

DESIGN DIALOGUES COURSEWORK 2

Name : Navya Vempati

Matriculation Number : 40342146

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1.0 Introduction

1.1 The proposed system

1.1.1 Context

The Lions Gate is an urban permaculture project being implemented at Edinburgh Napier University's Merchiston Campus. At completion, the project will feature self-sustaining gardens, a circular food system, outdoor performance spaces and laboratory, accessible pathways, and interactive elements (Egan, 2017; ScotLAND, 2016). The primary aim of the project is to blend permaculture and digital interaction in ways that:

- Encourage students, employees, local communities, and global visitors to reflect on the inherent interconnectedness of healthy ecosystems;
- Promote research into human-nature relationship; and
- Benefit body, mind and the environment through inspiring, playful, and sustainable actions and experiences (ScotLAND, 2016).

1.1.2 The proposed system – an augmented reality (AR) system for permaculture interpretation

The proposed augmented reality (AR) system for permaculture interpretation (hereafter also referred to as ARSPI) is a stationary stereoscopic device equipped with a computer system, sensors, and a set of AR binoculars. ARSPI will be stationed facing Merchiston Campus's grounds and gardens so as to fix the AR experience to different elements located in the grounds/gardens. Visitors will be expected move to the ARSPI stand, look through the binoculars, and rotate the device to focus on different points of interest. This way, visitors will be able to see contextual and interpretative information (in 3D) about permaculture within the

observed grounds and gardens. The idea is to expose hidden, yet invaluable information about permaculture ethics and principles in the real-world.

1.2 Motivations behind the project choice

The augmented reality (AR) system for permaculture interpretation (ARSPI) looks like the binocular stands that are often found in historic sites, site-seeing locations, museums, and amusement parks. However, contrasted with conventional binoculars that magnify objects and images, the ARSPI binoculars will overlay holographic details to provide a truly augmented reality experience about permaculture. The AR-based system takes the visuals human eyes can see and adds contextual information about the observed points of interest so that visitors can have a deepened experience of Merchiston grounds and gardens. This experience will help expose considerable information about permaculture philosophy and associated sustainable design practices – insights that would otherwise remain abstract if the material anchors exhibited by self-sustaining grounds/gardens were not felt or experienced by visitors.

Egan and Benyon (2017) argue that permaculture gardens may be used as the “material anchor” essential to enabling people to make their new experiences in sustainability concrete. In line with this, the proposed ARSPI is a novel and appropriate approach to demonstrating the blending of permaculture and UX to yield useful relationships. Basically, the in-development permaculture grounds and gardens at Merchiston will provide a “material anchor” for sustainability principles. It is the interactive experiences provided by ARSPI that will deliver practical insights into sustainability and human computer interaction (HCI). The new experience will invite visitors to reflect on the true meaning of sustainability and how they can contribute to a healthy planet.

1.3 Objectives to be achieved through the design

1. To provide visitors with a valuable stereoscopic augmented reality (AR) experience of Merchiston's self-sustaining grounds and gardens.
2. To allow Merchiston visitors observe and interact with 3D virtual objects representing different elements of the physical grounds and gardens at Merchiston.
3. To enhance the visitors' awareness, experience and understanding of permaculture through interactive 3D visualizations of sustainability in practice.

2.0 Design approach

Interactive systems should be accessible, usable, enjoyable to use, engaging, and useful.

To achieve these usability and user experience (UX) capabilities, the design of interactive systems must be human-centered. A human-centered design is the one that puts people (especially users), rather than technology, at the center of the design process. Other than a human-centered approach, it is important to use a design approach that prioritizes evaluation. There are many design approaches in which people and evaluation are treated as the core principles of design. Examples include value sensitive design (VSD), scenario-based, and participative or future workshops among others (Benyon, 2014).

A value sensitive design (VSD) is the proposed design approach for the augmented reality (AR) system for permaculture interpretation (ARSPI). VSD advocates for a design process that accounts for human values in a comprehensive and ethically/morally responsible manner. Examples of common human values include welfare, ownership, privacy, fairness, universal usability, autonomy, trust, informed consent, identity, and environmental sustainability. The design approach emphasizes personal preferences, moral perspective, and usability. VSD

focuses on the following three iterative types of investigations (Benyon, 2014; Friedman, Kahn, Borning, & Hultdtgren, 2013):

- **Conceptual:** Philosophically informed evaluations of the core constructs and concerns related to the design under investigation so as to understand and articulate the direct and indirect stakeholders, their values, and potentially competing or conflicting values.
- **Empirical:** Quantitative and qualitative studies concerned with the human response to the technological artifact as well as to the greater social context in which the artifact is situated. Empirical studies play a role in evaluating the success potential of a specific design.
- **Technical:** Analyses of the design and performance aspects of the technology under investigation to determine the degree to which the design suits stakeholders' values. Moreover, technical investigations focus on retrospective analysis of existing technical solutions and the design of new technological systems and mechanisms.

