Overview of the Intelligent Personal Assistants

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Introduction

As adoption of the intelligent personal assistants (IPA) (also known as conversational agents, smart speakers, digital/intelligent personal assistants, or voice-controlled agents) is on the rise (Kinsella, 2018), it becomes imperative to understand its strengths and limitations, as well as use cases in private and public contexts. This article reviews the most popular IPAs (e.g., Amazon Alexa, Google Assistant, Apple Siri and Microsoft Cortana), their technical architecture and common features, reported uses in private and public settings, and the main themes in current research on IPAs.

Technical Overview

IPA is a software that can reside on a dedicated device (e.g., Amazon Echo, Google Dot) or a mobile device or computer (e.g., Apple and Microsoft hardware). IPAs are designed to accept spoken or typed input, answer queries in a natural language, present search results, support simple conversations, play music, place online shopping orders, manage a calendar, control Internet of Things (IoT) devices, and perform other tasks (Canbek & Mutlu, 2016). The most popular IPAs include Amazon Alexa, Apple Siri, Google Assistant and Microsoft Cortana.

Most of the IPAs require an internet connection to connect to the companies’ cloud servers, or other networked devices, in order to carry out their functions. IPAs are usually activated when its speech recognition software receives a triggering word or phrase from a user. For Amazon Alexa this word is “Alexa” (which can also be changed and customized by a user, Clauser, 2017), for Google Assistant it is “Hey Google” or “OK Google”, for Apple it’s “Siri”. When the software is activated by voice, the user usually receives feedback in a form of lights (Google Dot, Alexa Echo), or changed screen (Apple or Google phones). Figure 1 shows the information architecture of user interaction with one of the main IPAs, Amazon Alexa. First, users produce an utterance or a request, which is filtered by Alexa through speech recognition, machine learning, and natural language processing. Alexa then accesses web hosted services, i.e. the cloud, and provides a response to the user. Included in the response process, Alexa
produces a “Card” of information which records user utterances and the resulting system response. The “Card” information is available to users through the Alexa app in a textual form, providing a record, or a log of interaction history.

In addition to obtaining data from the cloud servers, the software can be used to control smart home (IoT) devices, such as thermostats and lights (Dunn, 2016a).

While all IPAs share similar network architecture, they differ by their interface designs, hardware requirements, and the types of tasks they excel at. For example, since Amazon Alexa is linked to the largest online retail business, one of its strengths is support for voice-activated purchasing from Amazon’s website (Crist, 2016). Google Assistant is powered by two decades of web searching experience, so, not surprisingly, it excels in answering informational questions compared to other IPAs (Betters & Grabham, 2018). Integration with the large suite of Microsoft projects allows Microsoft Cortana to excel in task reminders, calendar management, and communication support (e.g. sending emails, Graus et al., 2016). Overall performance of the three IPAs is comparable and satisfactory on tasks related to music, navigation, productivity, cooking, home automation, and others (Chen, 2018).

**Figure 1.** Information architecture of Alexa, modified from Amazon Web Services (2017).
IPAs in Private and Public Setting

Since current IPAs are unable to support complex tasks or long conversations with users, most of the user interactions with them involve simple tasks, including straightforward reference questions and music playing. Use of IPAs differs by country, which could be largely explained by the popularity of certain hardware (e.g. android v apple platforms) and non-English language interface support (not)provided by IPA companies. In the U.S., about half of a population uses IPAs. IPAs are primarily on smartphones and valued for their support of hands-free interactions and convenience (Pew Research Center, 2017). A recent study of the Amazon Alexa usage in the U.S. households found that the most common interactions included checking weather, finding facts, listening to news, control other devices in the home, setting reminder/calendar alerts and playing music; among less frequently used tasks were set timer, tell a joke, play a game, and check the time (Lopatovska et al., 2018). A study from Denmark found that the most commonly used IPA is Apple Siri due to its support for the Danish language (Borges et al., 2019). The most commonly reported tasks reported by the study participants included setting alarms, managing calendars and emails, getting directions, playing music and controlling other devices.

