Department of Computer Science

BSCCS Final Year Project 2022-2023
Interim Report II

22CS129

Designing for Engagement: Re-collecting Agency of Displaced Fishing Community through Development Planning with Augmented Reality

(Volume ___ of ___)

Student Name	:	**QIN Yigang**
Student No.	:	**56197677**
Programme Code	:	**BSCEGU4**
Supervisor	:	**Dr LU Zhicong**
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Abstract

Hong Kong fishing communities are relocated from their traditional habitats to inland villages to accord with urban construction and marine protection. Relocated community members need to adapt to the new environment that is different from their original ones because the new community plan is designed by urban designers and may not fit the community's needs and aspirations. In the formative interviews with the villagers, I found their intentions of developing the community with their own needs considered. However, because of the low socio-economic status, the fishermen's community faces difficulties claiming their rights and expressing their voices, lowering their sense of community and agency. Therefore, this work presents the design of an Augmented-Reality (AR) based community development planning workflow that engages the members in discussing community affairs and helps them recollect the sense of community and agency. The workflow comprises designing the development plan with papers and a mobile AR application and sharing and showcasing the design to other members. The prototype first underwent iterative usability tests, then functional tests, and finally a planning workshop and a focus group were conducted to assess the user experience and how they perceive its effect on their thoughts about community.

Summary of Revisions Since Interim Report I

- Provided design rationale based on preliminary **formative study (interview)** with the potential users.
- Drew from **Value-Sensitive Design** framework to further introduce the broader motivation.
- Improved the design process to be more iterative by first conducting usability tests for the **prototype** and iterating the design.
- Described the application’s functional modules in a **class diagram**.
- Reported the **preliminary interview result** from the usability test for the prototype.

1. Introduction

1.1. Background Information

Back in the 1960s, Hong Kong was known for its fishery production. As it proceeds to the 21st century, fishery development and fishermen's lives were altered to align with the government's prospects for environmental protection and sustainable development (Cheung, 2011). The government proposed and deployed regulations on capture fisheries, which consistently limits the expansion and even survival of small fisheries.

Limited fishing opportunities re-oriented fishermen and their offspring to alternative livelihoods and often made them relocated citizens who live in areas other than their traditional places of residence. As the elderly fishermen retire, the younger generation seeks education and occupations in the cosmopolitan areas of Hong Kong, leaving the fishing communities with bare available human forces for fishery production and passing fishery skills over generations (Dryland & Syed, 2010). Some moved into new villages to accord with urban development planning, but the government often dismisses their appeals.

The decline of Hong Kong's traditional fishing communities comes with fishermen's reduced sense of community and agency. The fishermen were discriminated against for their limited formal education by people living in the urban cities. Even the fishermen and their children themselves do not respect or appreciate the fishery's livelihoods. Moreover, opinions of fishery communities regarding their rights are difficult to transfer to effective outcomes when negotiating with the government or other social organizations. Despite the tangible low social, political, and economic status and busy working for livelihoods, two major reasons could be a lack of solidarity among the members and a lack of awareness of responsibility and rights. It is also because of these two reasons that the fishermen are becoming increasingly incapable of soliciting support and achieving the community's goals. Such information is coherent with the findings from my preliminary formative study of fieldwork and interviews in a relocated fishing village in Sam Mun Tsai, Hong Kong. The formative study makes the technological intervention socially and culturally fit in addressing these critical issues by virtue of Human-Computer Interaction for Development (HCI4D) and Value-Sensitive Design (VSD).

1.2. Problem Statement

In the field of Human-Computer Interaction (HCI), there is an immense body of scholarly work that revolves around information technologies' relations with social development, which is named HCI for Development (HCI4D) (Chetty & Grinter, 2007). HCI scholars explored ways through which computing technologies can function as empowering tools to satisfy various essential needs of vulnerable populations and achieve effective results in practice. However, most of the work focuses on practical and functional needs but dismisses the issues, including culture, identity, and sense of belonging. Displaced indigenous communities usually face problems more seriously in addition to fundamental and physical needs than other communities (Sabie et al., 2017). These additional needs deal with the communities' identity, solidarity, and collective memory, all of which are essential because of their vulnerable identities. This work aims to fill this gap by exploring novel technology applications in empowering communities through an indirect approach.

