(Re)Constructing the Bukit Brown Cemetery using Augmented Reality

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Abstract

With growing interest in the discipline of computing in the cultural context, there is a need to consider both pragmatic and theoretical questions and frameworks. We report a case study from Singapore, where tensions run high amongst civil society heritage groups, conservationists, and heritage enthusiasts on the need to remove part of an old Chinese cemetery, Bukit Brown Cemetery, to give way to a new highway. The case presents a compelling need for computing intervention, in the form of an augmented reality system. The system serves two purposes: to preserve and document important information about each tombstone in Bukit Brown Cemetery, and to potentially facilitate user engagement with the heritage value of the cemetery as they visit. Two types of novelty are discussed within the paper: technical innovation in using natural feature information as a basis for tracking objects in the cemetery, and the design of the system as informed by cultural practices.

Introduction

> "To give us a sense of what could be developed in the Bukit Brown area - it can house 15,000 homes for around 50,000 residents; roughly 40% the number of homes in Toa Payoh town. These are homes for many many Singaporeans. This is not meant to trivialise the heritage value of Bukit Brown Cemetery, which I truly appreciate, but to put on the table the choices we have to make."
> *Minister of State for National Development, Tan Chuan Jin on his reflections of Bukit Brown Cemetery posted on his Facebook Community account on 3 February 2012.*

'The Bukit Brown area' refers to the Bukit Brown Cemetery, recognized by local conservationists as a distinct area of cultural and ecological value. In 2011, plans were announced by the Singapore Government to build an eight-lane carriageway across the cemetery to handle the increasing volume of traffic to the area. Since this announcement, civil societies and citizens alike have made use of both traditional and new media to create greater awareness of the significance of the area, at times, in the hope of reversing the development of the area. So why is Bukit Brown Cemetery so significant? Other than the natural heritage value of the flora and fauna to be found in the area, it is one of the oldest Chinese cemeteries in Singapore, and also the burial site for many well-known pioneers of Singapore, from ambassadors, scholars, philanthropists to businessmen.

The somewhat poignant reflection by the Minister of State for National Development in Singapore is perhaps best understood in the context of inevitable transformations in societies confronted by modernity. Giddens (1990, p. 1) described modernity as 'modes of social life or organisation which emerged in Europe from about the seventeenth century onwards and which subsequently became more or less worldwide in their influence'. In this context, Giddens differentiates between traditional

and modern cultural societies. In traditional societies, individuals are guided and sanctioned by social institutions and shared cultural norms. In modern societies however, the availability and flexibility of individual choices is more apparent as individuals are no longer as guided by precedents. In other words, modernised societies are more reflexive, bringing to limelight a particular tension between individual choices and established policies in place to guide decisions on issues as the Bukit Brown Cemetery (thereafter referred to as BBC). Such modernized societies are expected to undergo both extensional and intensional forms of transformations.

In the context of BBC, globalising influences in driving the urgency for urban development, and the availability of information and communication technologies in enabling and making dialogical communication possible present extensional transformations. On the other hand, the everyday practices of individuals, even as they make choices concerning their engagement with the significance and issue of BBC – make up intensional transformations. These two types of transformations are important to provide a theoretical context to the notion of what we refer to as a cultural system, in this paper. We will revisit these concepts again in subsequent discussions.

Related work

Computing and digital media technologies are transforming the daily experience of life. Society has gradually shifted towards an all-digital culture. There has been a transformation in the way people create experience, share and pass media on to future generations after death. We are close to that age where advances in digital capture and storage technologies make possible the archival of one's entire life experiences (Kelly & Jones, 2007), and also mediate how people make sense of their own legacies as well as those that have departed.

The obvious consensus might be that technologies aid in the preservation of memories and these digital memories have undoubtedly revised the bereaved's methods of personal remembrances. To a certain extent, digital memories have changed the way memory is produced. Indeed, memory, as of itself, is not an independent entity, it is intricately multifaceted, inter disciplinary in concepts and dynamic in nature (Dijck, 2007). However, the bereaved may experience difficulties in preserving the essence and significance of their memories of their loved ones in digital representations of inherited physical objects.

