Concept Design for Inclusive and Engaging Augmented Reality Assisted Disaster Prevention Guidelines

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Abstract: Disaster prevention guidelines are media aimed at the general public, that provide instructions to create safer environments and improve people's attitude during disasters, through graphics and easy to understand language. Previous work has documented that the citizenry usually do not read them or follow their advice, specifically, in cases when a user considers them hard to follow. Research in educational contexts have found Augmented Reality (AR) technologies to be effective in capturing students' attention. While in industrial contexts, AR technologies have been able to significantly reduce mistakes while workers follow instructions for maintenance processes. To increase public participation in disaster prevention activities, and produce better results while following its guidelines, this paper proposes a novel AR-assisted disaster prevention guideline interface design. Consisting of a simplified checklist interface with gamification elements to provide an easier-to-follow and more engaging guideline. Furthermore, a machine learning object detection model is used to reduce the subjective judgment of the user while recognizing the targets of interest of guidelines' instructions. Our work contributes new insight into the practical performance of AR and object recognition models, and what they are able to achieve under the restrictions of commercial mobile platforms. Also, since this targets a broad demographic, from young to elder adults, this interface also will able to survey the effectiveness of accessibility design and gamification features in AR application interfaces from an approach applicable to multidisciplinary contexts.

1. Introduction

Civil defense programs are government initiatives whose purpose is to increase the readiness of the citizens in a certain community against natural or man-made disasters. Around all of Japan, Civil Defense programs actively try to reach and inform the local and visiting population on preparedness for typhoons, fires or earthquakes [1], [2], [3]. Traditionally, printed and mass media is used to communicate preparedness knowledge in these programs. These documents are presented as a diverse collection of formats like pamphlets, books, or ads found in public spaces, television or the Internet. Their intention is to inform the public regarding actions that can be taken before, during and after and disaster has occurred. In these media, simple advice is given through easy to understand language, simple examples, and clear illustrations.

The consequences of non, ill-informed or an unprepared population experiencing a natural disaster such as an Earthquake, can range from an increase in private property and business damages [4], and the increase in minor or grave injuries due secondary hazards, such as falling objects or fires [5].

In a previous survey study, we found that traditional media used in civil defense programs, under-performs with regards to penetration in the population [6]. Less than half of the surveyed general population, regardless of their age, marital status or nationality are not used to read disaster prevention guidelines as shown in **Fig. 1**. More importantly, we found their expert advice being considered hard to apply in practice, even more in seniors of the sampled population as shown in **Fig. 2**. To address these issues, several applications using a diverse set of technologies have been developed. Regardless, literature surveys show that studies regarding their effectiveness on the general public are still lacking [7].

This situation can be framed as a knowledge transfer problem as found in Organizational theory; in which, "sticky information" refers to technical knowledge that is hard to transfer to a different organizational unit [8]. In this comparison, the government requires a transfer of technical knowledge — procedures, techniques, reference information — to the citizens who are expected to apply expert's advice into their surroundings.

In this document, we propose a novel interface design based on modern technologies that can be deployed in mobile platforms. Machine learning object detection models will be used to support the user with expert judgement, and AR virtual elements will be used to provide familiar elements expected to reduce information stickiness. We are exploring the particular knowledge transfer problem, where experts from an organization with a certain distance from its public — e.g. a local Disaster Management office — try to convey their knowledge to a generic public that spans a wide range of ages.

2. Related Work

Augmented Reality (AR) technologies effectiveness on improving learning rate and information retention has been widely