1.3. Scope, Aims, Objectives, and Deliverables

This project focuses on how to utilize technology design to strengthen the fishermen's sense of community and agency. The specific intervention where technology plays a role in community development planning. During this process, the community members propose arrangements for the infrastructures and buildings inside the community using our design workflow, which fosters considerations and tradeoffs for the community's well-being. Specifically, I design a workflow for designing a community development plan using papers and a mobile Augmented Reality (AR) application. Community members can scratch development plans on paper or arrange cut papers and use the AR application to visualize, interact with, and analyze the plan in real time. This workflow also supports collaborative design among multiple users simultaneously. The user testing shows positive feedback on the usability and effectiveness of the proposed workflow.

1.4. Report Organization

I organize the report as follows. In section 2, I review design practices, studies, and discussions from the fields of Human-Computer Interaction. Section 3 introduces our proposed design solution, technical components, and rationale. Then I detail the implementation and testing of the application in section 4. Section 5 reports preliminary result from the usability study of the prototype.

2. Literature Review

The section reviews related literature to lay the foundation for our design and discussion, both empirically and conceptually. It begins with a survey of previous work in the field of HCI that designs and evaluates technologies for communities. Then it moves to focus on designs for community building and solidarity.

2.1. Designing for Communities

A significant body of work in HCI utilizes design of technologies for communities' needs and aspirations. They usually focus on underrepresented communities characterized by various factors ranging from gender, class, race, and sexual orientation to migration, retirement, diaspora, veteran identity, and life transitions. Designing for communities means centering their practical needs, values, and aspirations in social life and trying to mitigate the problems instead of focusing on advancing technical interface or interaction design.

In the context of HCI4D, designing for the community aims to promote the people's living conditions by applying technologies informed by deep insights about the community (Thomas et al., 2008; Al-Ani, 2013). Many researchers work collaboratively with communities to ensure encompassing and addressing their needs in the design and maintenance process (Peters et al., 2014; Chopra et al., 2022). Designing with communities would be better than simply designing for communities - engaging community members in the design process produces more insights and viable solutions. While community-centered design can produce products that are beneficial to the community members, the design process itself can be a way of empowering members in the communities. Through design workshops researchers find that community-based design can engage underserved individuals in discussing community affairs such as health issues (Harrington et al., 2019). Enabling the members to propose their own community designs is similar in the effect of empowerment. This project adopts this rationale of designing technology to engage community members in discussing community affairs, strengthening their sense of community and agency.

The design effort in the work of HCI4D is in nature an intervention program, which has been reflected in terms of ethics and values by the theoretical framework of Value-Sensitive Design (VSD). VSD stresses the importance of accounting for ethical and human values of the stakeholders in the whole intervention process (Friedman et al., 2002). VSD makes explicit moral commitments to three fundamental human values: human well-being, justice, and dignity, which are analyzed in the early conceptual stage of investigation in the VSD process (Friedman & Hendry, 2019). The second stage of investigation is empirical, meaning conducting empirical studies to better understand the stakeholders' practices and relevant interactions with technologies. An important purpose of VSD manifested in many steps in the design process is the identification, elicitation, and evaluation of significant values. In general, VSD established a critical theoretical ground for considering human values in contemporary technological interventions. The methods used in this project are informed by VSD with the intention to better solicit the stakeholders' values and make the intervention culturally and socially appropriate in the context of use.

2.2. Building Communities

There is work in HCI attempts to strengthen or build the community through various technological designs. Whitney and Lipford (2011) designed a participatory sensing application where community members can broadcast information about their local environment to others so that the members become reliable to each other, strengthening their sense of community. There is also work addressing the problem indirectly through artistic representations of the community, such as community documentary film templates (Bartindale et al., 2016) and human-AI collaborative art authoring (Li et al., 2020).

However, most work does not situate in indigenous and displaced communities where the sense of community and collective memory is closely linked to their cultural identities and specific challenges (Sabie et al., 2020). Meanwhile, the effect of discussing community development plan on the sense of community is promising but not explored. More work and discussions are needed to explore such new design opportunities.

This work focuses on displaced fishing communities that have strong needs for development planning but with a scarce sense of community. This work utilizes culturally informed computing technologies to help build their sense of community and agency.

3. Proposed Design

I design an AR-based collaborative community-development planning workflow. This section introduces the preliminary design components. The workflow comprises tangible objects and an AR application running on mobile devices to visualize the development plan.

