Wearable Wisdom: An Intelligent Audio-Based System for Mediating Wisdom and Advice

Pat Pataranutaporn
Massachusetts Institute of Technology (MIT)
77 Massachusetts Ave,
Cambridge, MA 02139
patpat@media.mit.edu

Abishkar Chhetri
Massachusetts Institute of Technology (MIT)
77 Massachusetts Ave,
Cambridge, MA 02139
abishkar@mit.edu

Tomás Vega Gálvez
Massachusetts Institute of Technology (MIT)
77 Massachusetts Ave,
Cambridge, MA 02139
tomasero@mit.edu

Pattie Maes
Massachusetts Institute of Technology (MIT)
77 Massachusetts Ave,
Cambridge, MA 02139
pattie@media.mit.edu

Lisa Yoo
Massachusetts Institute of Technology (MIT)
77 Massachusetts Ave,
Cambridge, MA 02139
lyy@mit.edu

Abstract
Having good mentors and role models is important for personal growth. However, they are not always available at the time of need. Some of our personal heroes have passed away leaving only their wisdom through writings and other artifacts. We present Wearable Wisdom, an intelligent, audio-based system for mediating wisdom and advice from mentors and personal heroes to a user. It does so by performing automated semantic analysis on the collected wisdom database and generating a simulated voice of a mentor sharing relevant wisdom and advice with the user. The results show that our platform is statistically superior in delivering relevant, yet abstract wisdom as well as providing more inspiration compared to control. We describe the implementation of the Wearable Wisdom system, report on a user study, and discuss potential applications of wisdom computation for supporting personal growth and motivation.

Author Keywords
Wearable Technology; Intelligent Agent; Voice Interfaces; Context Aware System; Wisdom; Advice;

CCS Concepts
- Human-centered computing → Auditory feedback; Sound-based input / output; Ubiquitous computing; Computing methodologies → Natural language processing;
Introduction

One of the promising opportunities of wearable technology is its potential to augment human intelligence by providing just-in-time useful information. Researchers have shown that information and feedback provided through a wearable device can help users in task memorization [21, 5, 13, 16], being mindful [22, 9], and being attentive [24, 10]. However, humans do not just seek information, but also motivation and inspiration to live a fulfilling life. Having good mentors and role models is important for personal growth [8]. Wisdom from mentors that one admires - whether family, friends, personal heroes or historical figures - can inspire and motivate individuals when making choices or facing challenging situations. Empirical research from psychology has shown that having insights from a role model or a mentor can positively affect the performance and progression of a person’s career [23], increase motivation [15], change goals [2, 6], and reduce stereotype threat [3, 17]. However, such mentors or role models are not always available at the time of need [14]. Some of our personal heroes have passed away leaving only their wisdom through writings and other artifacts. Even when mentors are still alive, they are not always accessible in moments when we need their advice the most. This paper explores the idea of using computation as a medium of wisdom and inspiration, presenting Wearable Wisdom, an intelligent, audio-based wearable system for mediating advice from mentors to the user. Through audio-based augmented reality glasses, our system offers just-in-time wisdom and advice based on the user’s query and context by generating a simulated voice of a mentor.

What is wisdom?
The term wisdom derives from the proto-indo-european root "weid-”, to see, and is related to a great number of words including advice, guide, idea, and vision [4]. In modern research, wisdom is thought to be multidimensional, involving intellect, emotion, compassion, and self-reflection embodied in a person [20]. In this paper we use the term "wisdom" in the broadest sense. We broadly define wisdom as knowledge and information that is thoughtful, insightful, and inspirational. We do not aim to discuss specific criteria for what is considered wisdom or not, but rather include what in general is being valued by society as wisdom coming from sources such as books, interviews, speeches, or records by accomplished individuals that are honored and admired by individuals or society.

