about to perform a repetitive task. This would allow the user to be in control of system adaptation, but not necessarily require the user to become an expert programmer.[19]

Technical Limitations and Ethical Concerns

The greatest limitation inhibiting the development of NUIs is that they are extremely expensive. NUIs are still developing their reliability and overall functionality. At this stage in development, the interface is only able to acknowledge instructions that have already been programmed. Furthermore, the necessary programming is still highly difficult to perform; using an NUI often requires users to quickly go from novice to expert. Another limitation is that the commands that are meant to represent natural behaviors and gestures are sometimes not very natural and require the user to learn and memorize new behaviors. Overall, NUIs still require the user to undergo some form of training, even if it is only minimal.

From an ethical standpoint, NUIs may have limitations with regard to data privacy, data misuse, and deception within their design. Expanding the smart personalization of NUIs may require collecting some personal data from the user to make certain customizations. This could cause privacy and security issues with the data collected. For example, the data could be distributed to various sources that could abuse the data through unsolicited contact to the users. The designs could also be created in a way that enable users to make accidental purchases and unintended selections.[20]

[19] Weld et al. (n.d.).

[20] Swann, M. (2022, July 19). *Ethical technology issues to watch out for in 2022.* [Blog, Cybersecurity, IT]. Edafio Technology Partners. Retrieved December 23, 2022

[21] Contributor, T. T. (2011, March 22). *Definition: brain-computer interface (BCI).* WhatIs.com. Retrieved December 23, 2022.

Future Trajectory of NUI Technology

In addition to continuing to enhance smart personalization, the future looks bright for NUIs. In March 2011, tech giant Lenovo announced their development of the world's first eye-controlled laptop; the technology is called **Gaze-Tracking.** Gaze-Tracking interfaces enable users to guide a system through the use of eye movements. This technology utilizes an infrared light source with a camera to collect the reflections of glints from the user's eyes.

Another technology on the rise is the **Brain-Machine**.[21] Brain-Machine interfaces scrutinize cognitive signals and use various software programs to interpret those signals into action. This interface requires the user wear a cap that reads neural signals directly from the brain, taking the place of an intermediary device such as a cursor. This type of technology has the potential to enable a paralyzed individual to manipulate computers, motorized wheelchairs, and even prosthetic limbs with their thoughts.

Conclusion

Although they have their set of limitations and some disadvantages, with further experimentation and growth, NUIs will likely advance in the future of human-computer interaction. RTI could develop partnerships with major players like Apple, Microsoft, and Lenovo to expand the development of natural user interfaces, particularly in the area of the smart personalization of these interfaces. Rather than building their own devices, which would have extreme cost ramifications, RTI could focus their resources on making the systems more intuitive, natural, and simpler to personalize.

Work With Lab 58

Thanks for your interest in our work! We want to help you explore opportunities to work with natural user interfaces and smart personalization.

Please email us at Lab58@rti.org. We will set up a 30-minute, one-on-one chat to discuss opportunities and answer any questions. We are interested in partnering with you to find a solution that meets your needs.

For more information, contact Lab58@rti.org.

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