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Personal Digital Assistants: The Need for Governance

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Abstract—New technologies such as voice-based personal digital assistants (PDA) provide many benefits and new efficiencies, but they also may have negative effects on socially vulnerable groups. There are a number of ways in which PDAs could be used that can create new ethical and legal issues. In this article, we discuss the conceptual and practical challenges around PDAs and their impact on digital governance.

■ **BY INTERACTING WITH** us in a human-like way, personal digital assistants (PDA), can, in addition to provide all types of information, anticipate and fulfill needs and requests.¹ They can, for example, search the Internet, play music and videos, make phone calls, control home devices, and manage lists of daily tasks such as email and calendars with verbal commands. Digital assistants can be found in home, office, car, and other places. The big tech companies have PDAs linked to their

platforms, such as Amazon's Alexa, Google Assistant, Microsoft's Cortana, and Apple's Siri. PDAs are artificial intelligence-based digital voice assistants. PDAs are available in many devices, like smartphones, notebooks, or in smart speakers, such as Google Home, Amazon's Echo and Apple's Homepod. Smart speakers have built-in microphones that allow users to interact with other smart devices or Internet services using their voice. A PDA is a software service that takes the voice of a user as its input, identifies a command or question, interacts when necessary with other services and provides spoken response. According to the article by Koksai,² a total of 146.9 million smart speaker units were sold across the world

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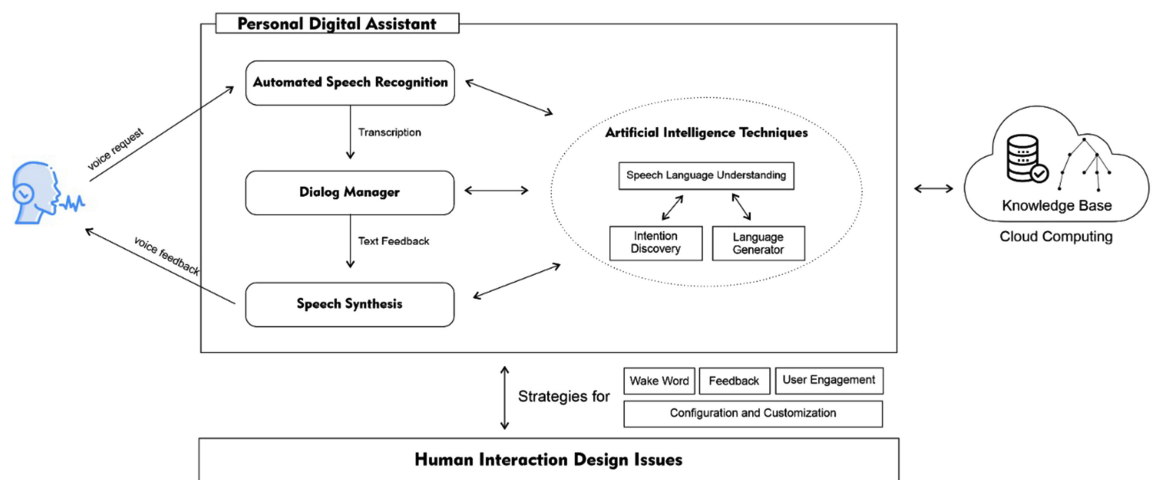


Figure 1. Architecture of a PDA with main components and their interaction with artificial intelligence techniques.

throughout 2019. The largest impact of the widespread use of PDAs may be years away, but the society needs to prepare now.

There are a number of ways in which PDAs could be used that can create new ethical and legal issues. Smart speakers are always listening, but they do not transmit everything they hear. Only when a device hears the wake word, such as “OK Google” or “Alexa,” it starts sending speech to the cloud for analysis. Digital assistants can collect and record many pieces of sensitive personal information, such as conversations, images, and location.

In 2016, detectives that investigated a murder in Arkansas sought access to audio that may have been recorded on an Amazon Echo PDA. The voice-activated device had seven microphones and was equipped with sensors to hear users from any direction up to about 20 ft. The owner of the house was charged with murder, and the investigators asked Amazon access to the data captured by the Echo/Alexa during the night of the crime. The case raised serious privacy concerns among right-to-privacy supporters and an expert stated that there is a need of “clear legal standard that governs law enforcement access to machines that make up what has become known as the Internet of things.”³

A study published in the Proceedings of the National Academy of Sciences⁴ evaluated the five state-of-the-art Automated Speech Recognition (ASR) systems that are key components of PDAs. The study focuses on the analysis of racial

disparities in five commercial speech-to-text products developed by Amazon, Apple, Google, IBM, and Microsoft. The study shows that these systems understand some voice better than others. For example, the average word error rate was 0.35 for black people, compared to 0.19 for white people. As voice becomes a popular way human and machines interact, it is clear the importance of removing any type of discrimination in speech recognition.