3.1. Paper Map and Markers

The tangible objects of the workflow contain a paper map and a collection of pieces of paper. The paper map is a miniature of the community map, excluding all the marks of infrastructures, buildings, and roads. It only includes the contour of the community, marks of terrain, and marks of adjacent areas. All the design work is completed on the paper map using paper markers.

The markers are pieces of paper differing in colors, sizes, and shapes. Each type of marker represents one type of building or infrastructure of the community, including the harbor, grocery store, restaurant, residential building, playground, and landfill. The sizes and shapes of the markers are identical to the actual shapes of the buildings they represent. The color is for easy distinguishment and recognition for the AR application.

The users can place the markers on the paper map and arrange them to form their development plan. They can also draw lines using pencils on the paper map to indicate roads in the community. The paper map and the markers have orientation, meaning the buildings they represent are facing in specific directions.

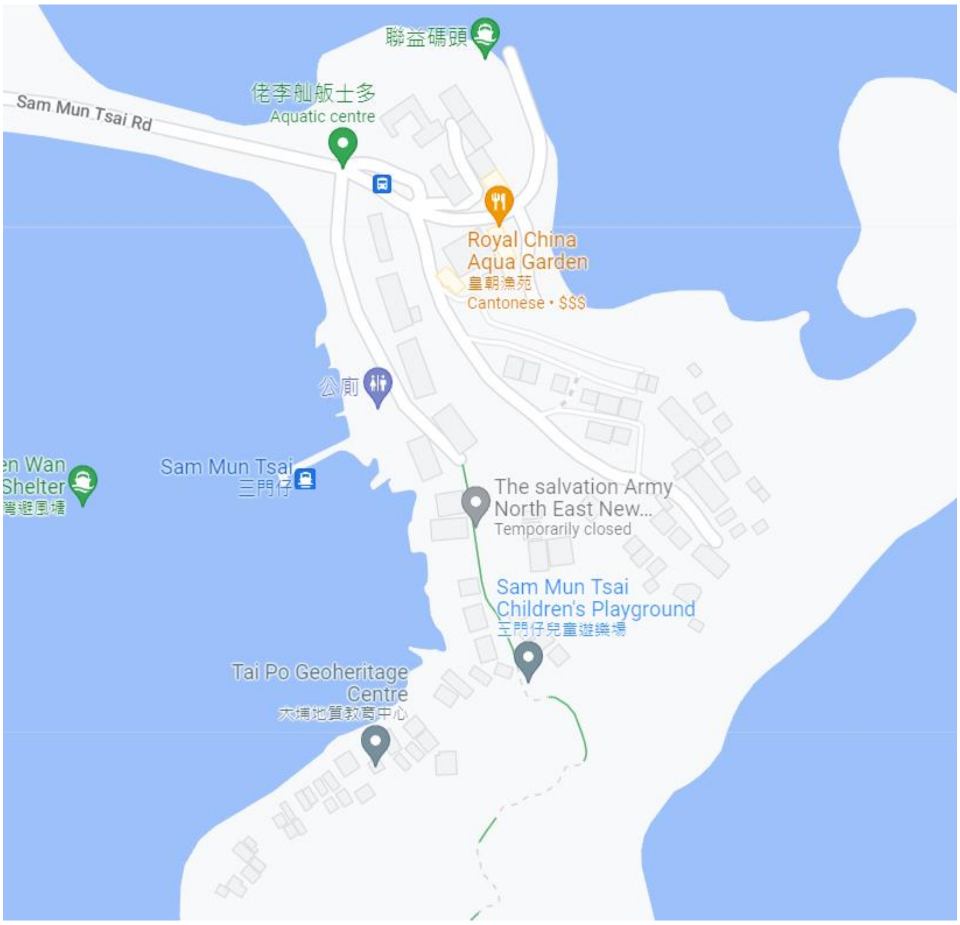

Figure 1. Example of Community Map. The paper map excludes all the marks above and allows users to design a development plan from scratch.

3.2. Mobile Augmented Reality Application

Track images & render models

An augmented reality application (supporting Android and IOS) is developed to visualize the development plan on the paper map. In the design stage, it detects multiple markers and pencil lines on the paper map and renders 3D virtual buildings, infrastructures, and roads with certain orientations on the device's screen. The users can try and modify their designs on the paper map at any time during the design process.

Save the plan to local files

When the users finalize their development plan on the paper map, they can save the design on the mobile device by taking a photo of the paper map and using the *Save* function of the AR application. The application then converts the design on the paper map to an ad-hoc format for storing the design data on the device. The users may also title the design and provide a brief description.