Conducting the investigations iteratively may allow the designer(s) to continuously change the design. This way, it is possible to continually improve the design (Friedman et al., 2013).

When it comes to the proposed ARSPI, the context of use has been identified as permaculture grounds and gardens at Merchiston where the solution will allow visitors to effectively experience sustainability. The stakeholders are Merchiston visitors, including the students, staff and the general public at large. A conceptual investigation is needed to determine the key values of each stakeholder group. Moreover, it would unearth potential value conflicts. For empirical investigation, the ARSPI designer may employ interviews, surveys, observations,

or any other suitable qualitative or quantitative research method to understand the stakeholders' opinions and concerns regarding the proposed technological solution. When engaging technical evaluations, design trade-offs will be identified and analyzed thoroughly to eliminate or mitigate conflicting values.

3.0 Understanding

Understanding is one of the fundamental processes involved in the design of human-centered interactive systems. The process focuses on what the system should do, what it should be like, and how it should integrate with other “things” so as to meet particular user and technical requirements. To a greater extent, understanding focuses on the requirements of the system, product or service under development. Designers should research the kind of stakeholders, processes and contexts applicable to the field they are investigating in order to understand the functional and non-functional requirements of the system to be developed. Requirements are elicited through conversations and interactions with stakeholders, particularly the end users and people who might be affected by the proposed system. Alternatively, requirements may be generated by observing existing systems and researching into similar systems. Additionally, designers ought to understand both the opportunities and constraints that come with different technologies (Benyon, 2014).

Understanding techniques may include interviews, questionnaires, probes, background research, and card sorting (Benyon, 2014). For the purpose of the augmented reality (AR) system for permaculture interpretation (ARSPI), a desk research related to the core functions of an augmented reality (AR) system was conducted. Then, findings from this research were customized to suit the functions of the AR system to be used in the context of outdoor grounds and gardens.

The other understanding technique that was used is studying how similar or related systems work to get ideas for the proposed design. This way, it was possible to discover the good and bad ideas for specific design problems.

Depending on findings from the two understanding techniques, the following insights into augmented reality (AR) systems were derived:

1. Popular AR solutions: Microsoft HoloLens, Magic Leap, and Layar.
2. Common AR devices: Mobile devices, connected (PC or TV) players, and head-mounted displays (HMD) and glasses.
3. Primary hardware and software components: Processors, memory, input devices, display, optics, I/O resources (like speakers and Bluetooth), sensors, operating system and AR software, and a remote server.
4. Fundamental building blocks: Motion controllers, gestures, spatial mapping and sound, and voice input.
5. Working principles of AR: Marker-based or recognition-based and location-based.

4.0 Envisionment

A system design should be visualized to enable the design team to clarify and evaluate their ideas. Envisionment focuses on finding an appropriate platform for rendering design ideas – both the design process and design representations. The platform needs to be suitable for the audience, available resources, and the issues that designers are trying to tackle (Benyon, 2014). Therefore, the main goal of envisionment is to bring abstract ideas to life – externalization of thoughts.

There are many envisionment techniques that designers may use. These methods may include the following: stories, scenarios, sketches, snapshots, paper prototypes, fully or partially functioning prototypes, storyboards, presentations, and cardboard mockups (Benyon, 2014). As such, envisionment methods help work through design ideas so that the primary issues become clear. For the current case study, conceptual scenarios and sketching were used as envisionment techniques.

Conceptual scenarios represent a crucial aid to understanding abstract activities, situations, or system requirements. These scenarios do not specify underlying technologies or how various functions will be implemented (Benyon, 2014). The following are the core high-level conceptual scenarios for the ARSPI design:

1. Visitors with any level of computer skills will move to the ARSPI stand, look through the AR-enabled binoculars, and rotate the device to focus on various scenes within Merchiston's grounds and gardens.
2. ARSPI will recognize and capture various permaculture elements in the field of view.
3. Based on the recorded location in the grounds or gardens, ARSPI will overlay 3D computer-generated (CG) models or information to the particular real scene.
4. Visitors may interact with different virtual objects (or holograms) and actual objects within the augmented reality (AG) scene.
5. Visitors can use a hand gestures (single-tap, double-tap, swipe, pinch, tap and hold, hold and drag, and bloom) and voice input.