Related Work

Intelligent Agents
Conversational intelligent systems such as Siri, Alexa and others have impacted how humans interact with computers in daily life [27, 7]. HCI researchers have studied interactions between humans and conversational agents, finding that by increasing naturalness of interactions, spoken input by the system can promote warmer attitudes in participants and richer language used in their conversations [19]. HCI researchers have also demonstrated the use of a personified agent to model a person’s attitudes and opinions. In “What Would They Think?”, a proactive interface provided users with opinions of people on specific topics. This was achieved by generating digital personas from automated analyses of personal texts using Natural Language Processing (NLP) and commonsense-based textual-affect sensing [14].

Wearables for Cognitive Enhancement
Previous work on wearables for cognitive enhancement have focused mainly on providing real time information, including Forget-Me-Not, which provides visual contextual cues for promoting recall [13]: iRemember, which records interactions with other people and provides an interface for
browsing and reviewing previous memories [21, 26]; and comMotion; which delivers audio-based reminders given the user’s current location [16]. According to our knowledge, audio-augmented reality wearables haven’t been used to provide wisdom that has been previously generated by other humans to augment the user’s motivation and inspiration in real-time.

Motivation and Contributions

Our aim is to leverage state of the art wearables, NLP, and intelligent agent systems to create technology that can provide the user with motivational feedback beyond factual information. As research has shown the psychological importance of wisdom sharing from a mentor to an individual, we envision future wearables that work as a seamless extension of an individual to the collective wisdom of humanity. In this paper, we introduce "Wearable Wisdom" which offers just-in-time advice and wisdom from mentors and personal heroes to the user based on their inquiry and context. Our contributions are: 1) development and implementation of the software architecture for a wearable audio-based system capable of sensing and offering real-time feedback to the wearer, 2) demonstration of the algorithms capable of delivering relevant, yet abstract wisdom and advice to the user, and 3) exploration and evaluation of the novel area of wisdom computation through user studies.

Implementation

To demonstrate our vision, we designed and developed Wearable Wisdom, a platform for mediating wisdom from mentors to users. The system consists of a wearable audio I/O device, a smartphone capable of real-time utterance recognition and context detection, and a back-end infrastructure for storing the mentor profiles and wisdom, processing user input and providing responses.

We use an off-the-shelf, Bluetooth-enabled audio interface in a glasses form factor, namely the "Bose Frames", as the Wearable Wisdom device. We chose glasses as they represent a socially acceptable form factor that users could wear continuously, thereby always having quick and convenient access to advice from mentors. These audio-based augmented reality glasses provide a private audio stream without blocking the ear canal, thus still allowing auditory awareness of the surroundings. They also contain an Inertial Measurement Unit (IMU), which allows the glasses to sense the physical activity of the wearer. The audio interface connects to the Wearable Wisdom mobile app, which receives, processes, and transmits back audio content.

We determine the location of the user using iOS CoreLocation framework, and the current date and time with the iOS Foundation framework. By means of the user’s location we determine whether the user is at home, at work, or at the gym. By means of the date and time, we deduce whether the user is in a productivity or recreational context. These two contextual features are used to infer which mentor’s advice would be most appropriate for the user’s context based on the mentor domain expertise recorded in the mentor profile. The user also has the ability to associate the mentors with the context manually.

We also gathered the accelerometer data obtained from the IMU embedded in the glasses and the phone. Using an off-the-shelf machine learning framework, we performed a preliminary assessment of this data. Given this, and previous work [12, 1], IMU data can be used to further recognize the user activity such as sitting still, walking, exercising, eating, drinking, and more.

Wisdom Pairing Algorithm

We developed a Wisdom Pairing Algorithm (WPA) based on the Word Mover’s Distance (WMD) method [11] to mea-
sure the semantic similarity between two given phrases. At a high level, this algorithm uses word embeddings to output the distance or dissimilarity between two texts. Given two words, i and j, we can compute \( c(i,j) \), which is the Euclidean distance or "cost of travel". The overall distance between two texts is defined as the minimum cumulative cost required to move all words to transform one text to another.