Share via Bluetooth and load from local files

To facilitate discussion among community members, the application also supports sharing designs among the users. After a user stores a design on the mobile device, he/she can share it with others using Bluetooth. The sharing process is completed in the application, and no separate file-sharing through the system function is required, making the sharing convenient. The application does not use a host server for sharing the designs among users because the sharing happens at a close distance where Bluetooth is more appropriate and feasible.

Showcase
The users can not only view others' designs on the mobile device but also in the real environment with a showcase marker. The showcase marker is a piece of paper with a pre-defined pattern and will be placed on any flat surface in the environment. The AR application will detect the showcase marker and render the selected development plan. The size of the development plan is also adjustable to fit in the real environment.

4. Methodology and Implementation

4.1. Implementation

The application consists of four modules handling the major use cases of this mobile application: (1) *Tracking and rendering* module, (2) *Saving* module, (3) *Bluetooth communication* module, and (4) *Showcase* module. A class diagram (Figure 2) shows the relations between these modules.

The *Tracking and rendering* module (*PlaceTrackedModels* class) is responsible for tracking target image patterns in the environment and rendering corresponding 3D virtual objects onto the mobile screen. The targeted image patterns are wrapped by the *ReferenceImage* class, which provides helper functions such as resizing and renaming. These wrapped images are referenced by the *ARTrackedImageManager* class (implemented by the Unity's AR Foundation Library[1]) while the references to 3D objects to be rendered are stored in the *PlaceTrackedModels* class. The *OnTrackedImagesChanged* function inside the *PlaceTrackedModels* class is executed when the target image patterns change in terms of existence, positions, and orientations. It accepts an instance of the *ARTrackedImagesChangedEventArg* class that contains information of the change event and re-renders the virtual objects to align with changes in the environment. The module also supports resizing the rendered objects.

The *Saving* module (*SavePlan* class) is used to save the design plan as a local file with a specific format that can be read and restored in the showcasing use case. The plan file stores data about the positions and three-dimensional orientations of all the rendered objects relative to the base plane in the scene, i.e., the horizontal plane where the paper map situates. This module formats the data into a JSON string and write to the local file system.

The *Bluetooth communication* module (*BlueToothCom* class) becomes activated whenever the user wants to share the plan file with others. It handles all operations regarding Bluetooth connection and file sending and receiving. For testing this module, I first conduct unit tests: set test cases for all the Bluetooth functions and try to maximize the testing coverage. Then I conduct integration test with the file system.

The *Showcase* module loads a plan file from the local file system and renders it relative to the showcase marker placed in a real environment. It tracks the position and orientation of the marker and renders virtual objects based on the plan file that consists of relative positions and orientations. The module also supports resizing and rotating the rendered plan. Similar to the *Tracking and rendering* module, unit tests are first conducted, and integration tests with associated classes are followed.