In addition to the private uses, IPAs are increasingly being adopted by organizations in public settings, including, hospitals, museums, classrooms, hotels and university dorms. The Boston Children’s Hospital was one of the earliest adopters of IPA for assisting patients with intake forms, providing updates to families in the waiting room, providing patients with a hands-free phone call, text message, or email functions, as well as for control of lights and temperature in the room (Nguyen, 2016). Several museums in the U.S. installed IPA hardware in their galleries and found that users were often unaware of the technology, shied away from interacting with it in a public setting, or were disappointed with IPAs’ limited word recognition (systems often did not “understand” foreign names such as Cézanne, Matisse, and Rousseau, see Bernstein, 2016; Moore, Pan, & Manish, 2017; Nguyen, 2016). Within museum
settings, IPAs have the potential to provide general information to the visitors and, through analysis of user utterances, learn more about their interests.

IPAs have also been tested in an educational setting. Flanagan (2016) tested the use of Amazon Alexa in an elementary school setting and found that interaction with an IPA improved students’ speaking and listening skills. The author observed students using the technology for spell-checking, thesaurus, and assistance with simple math problems. Placement of the Amazon Echo device in a public academic setting produced somewhat disappointing results as many graduate students did not utilize due to lack of need, awareness of a device, or hesitations associated with privacy and distracting effect of its use in a public space (Lopatovska & Oropeza, 2018). IPAs have been recently installed into university dorms, primarily for answering questions about campus (Shoot, 2018), and hotels for addressing location-specific questions (Welch, 2018). User acceptance and adoption of IPA technology in these settings would need further investigation.

Current Research on IPAs

Research on how users interact with IPAs and how these interactions can be improved transpires in parallel with IPA adoption. The main threads in scholarly publications on IPA focus on factors that attribute to user valuation and satisfaction with IPAs, privacy concerns surrounding IPA adoption and anthropomorphizing of this technology. Studies generally find that IPAs are valued and used in situations where users are engaged in other activities (e.g. driving, playing with children, cooking) thus gaining the most benefit from hands-free voice-based interactions with their digital assistants (Cowan et al., 2017; Luger and Sellen, 2016). For the population of disabled and visually impaired users, IPAs offers additional accessibility to digital resources and services, as well as provide some unexpected support for speech therapy and other daily needs (Pradhan et al., 2018). User satisfaction with IPAs has been linked to task complexity (the easier task, the greater the satisfaction) and in-/output modes (voice, text, gesture) involved in task completion (the
more modes, the lower the satisfaction) (Kiseleva et al., 2016). The mentioned above study of IPA adoption in Denmark found higher satisfaction with higher frequency tasks, possibly pointing to the positive correlations between task simplicity, frequency and satisfaction (Bogers, et al., 2019). User satisfaction has also be linked to IPAs (in)ability to provide appropriate feedback on the status of software activation and task progress (Luger & Sellen, 2016; Sörenson, 2017), a (mis)match between input and output modes (e.g., a spoken command that produces screen text) (Luger and Sellen, 2016), quality of speech recognition (Moore et al., 2016), lack of understanding on the part of the user regarding how to best utilize IPAs (Bopp, 2018; Cowan et al., 2017), and quality of the IPA-provided information along with its sources (Lei et al., 2017; Kreuser, 2018; Lopatovska et al., 2019).

A large number of IPA research examines users’ privacy and security concerns with this technology. Some of the concerns are related to the design of IPAs that rely on recording and analysis of users’ private conversations (Liao, et. Al., 2019). Recent news about Amazon Alexa’s unauthorized recordings, storage and analysis of user utterances (Day, Turner & Drozdiak, 2019) suggest that users’ mistrust in companies’ abilities to handle data ethically is justified. Another privacy risk discussed by researchers is the possibility of an attack on IoT devices linked to IPAs (e.g. thieves can disable alarms or place unintentional online shopping orders by hacking into IPA devices, see Lei et al., 2017; Brenner, 2017).