Considering that the design in the current scenario is at the initial or concept stage, it is only practical that a high-level sketch of the system would serve the purpose of envisionment. Benyon (2014) argues that prototypes, anything from paper-based sketches to semi-functional products, are commonly used to represent scenarios in a possible technology. Depending on the outcomes of the scenario or prototype walkthrough, designers usually conduct modifications and iterations as necessary. Sketching is one of the most popular techniques practiced by designers. A sketch quickly visualizes ideas and thoughts to oneself and to others. A design may have several snapshots that illustrate fundamental moments in a particular interaction. Snapshots are important tools for visualizing and exploring the how a particular design looks like (Benyon, 2014). Figure 1 shows a high-level sketch for the proposed ARSPI, demonstrating the basic process of overlaying AR content with digital information.

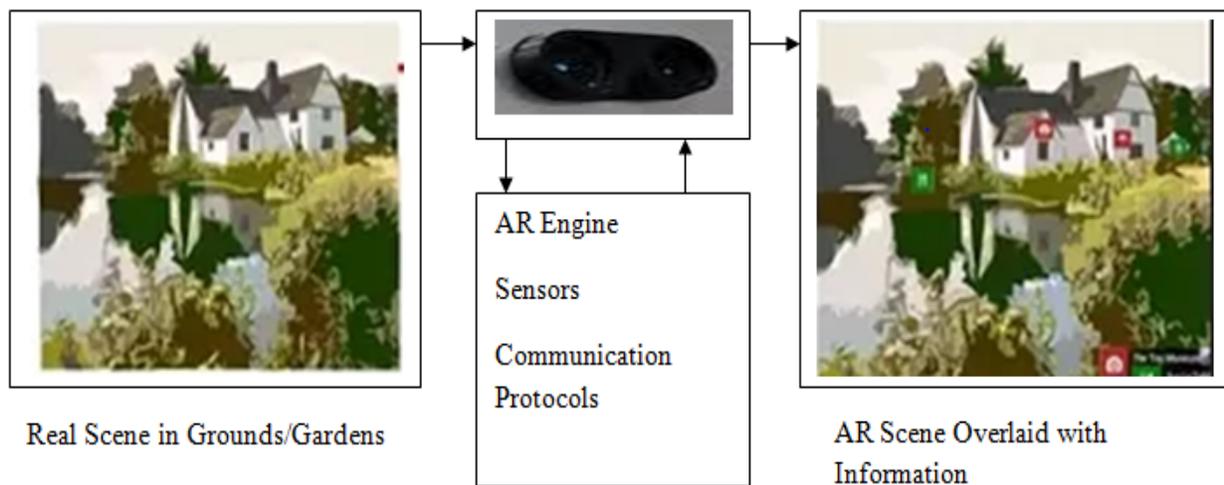


Figure 1: A high-level sketch of the ARSPI

5.0 Testing

Testing methods are the strategies used to assess a specific product with respect to its fitness for purpose. Typically, testing is concerned with determining whether or not a system meets its specifications. It is also important to confirm that the system is free from adverse side

effects, especially when used beyond its design parameters. There are two main categories of system testing methods, namely functional testing and non-functional testing. The former entails unit, integration, system, and acceptance testing, while the latter entails performance, usability, security, and compatibility testing (Navabi, 2010). However, functional and non-functional tests are conducted using a variety of specific methods. Some of these methods include black box testing, white box testing, “try-to-destroy-it”, wizard of Oz, and A/B testing (Benyon, 2014; Navabi, 2010).

For the proposed ARSPI project, system testing and usability testing were deemed essential. System testing is mainly aimed at verifying that the components of a system functions correctly. Usability testing focuses on the target user’s ease of using, accessing and learning the system at hand (Baltzan, 2018). Table 1 shows the test conditions applicable to the ARSPI project’s system and usability testing.