Word embeddings and WMD work particularly well for our purposes, since we are trying to compare questions with non-factual answers. WMD allows flexibility in deducing the meaning of the text. For the semantic matching scheme in our project, we used the Google News \textit{word2vec} model. WPA pre-processes the user’s input query by removing stop words and non-alphabetic characters. Given the question from the user input, we calculate WMD for all potential answers in the database (described below), and provide the most appropriate response with the smallest semantic distance.

Finally, we discuss the flow of the Wearable Wisdom system as well as how the user interacts with the platform.

\textbf{Step 0 : Wisdom Data Collection}
To create the wisdom database and mentor profile, we developed an algorithm to scrape mentors’ wisdom and advice from a variety of online sources as well as meta information about the mentor such as gender, age, and areas of expertise. The initial list of mentors was curated by the authors to include experts, public figures & heroes, and fictional characters from various backgrounds, but could be expanded to include other figures of interest to the user.

Based on a prior study regarding creating digital personas [14], suitable texts must include the following characteristics for inclusion: 1) the texts should be original to represent the thoughts and opinions of the mentor, 2) texts should include emotional expressions that are interpretable by reading or listening to the text, 3) the personal texts should cover a variety of topics to represent the different dimensions of a person. Lastly, 4) the text source should include attitudes and opinions of a person on day-to-day life [14]. On average, our wisdom database for each mentor contains around 200 collected wisdom quotes. This platform could be scaled to accept additional mentor profiles based on user input.

\textbf{Step 1: Begin interaction}
To ask for advice or wisdom, the user double-taps on the glasses frame and asks a question beginning with the mentor name such as "Hey Einstein, how can I be more creative?" The user has the option to direct the question to a specific mentor, select one of the recommended mentors, or choose another of the supported mentors regardless of the suggestions.

\textbf{Step 2: Utterance Extraction}
Once the double tap has been detected, we use the iOS Speech framework to start recognizing spoken words from live audio, without the need to store the user’s speech data. The speech recognizer is configured to use the microphone integrated in the glasses. When no words are detected for over 2 seconds, speech recognition stops.

\textbf{Step 3: Wisdom Computation}
The utterance and selected mentor are sent using a HTTP POST request from the iOS app to a Python server. The server runs the WPA to understand the content of the utterance, and then selects the most relevant quote within the wisdom database of the selected mentor. This quote is sent back as part of the POST request’s response.

\textbf{Step 4 : Wisdom Delivery}
We designed custom speech profiles for the initial set of mentors available in the Wearable Wisdom system. The
speech profiles allow each wisdom quote to embody certain characteristic of the mentor such as their accent, gender, and age, thereby promoting diversity and appropriateness in the voices used for audio delivery [25]. The modulation of the speech profile is based on acoustic parameters offered by the iOS AVFoundation framework, with pitch and speed modifications. Using the framework, we deliver the quote using the mentor’s custom speech profile through the Bluetooth audio interface of the glasses.

**Exploratory Studies and Results**

To evaluate the platform, we conducted studies on different aspects of the Wearable Wisdom system: wisdom pairing performance, technical design choice, mentor choice, and potential use cases. These usability studies are exploratory, aiming to provide insights for future longitudinal research of the Wearable Wisdom platform.

**Wisdom Pairing Algorithm Performance**

First, we tested WPA against control to see if our algorithm could efficiently find the relevant wisdom based on the user’s query. To do so, we came up with test questions based on popular questions that people ask when seeking for wisdom online. We used WPA to compute and find the most relevant wisdom from the three selected mentors’ databases of quotes (Albert Einstein, Steve Jobs, and Pablo Picasso) and also created a control set of answers by randomly selecting wisdom from the same mentors.

To evaluate the platform, we created a survey that randomly ordered question-answer pairs from both WPA and the control set, and asked participants to help rate the question-answer pairs in terms of relevancy (how relevant is the answer to the question) and how inspirational the answers are (imagining that the participants ask the question) using a Likert scale of 1 (minimum) - 5 (maximum). Through T-test statistical analysis, our results from 420 ratings (n = 10; population: university students & staffs) show that our algorithm is statistically superior in pairing the wisdom and advice with the questions (p-value < 0.001), as well as in delivering more inspirational wisdom (p-value < 0.05) compared to the control. These results demonstrate the promise of our algorithm to deliver relevant, yet abstract wisdom and advice to the user.