As many other computing devices, smart speakers are at a risk of being hacked, resulting in privacy breaches. These previous examples open up new levels of concern regarding ethical, legal, and technical failures of PDAs. Thus, here, we discuss the conceptual and practical challenges around PDAs and their impact on digital governance.

ARCHITECTURE OF PERSONAL DIGITAL ASSISTANTS

PDAs are software agents that perform tasks or services for an individual based on voice interaction. PDAs use conversational interfaces technologies that have been developed since the 70’s in order to make transactional tasks feasible, such as searching for information, controlling an equipment, scheduling an appointment, etc., PDAs have, in their structure, three main modules: an ASR, a speech synthesizer (SS), and a dialog manager.⁵ The first one transforms user utterances into text. The second one transforms text into speech in a way that is understandable to the user. It is up to the dialog manager to coordinate

the actions of the first two modules, ensuring that the users' requests are fully met. Figure 1 depicts the three main components of a PDA. They interact strongly with components responsible for semantic processing such as the speech language understanding component, the module that generates the answer and the module that understands the intentions of the interlocutor. These modules make the use of both knowledge of the world and knowledge about the context of the interaction. The ASR component typically consists of a language model trained on text datasets and an acoustic model trained on audio data. Some of the modules or parts of them are typically stored in a cloud infrastructure. Therefore, in many cases, user data are transmitted to the cloud.

Success of PDAs is measured in terms of how well the system fulfills the needs of the user relative to his/her intent and expectations. In order to have more processing capability available, PDAs may make use of resources in the cloud, which is enabled through distributed web services over many repositories.

DESIGN CHARACTERISTICS

The components and technologies described in Figure 1 bring artificial intelligence capacity to the voice assistant and, primarily, focus on understanding the users' needs and ways to satisfy them. However, it is important to note that the success of an interaction also depends on design decisions that define forms of communication that influence the usability of the assistant and can positively or negatively impact the User eXperience (UX). An example of this is the use of audible or visual signals sent by the PDA as feedback that a message has been received or that the PDA is ready to receive a message. This type of communication is crucial when the PDA works on devices such as speakers, which do not allow multimodal feedback.

In addition to usability issues, design decisions impact the user's trust on the relationship with the PDA as well as also other issues, such as security, privacy, accountability, and transparency. The decisions can be grouped into the following categories: design of feedback, design of wake-word and silence, design of strategies for user engagement and trust, and design of configuration and customization.

Feedback. A good usability practice for an interactive system is to provide feedback during UX, taking into account what to show, how to show, and when to show. In the case of a PDA, feedback is essential and includes particularities depending on the type of device on which the assistant is installed. On devices such as smartphones and computers, where various modes of interaction (e.g., audio, visual, graphics, sound, light) are possible, multiple feedbacks can be given.

The user profile must be considered in the design of the feedback. For example, illiterate or semiilliterate users should receive feedback via audio. Certain types of users, such as novice users, become frustrated when asked by the PDA to visually interact with a screen instead of using speech.⁶ When a PDA works on devices with multimodality restrictions (e.g., speakers, watches, wearables) and feedback must be done by voice, the design of the feedback is more challenging. Each use case may require special care. The lack of feedback, or a feedback in an inappropriate time, affects the efficiency of interactions, the naturalness of dialogue, user satisfaction, among others.

Wake-word and silence. PDAs add a new component to the design of human-computer interaction. Voice commands are volatile, in the sense that they only last as long as the message was sent or that a dialogue is taking place. The assistant needs to capture the meaning of the message at the right time. Identifying this correct moment of a dialogue is a challenge. PDAs are constantly listening to the environment to verify if they are triggered by a wake-word. Activation errors may lead to ethical problems, such as listening or recording an unwanted personal speech. In general, a good interaction design must ensure that the user clearly understands when the PDA is listening. If the PDA does not show a clear-cut specification about the way it communicates to the user it is listening to him/her, trust on the system may be affected. The treatment of silence is a special theme in PDAs.⁷ The assistant's silence may indicate an error in understanding a user's request, and it can also be a signal to the user to reformulate the request.