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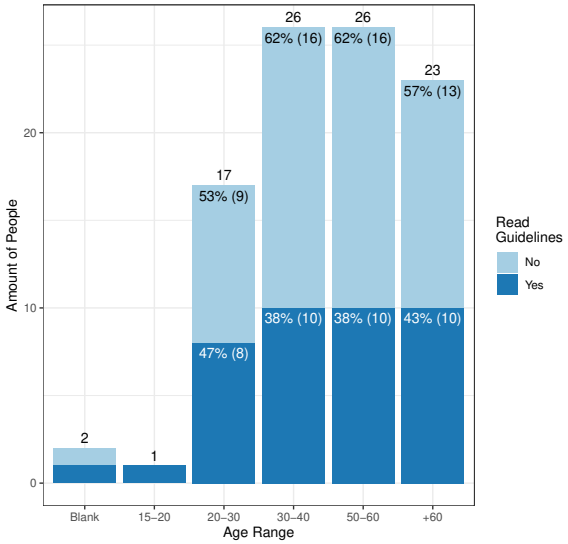

Fig. 1 People usually do not read Disaster Prevention Guidelines (this figure taken from [6])

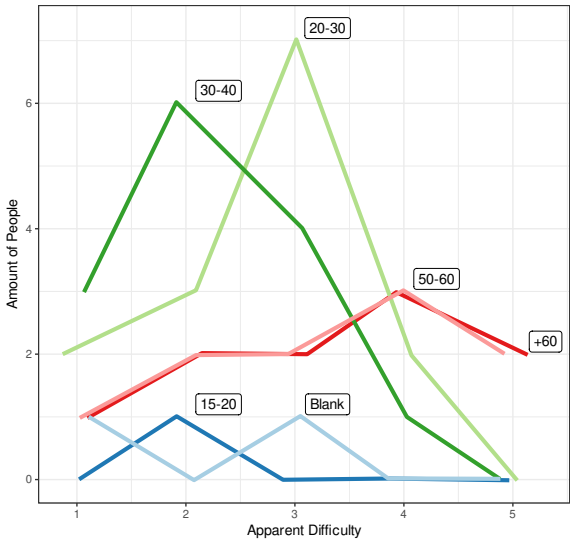

Fig. 2 Older generations regard DPG's as more difficult than younger groups (this figure taken from [6])

studied on education, elderly care and support, and industrial maintenance contexts [9]. It is found that even on traditionally low engaging school subjects like History, AR technology successfully helps students to retain attention to the lesson [9]. Tzima *et al.* highlight how teachers' opinion regarding AR in the classroom is favorable, since in a laboratory practice context, can also serve as a better instructor on proper equipment operation [10]. Taking into account the broad research on AR impact on elder care and its ease to use, Leonardi *et al.* have noted the impact of familiar elements in AR interfaces. Such familiar elements and methodology are able to reduce the barriers affecting the elder population acceptance of AR technology, such as the perception of technological superiority and the expectation of a low return on invested time used on new technology [11]. These familiar elements are noted relevant as the potential of AR applications can be extended to the daily life of elderly people outside of their homes. On this, Kong *et al.* showcase the potential of AR daily life guidance applications, where elderly people can be further supported in the operation of common interfaces such ATM's, cinema ticketing machines or a cafeteria's order taking machines [12]. In the case of industrial maintenance contexts, Obermair *et al.* explored the difference between the performance of AR-based and traditional instructions. They have found how AR technology in maintenance tasks can significantly reduce misidentifications of the objects that need to be manipulated for a successful procedure [13]. Regardless of the benefits, Matthias *et al.* have tested these applications and found inherent problems in handheld devices, such as that their one-hand manipulation impedes semi-complex double-handed tasks [14], common in maintenance processes.

Thus, an inductive approach from the survey of the literature shows that, the aforementioned AR-based applications present each, different sets of requirements needed to achieve their goals. Requirements that reflect on each interface implementation design.

Clear examples shown in Effie Lai-Chong *et al.* systematic review on usability and user experience of AR in school settings, highlight the importance of teacher involvement during the usage AR-based educational applications in the classroom [15]. Additionally, Dunleavy *et al.* identifies an interesting and undesirable consequence of the game-like characteristics of AR applications: competition between students to finish the presented tasks at hand [16], which they implicitly recommended to reduce. In industrial maintenance context as Matthias *et al.* point out, there are cases where workers found themselves in the need to be guided around machinery. This produces the particular need of 3D exploration guidance, that is then addressed by the implementation of new interfaces elements, such as those reviewed and proposed by Perea *et al.* [17]. Lastly in the case of AR applications targeting the elder part of the population, there are informal and formal documentation on accessibility, such as the guidance provided by the W3C Web Accessibility Initiative [18]. These guidance attend the particular needs that wide groups of elder find needing due their skew from the standard in cognitional and physical skills, as Yu Fu *et al.* design considerations for AR-based games for elderly population applies in their interface designs [19].