**Technical Design Choices**

Through a qualitative and quantitative survey, we asked participants (n = 13; gender: 9 male & 4 female participants; age: 20 - 62 years old) to choose what contextual information they want the platform to sense in order to provide just-in-time wisdom and advice. The choices were: emotional, physiological, gestural, behavior/activity, interaction with other people, location, and time of day. Most of the participants preferred all of the contexts as there tended to be a general belief that more context would lead to better recommendations, as long as the information collected would not be misused, as reflected in P.9’s response: “The more information a system has, the more accurate its decisions can be. As long as it doesn’t sell that data or misuse it.” When asked if the participants prefer the platform to proactively provide the wisdom based on the current context, without an explicit request from the user, 61 percent of the participants said yes. P.9 elaborated “As long as it did not become annoying/repetitive and was able to accurately detect the best wisdom for the situation, then yes. Otherwise it could be more trouble than what it was worth.”

**Mentor choices**

In terms of mentor choices, participants reported that their top three candidates whose wisdom they wanted to receive through an audio interface were personal heroes, friends, and family members. Participants elaborated that “People
whom I consider to be good mentors are the prime candidates for seeking advice. Hence family members and personal heroes” (P.5). P.4 reported that relatability is an important factor for considering whose wisdom to have access to "Anyone I have read about..., mathematicians, scientists, people who have struggled and succeeded. Someone who I can relate to." Participants also mentioned that there is a specificity within the category of mentor that determines whether the mentor is useful or not in the specific context: “a celebrity's advice would generally be useless outside the context of why they are famous. A fictional character could be useful or terrible depending on the character. Friends/family/personal heroes would be best” (P.9).

Use case Scenarios
Finally, we asked the participants to imagine potential applications of Wearable Wisdom. Based on the information provided by the user, we performed a thematic analysis and came up with 3 use case scenarios for the Wearable Wisdom system:

On-demand multi-perspective advice
In productivity and recreation contexts, it is helpful to have mentors provide different perspectives on a topic to support "cognitive diversity" [18] and perspective taking. The Wearable Wisdom system allows users to verbally request a quote from specific mentors. For example, the user can ask, “Hey Einstein, what’s your definition of success?” The same question can also be asked to Marie Curie, Pablo Picasso, Steve Jobs, Emily Dickinson, and more. The user would get different perspectives in return from each mentor.

Proactive motivation and support for behavioral change
The user can set a specific context to support proactive interactions. Specific mentors can be selected in advance for particular contexts, or a wisdom quote chosen from the most relevant items in the database. This feature could proactively cheer up, provide inspiration, or encourage users in contexts they deem appropriate such as exercising or changing unhealthy habits.

Reconnecting with individual cultural heritage
The Wearable Wisdom platform lends itself for reconnecting with family and cultural heritage. The system could permit users to create new personal mentors, add their quotes, and define their voice profile. For example, a user could add their grandmother as a mentor to recall her wisdom and advice, allowing the preservation of family and community knowledge from generation to generation.

Conclusions
We presented Wearable Wisdom, an audio-based system for mediating wisdom from mentors and personal heroes to a user. We implemented the software architecture for the intelligent wearable system capable of sensing and offering just-in-time wisdom. This is a significant first step toward our vision for future wearables that function as a seamless extension of an individual to the collective wisdom of humanity. Finally, we explored the novel area of wisdom computation through user studies. The insights learned from these studies can be used in the design of future wearable wisdom interfaces, with the goal of providing inspiration and motivation that users value to live a fulfilling life.

Acknowledgments
We thank Dan Gauger and Bose Corporation for providing us with Frames prototypes and technical support for the project.

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