User engagement. Design solutions aim at giving users a feeling of empathy and trust in the PDA in order to increase user engagement. They refer to the ability to choose the genre of the

PDA, its voice, and an accent that is similar to the way user speaks.⁶ Design solutions to ensure trust usually include the following: a) explanations about the reasons why a particular action was taken; b) tailored responses and follow-up questions; c) users whose voices can be picked up by PDAs, especially when the smart-speaker is in an environment containing children; and d) the identification of the user's voice.

Configuration and Customization. The integration with other devices and systems should require no more than a fast and easy set-up. The article by Pyae and Joelsson⁸ shows a web-based survey with 114 users to investigate usability of the Google Home smart speaker. Participants complained about the difficulty of integrating it with other devices. It is important to note that if the user does not realize when the integration occurs, it is difficult to detect unusual network activity, such as transmission of personal data or a malicious attack. The social context plays an important role in the way PDAs interact with users. The article by Moorthy and Vu⁹ shows that people are more likely to use their PDAs in private locations to transmit non-private information. They are more likely to use a smartphone keyboard instead of a PDA to transmit information because they think that the interaction with a voice agent in public-spaces could be socially unacceptable.

As proposed in the article by Amershi *et al.*,¹⁰ design guidelines for human-AI interaction should aim at matching relevant social norms, in order to “ensure the experience is delivered in a way that users would expect, given their social and cultural context.” Another key characteristic to be observed in the design of PDAs is the need to mitigate social biases, “to ensure the AI components do not reinforce undesirable and unfair stereotypes and biases.”

NEED FOR GOVERNANCE

The risks and dangers of PDAs have been extensively reported in the news^{3,11,12,13} and also in academic articles.⁴ PDAs collect and use data that include personal, potentially identifiable, and possibly sensitive information.¹¹ PDAs can also be targeted by hackers, interested in accessing sensitive personal data.

Government and private company surveillance will be another serious issue in the age of PDAs. As pointed out by Zuboff¹⁴ “... every Internet-enabled device, every digital assistant, is simply a supply chain interface for the unobstructed flow of behavioral data on its way to predicting our futures in a surveillance economy.”

The increasing popularity and availability of PDAs can contribute to widen the digital divide phenomenon. ASR is one of the main engines of the architecture of PDAs. The article by Koencke *et al.*⁴ shows the results of an assessment of five popular ASR systems. The results demonstrate large racial disparities in the performance of the five systems. It also suggests that is considerably harder for African-Americans to take advantage of voice-based PDAs. Another empirical study pointed out that Google and Siri Assistants presented different performance results as function of the accent of the people that participated in the study. The study also shows the two systems present worse results for people with accents from least wealthy regions of a developing country.¹⁵

In light of the potential social impact of PDAs, the question that naturally arises is: do PDAs need new mechanisms for its governance, or are the existing internet governance bodies and rules sufficient? It seems evident that PDAs governance should not be discussed in a separate or isolated way from the general Internet regulation. Several PDA problems, such as privacy and surveillance, might have solutions through the implementation of governance mechanisms, as occurs with the general Internet. For example, the General Data Protection Regulation (GDPR) has become an important regulatory framework for multinational technology businesses.¹⁶ But there are other potential societal harms of discrimination raised by the use of PDAs that need to be addressed, in particular in the developing world.

As proposed in the article by Floridi,¹⁷ digital governance can be viewed as “the practice of establishing and implementing policies, procedures, and standards for the proper development, use, and management of the infosphere.” It is also a matter of convention, good communication, and coordination. For example, makers of ASR systems, speech and voice researchers in academia, government agencies that fund speech

recognition research should have in mind that those systems must be broadly inclusive.⁴ Digital governance should encourage governments and private companies to be accountable and transparent regarding new technologies such as voice-based digital personal assistants.¹⁸

Even considering the importance of PDA governance that addresses social and ethical issues, the way it can be structured is absolutely open for debate. Common principles could be the element that will put together different interests and concerns in an inclusive, effective, and legitimate governance framework.¹⁹ Principles could contribute to contextualizing PDA as part of digital resources that should be managed in the public interest. In this sense, we suggest a small set of principles that should be considered by designers and makers of PDAs: i) avoid digital divide; ii) protect privacy and security; iii) provide mechanisms for accountability and transparency.

Digital technology has been incorporated into every facet of everyday life. While new technologies such as voice-based PDAs provide many benefits and new efficiencies, they also may have negative effects on socially vulnerable groups. Governance mechanisms should be adopted to protect vulnerable groups of society and to enhance public well-being. Governance of the digital world will always rely on a dynamic equilibrium among society, governments, and private companies, which requires adaptive capacity. Responding to changing conditions and new technologies, such as PDAs, in the digital world will demand a new equilibrium that reshapes governance arrangements.¹⁸

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