Test Condition	Expected Result	Actual Result	Pass/Fail
Rotate the ARSPI device towards a particular real-world scene	The input devices (like the camera and GPS) capture real permaculture content and sends it to the processor		
The processor requests virtual objects from the remote server	The remote server sends the virtual objects to the processor		
The processor sends the augmented content to the AR application	The AR application prepares the augmented content for display		

The AR application displays the augmented content on the ARSPI display platform	The ARSPI display streams the AR scene to the user		
The visitor clicks the menu item	The ARSPI displays different menu items		
The visitor selects a menu item	The system opens content or options related to the menu item that was clicked		

Table 1: Test conditions

6.0 Evaluation

Design is considered to be a messy process. And, designers attempt to work out this mess by evaluating how target users will use interactive systems without experiencing restrictive usability challenges. Evaluation is concerned with assessing the completeness and correctness of a design or design brief. However, a list of requirements, a conceptual model, or functional prototype could be evaluated. Many of the understanding techniques may be applied to evaluation. Evaluation may involve a usability or interaction expert who reviews the envisioned design version – expert-based evaluation methods. Alternatively, designers may recruit people (preferably end user representatives) to use the envisioned design version – participant-based methods (Benyon, 2014).

For the current scenario, informal expert evaluation was identified as the most suitable evaluation technique. Here, the high-level AR functions, conceptual scenarios, and the sketch documented during the understanding and envisionment were used to support the expert evaluation process. A heuristic-based approach was adopted, with the researcher assuming the

role of an expert UI/UX designer. To enhance the accuracy and relevance of findings, the following major heuristics were included in the evaluation: system visibility, consistency, navigation, gestures and voice input, and feedback mechanism.

Another suitable evaluation approach is the cognitive walkthrough technique. This technique entails an intensive paper-based approach to reviewing the detailed design and the logic of interaction steps. Essentially, cognitive walkthrough involves a usability expert who steps through a set of cognitive tasks that eventual users are expected to carry out. The approach assures a systematic approach to evaluation. In addition, it relies on a well-established theory as opposed to trial and error (Benyon, 2014). The following inputs were prioritized:

1. An understanding of ARSPI users – visitors who may be Merchiston students, staff, and the general public at large.
2. Conceptual scenarios (identified in envisionment).
3. A collection of concrete scenarios, namely:
 - Information collection from real scenes.
 - Display digital information for visitor's eyes only.
 - Display digital information in real scenes while constantly changing the focus.
 - Display information that makes sense within the permaculture context only.
 - Allow users to interact with 3D virtual models and information representing the real scene.

4. With the above-mentioned inputs, the following questions were asked:

- Will the target users achieve the desired effect?
- Will users discover that the right action is available?
- Will users associate the right action with the actual effect they are attempting to achieve?
- If the right action is executed, will users recognize that they are making progress towards the ultimate goal?

All the questions were answered in the positive. Therefore, no usability issue was identified.

7.0 Conclusions

This work proposed an augmented reality (AR) system for permaculture interpretation (ARSPI) – a device aimed at helping Merchiston visitors to better understand and interact with different permaculture principles in practice around the campus's self-sustaining grounds and gardens through AR. Unlike most AR devices that require users to wear a headset and walk around with it, the ARSPI will be designed as a stationary AR system. The proposed system will, at minimum, label different points of interest within the user's field of view and incorporate contextual information about the observed scene. By providing contextual information, the new system will deepen the experience of visitors being around permaculture grounds and gardens. The stationary approach implies that ARSPI will provide a focused approach to permaculture interpretation.

For understanding purposes, a desk research and an exploration of existing augmented reality (AR) systems were conducted. This helped identify and understand the core functions, components, and working principles of AR systems. Conceptual scenarios were used for the purpose of aiding envisionment – or ideation. They helped describe the key functions of the proposed system. A sketch of the proposed system was also used for envisionment purposes. Sketching is a quick, cheap and technology-neutral tool for demonstrating basic concepts. Testing was carried out using system and usability testing techniques, especially focuses on the fundamental offerings of the proposed system. Finally, an informal expert evaluation based on two techniques, heuristic-based and cognitive walkthrough, was conducted. Working with conceptual and concrete scenarios in the envisionment and evaluation stages implies that the adopted methods are related to the scenario-based design approach to some extent.

It should be noted that there were no human participants involved in the design understanding, envisionment, testing, and evaluation stages. More precisely, no personally identifiable information (PII) about human participants was captured since there were no interviews, probes or questionnaires. Moreover, no observations were carried out. Therefore, there were no ethical issues that could directly apply to the entire design process. The only major ethical consideration that was made is acknowledgement of all ideas borrowed from existing documents. This acknowledgement was done through APA referencing.

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