Related to the privacy concerns are issues around social norms of having IPA conversations in public places. In a study of Alexa usage in a common area of an academic department, students avoided using the IPA and expressed concern about interrupting activities of other students by talking to Alexa (Lopatovska & Oropeza, 2018). Similarly, Easwara and Vu (2015) found that people tended to avoid using voice input in public settings due to concerns regarding both privacy and socially acceptable behavior. This same finding was also produced by a study of smartwatch use (Efthymiou & Halvey,
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When users choose to engage with IPAs in a public setting, they often stick to information seeking (Porcheron et al., 2017).

A number of studies examine how users anthropomorphize IPAs, the trend that is hardly surprising considering that the IPAs have names, gender-specific voices, and can support simple short conversations, creating an impression of being “human”. Lopatovska, Williams (2017) and Kiseleva et al., (2016) found that IPA users often express gratitude and greetings towards the software, or do not want to hurt the IPA’s “feelings” (Cowan et al. 2017). Luger and Sellen (2016) study participants found Siri responses “sassy” and sarcastic, attributes that would usually be associated with a human personality. The study involving children found that “some children [...] felt a genuine, give-and-take relationship with the machines” (Botsman, 2017: 4). While anthropomorphizing of IPAs might help their adoption rates (Han and Yang, 2018), it is also associated with negative consequences. One such consequence is over-trust in this opaque technology. Users do not have a full understanding or much control over the sources and/or quality of presented information. For example, step-by-step instructions on how to clean stains is offered by the Tide’s Stain Remover skill, i.e., a built-in capability on Amazon Alexa; and Campbell sponsors a skill for recipes and shopping lists (Lei et al., 2017; Kreuser, 2018). In these examples, users do not usually question the quality of the information they receive from IPAs. Anthropomorphizing also often leads to high expectations for this technology, which in turn can lead to disappointment and abandonment (Bopp, 2018; Cowan et al., 2017; Kiseleva et al., 2016; Luger & Sellen 2016).

Promising Lines of IPA Research in the Ukrainian Context

International research on IPAs is limited to the countries in which their language is supported by IPA platforms. The only Slavic language that is currently supported is Russian by a single IPA, Siri on Apple (and there is no extensive evidence of IPA research in this linguistic context). Ownership of hardware that hosts IPAs, awareness of this type of software and its functionality are impediments to IPA
adoption. However, the increasing omnipresence of voice interfaces in all aspects of our lives, from the control of smart home devices to automobiles, makes gradual IPA adoption in Ukraine only a question of time and necessitates research in this area. A few promising lines of research come to mind:

1) Determining usage baseline by conducting studies on voice interface, and, specifically, IPA adoption and usage. Such studies can focus on answering whether Ukrainians use IPAs differently from users in other countries? What is the IPA adoption rate and why is the rate high/medium/low?

2) Determining requirements for IPA functionality for the Ukrainian market, identifying the needs of Ukrainian users and specifics on how they can be addressed.

3) Collaborating with IPA producers to support Ukrainian language functions of IPAs.

4) Testing IPA usage in public spaces, perhaps first within relevant linguistic context such as an English language library collection or foreign language classes in elementary schools. And as more support for the Ukrainian language is developed, other public and private settings could be considered.

While it would be tempting to finish this brief overview on the enthusiastic note, praising this emerging technology for its benefits to users, the reality is whether we like it or not (e.g., studies suggest that IPA-dedicated devices are often received as gifts and/or met with lukewarm reactions), voice interfaces are here to stay. The research on this technology in the Ukraine would be welcomed as it could inform Ukraine-centric IPA design features and smooth adoption of Ukrainian language voice interfaces.
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