[1] Unity AR Foundation: https://unity.com/unity/features/arfoundation

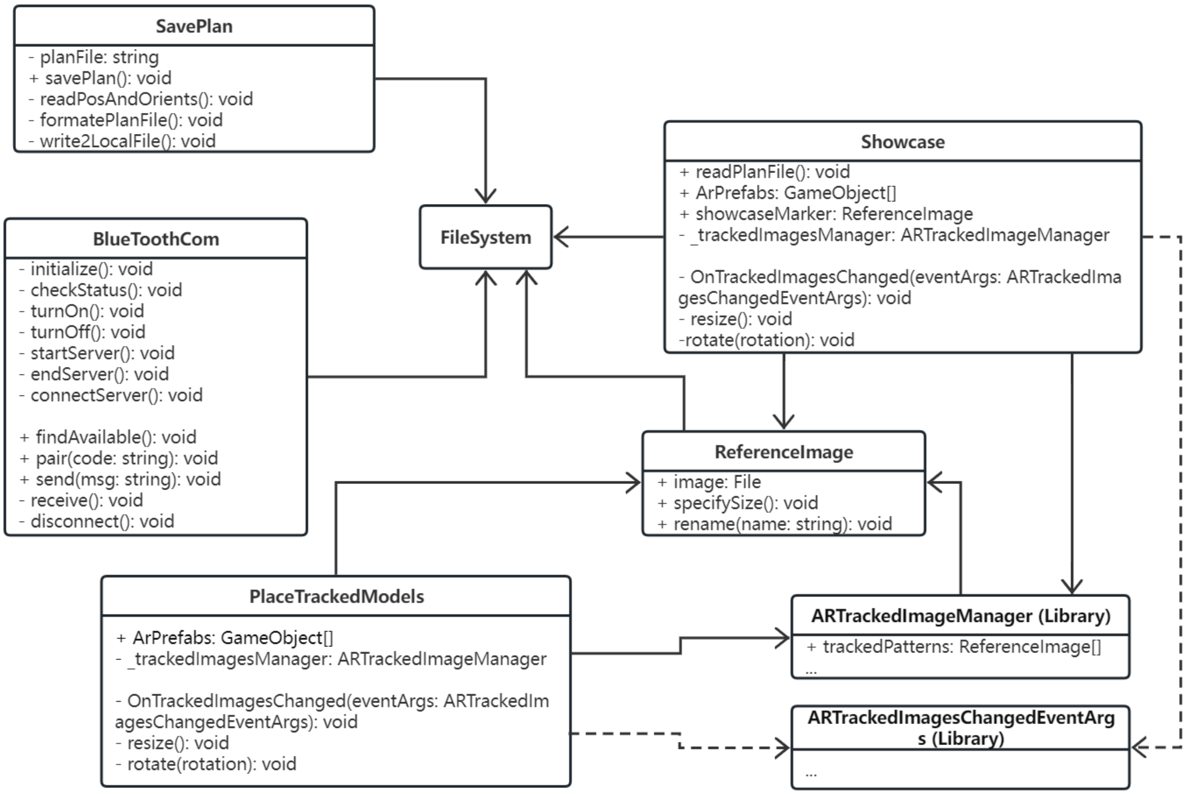

Figure 2. Class diagram of the major functioning classes.

4.2. Testing

When the major functions are implemented, I first conduct preliminary semi-structured interviews with four potential users to find usability issues in the early stage and correct them in a following iteration. After two iterations, a new iteration does not raise new unsolved issues, after which I conduct unit tests for each functional module. Then I proceed to integration and system testing, during which I also check compatibility across different mobile operating systems, i.e., Android and IOS. In the end, I conduct user tests to study the users' experiences.

For the user test, I first invite participants of various occupations and roles in the community to individually use the designed workflow, during and after which I seek their comments about usability issues by asking them to think aloud and participate in interviews. Their initial designs are saved in photos properly for later use. After collecting the feedback about usability, I identify and address those issues reported by the users and iterate the application once. Next, I invite users to a workshop to share their development plans and discuss them with others. They first view others' designs through the Bluetooth sharing function. Then, they discuss others' designs and collaboratively propose another design using the AR-based workflow. I moderate the workshop and record the group's interactions and thoughts through recording videos. When it finishes, I host a post-use focus group activity, to ask questions about user experience and thoughts related to community building. In the end, I analyze the record of discussion, collaborative design, and the focus group using open coding and thematic analysis.

5. Preliminary Result and Future Improvement

5.1. Usability Test Result of the Prototype

Coding and thematically analyzing the usability interview transcript, I found rare to no issues regarding reading the text and interacting with the interface on mobile devices. There was no inconsistency between the users' intention of interacting with the interface and the actual execution in the menu and other plain 2D scenes. Also, the users felt little discomfort or dizziness when using the application and were comfortable with the camera field of view (FOV) in the AR scene.

Users reported the need for clearer and more explicit instructions within the application about interactions and available functions. Three out of four of the users expressed the application's deficiency in efficiently detecting the roads they drew by pencils on the paper map and the unnatural appearance of the rendered roads (rendered by interconnected short sections of road and thus with seams around the connections). Moreover, several bugs in the Bluetooth module were reported by the users as well. They found issues about how the connection status would be falsely changed or remained by accidental alternative operations.

5.2. Future Improvement

- Set initial instruction on how to navigate the view and manipulate the virtual buildings.
- Difficulties of detecting the roads drew by pencils and rendering objects on them.
- Fix the bugs about the Bluetooth function, e.g., not updated connection status when aborted in the middle of connection.

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Monthly Log

October:
- I drafted the interim report of my project, which includes introduction and literature review.
- I visited the fishing community in person and searched for literature to know their challenges initially.
- I contacted the NGO serving for the community to seek possible coordination and support.

November:
- Searched for AR and Bluetooth developemnt techniques.
- Reviewed literature.

December:
- Design technical solutions
- Implementation

January:
- Implementation and test of prototype
- Revision of report