The interface design considerations for each context in the current literature, reflects the need of developers and researchers to specialize each application to their intended audience.

The aforementioned specialization in AR-based applications for instruction based tasks, have resulted in a gap in literature recognized by literature review as documented by Marion *et al.* [7]. Marion *et al.* identify the lack of research in the effectiveness of applications' interface design when targeting the general public, the public that disaster prevention guidelines are intended for. The interface design proposed on this paper intends to serve as a platform to further study this under-documented combination of mobile technology and this specific diverse audience.

3. Proposed Interface Design

To improve citizenry participation in Civil Defense activities and ease the sticky information nature of expert advice found in

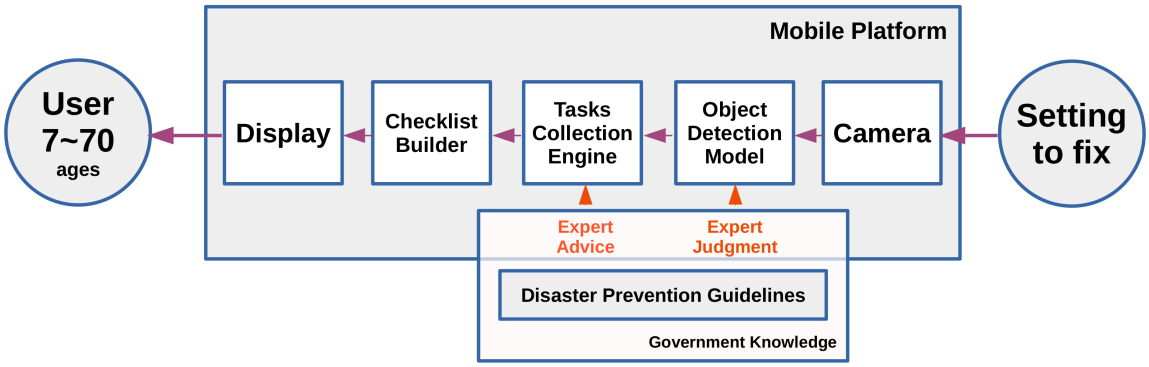

Fig. 3 Interface design and information integration flow.

traditional disaster preparedness guidelines, we propose a new information delivery media and method, using mobile technology.

In this proposed interface design, advice on how to prepare home appliances and furniture against earthquakes, is synthesized in simple "Tasks to Complete." Then, the user is shown AR virtual checklists over relevant objects identified by a machine learning object detection model (ODM). Through the integration of expert advice in the task collection engine, and the expert judgement in the ODM as shown in **Fig. 3**, we expect to improve the transfer of knowledge from disaster management offices to the public.

3.1 Virtual Elements' Familiarity

A checklist has been selected as a control element since it is a familiar form input known by both young and elder audiences, regardless of their familiarity with digital media. With this, we expect to improve the acceptance of technology in elderly people by reducing perception of technological superiority and the negative expectation in return of investment of product usage, as described by Leonardi *et al.* [11]. Additionally, this element can be enhanced with optional accessibility features, including:

- Increased contrast.
- Bigger font size.

Fig. 4 Simulation of the AR checklist and progress status elements

- Diverse color schemes for colorblindness variation.
- Ability of opt-out distracting interface elements to avoid distraction.

As recommended by W3C Web Accessibility Initiative guidelines [18]. A simulation of this AR overlay can be seen in **Fig. 4**.

3.2 Transfer of Expert Judgement

In the industry context, it has been found that object detection engines on AR-based applications, are able to reduce errors on the identification of machinery parts during a maintenance process [13]. In our design, a machine learning object detection model identifies the Targets of Interest (ToI) that disaster prevention guidelines ask the public to pay attention.

Through the integration of a ODM, it is expected a decrease in users' mental load of trying to interpret and apply expert knowledge that is otherwise encoded as simplified graphics and limited examples in traditional physical guidelines. Since the general public is in principle less experienced than the experts writting the guidelines, we expect an improvement in the user ability to identify potential hazards in their everyday living environments.

3.3 Improving Engagement in Disaster Prevention Activities

The engagement of the activity of fixing potential hazards will be improved through gamification elements to indicate the progress of advancement in securing their environment. Game like features, such as progress indicators, can be included to leverage the competitiveness attitude that appears during AR educational applications usage. This natural occurring behavior is regarded as undesirable in the classroom [20], but in the household context, it is expected to improve young family members' involvement in disaster prevention activities.

4. Expected Contributions

Augmented Reality applications' knowledge transfer effectiveness has been widely studied in diverse contexts, where the designed and tested applications present a specialized design for each of such specific contexts. Through an inductive approach and our implementation of this interface design, we expect to shed light on the diverse features that can improve the effectiveness of the transfer of expert knowledge to a different public,

under-explored on the current literature.

The expected contributions of this design are the following:

- Integrate design knowledge produced from the research on AR applications used in education, maintenance and elderly care.
- A design suited for applications that in practice, using datasets with classes of high feature diversity, will be able to test compresed object detection models generalization capacity.
- A positive social impact by increasing the public engagement and usage of disaster prevention guidelines.

4.1 Knowledge Integration

This design will integrate the knowledge gathered from studies in the education, industry, and elderly care contexts. The subjects surveyed in those studies, reflect the wide age range of the general population, users of this interface.

Consecuently, our design leverages a behavior that in the educational context is considered as undesirable: competition between students to finish first each task. We think this behavior described by Tzima *et al.*, on using AR applications in the classsrom, will promote the participation of young family members in a household. On the other hand, including the accessibility design considerations found in research on AR applications for the elderly population, we expect to provide a comfortable and familiar experience to the elderly.

4.2 ODM Generalization Capacity

Using this design in a practical implementation in real-world smartphone applications, will require the use of simplified versions of state-of-the-art machine learning object detection models. These simplified versions are a technical compromise, where their complexity and layers are reduced, to improve their speed in mobile devices [21]. We expect this interface to be suitable to applications where an ODM needs to identify everyday objects, that due their commonplace present a high variation in their appearance. By also targeting the general public, we believe it is a suitable platform for applications that can gather datasets big and diverse enough to test these models' feature generalization capacity.

4.3 Social Impact

Public engagement in disaster prevention activities has been found low, in public surverys data [6]. Relevant factors include a perceived difficulty in following their guidance. Through familiar smartphones and tablets, we believe our interface is capable to provide an easier-to-follow guidance, on securing the citizenry households from inevitable natural disasters.

The integration of design advice from research on AR, in education and elder care, it is expected to improve a family engagement in disaster prevention activities.

5. Conclusions

In this paper we propose a novel user interface intended to improve the effectiveness of disaster prevention guidelines. This will be achieved by three main elements:

- Checklists as task completion forms, familiar to all age ranges of the intended audience.
- An object detection model, to reduce the misidentification of relevant targets.
- Gamification elements such as progress indicators, to leverage competitive behavior between young family members.

Integrating the knowledge in current research on AR-based specialized applications in three main contexts: education, industrial maintenance and elder care.

This novel implementation of a disaster prevention guideline, will address the issue of current disaster prevention media having, a low penetration in the general population.

Through a following study, we will explore the impact of an smartphone application, that in particular, targets a public of high diversity. We will measure and analyze their engagement, the user experience, and their knowledge retention. Through this research, we will be able to get a broader perspective of the factors that affect knowledge transfer, in governments' civil defense programs by using common everyday mobile platforms.

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