The role of technology and other meaningful digital artefacts in the bereavement and remembering process of the dead has become an increasingly relevant issue to HCI research, till recently little was known about how bereaved families use technology to cope with their losses and to remember the dead. Recent studies have explored how the bereaved are using technologies to cope with the death of a loved one (Massimi & Baecker, 2010; Odom et al, 2010). For example, Massimi and Baecker (2010) proposed three major dimensions for the use of technology; how the personal technologies were inherited, what properties made technologies possible/impossible to inherit and how the bereaved shift their technology use.

In the context of BBC, symbolic significance extends far beyond the bereaved and families, as memories of those who are buried in the cemetery also represent a meaningful aspect of Singapore's heritage and connections with China and prominent historical figures such as Confucius and Sun Yat Sen's revolutionary efforts in China. None of the previous work has also examined how cultural and natural aspects of sites of remembrance (such as cemeteries) may also influence design.

Culture and computing: Approach to our analysis

The definitions of culture are so wide-ranging and coming from various disciplines, that coming up with an explicit and widely accepted definition is almost impossible. But this has to do with the context that is inseparable from the concept of culture. But we begin from a literal translation. 'Culture' originated in Latin, cultura, which means 'to cultivate' (Edirisinghe et al, 2011). The literal translation is also consistent with the use of the word in Giddens' structuration theory, which described cultural context as generated and regenerated through the interplay of action and structure. In other words, the cumulative effect of people's living and working within social frameworks is the production and reproduction of culture. Social practices thus form the basis and "root of the constitution of both subject and social object" (1984, p. xxii). To Schatzki (1996), social practices provide the construction of human coexistence, in the sense that individual lives are "interrelated within and through practices" (p. 14). Culture is therefore intricately associated with everyday social practices, and that is the object of analysis for us in the analysis of culture.

On the other hand, the study of social systems typically involves two broad traditions of assumptions: social reality as subjective or objective (Orlikowoski and Robey, 1991). This opposition in theory is reflected in the assumption of social systems (of which computing technologies are a part of) as the result of "meaningful human behaviour", representing social realities as subjective; while the other focuses on the organisational aspects of social systems, independent of and constraining human actions, representing social realities as being objective (Bhaskar, c.f. Orlikowoski and Robey, 1991).

Research assuming the subjectivity of social systems focuses on subjective human experiences, interpretation of them, and elements of human behaviour modifying the world. The contrasting view of objectivism focuses on the properties of institutional elements shaping social systems, providing explanations for their influences on human actions and relationships.

This seemingly dichotomous view of social systems is problematic. In focusing on objectivity and the functionalist view of social systems, scholars face difficulties in defining the totality of social reality. On the other hand, the interpretivist view focusing on the subjectivity of human actions may also be limiting. To clarify the problem, Giddens (1979) asserted that the grounds of mutual exclusiveness between functionalism and interpretivism is flawed, and developed the theory of structuration to accommodate the two traditions. Structuration theory views the subjectivity and objectivity of social realities as equally important. Social frameworks both support and constrain the endeavours of individuals, communities and societies. This is also referred to as the duality of structure (Giddens, 1984), seeing that institutional properties of social systems are created by human actions, and in turn shape future actions.

By the reasoning that cultural practices are shaped by, and shape social systems, it is therefore imperative that we see 'computing' a systemic agent in facilitating both extensional and intensional transformations. As an infrastructure and making international connectivity and interactions possible, it prompts extensional transformations with increased velocity. As interactive systems for individuals, it facilies intensional transformations as individuals use such systems to interact with information and cultural artefacts in their natural environments.

In simple terms this implies that we need to understand 'computing' inherently as a part of culture – in both shaping, and are shaped by cultural practices. This point is of essential importance in our

context, as it leads us to reason that the sustainability of technologies in use are thus dependent, and how well they are integrated with cultural practices. Likewise, the sustainability of practices, even though they may be changed or somewhat altered by the technologies in use may be highly dependent on the sustainability of technologies facilitating them. For example, social media tools such as Facebook facilitate and enable certain interactions between individuals who may be otherwise disconnected. Should the existence of Facebook be threatened, such groups and perhaps how they share music or other crafts becomes vulnerable.

(Re)Constructing Bukit Brown using Augmented Reality (AR)

The tension arising from the need to preserve the heritage and cultural value of BBC confronted by growing urbanisation and developmental needs presents a compelling case for computing intervention. Firstly, there is much urgency to document information and cultural aspects of BBC, such as the unique typologies of the design of the graveyards, aesthetic and symbolic features of each tombstone, and the historical backgrounds of famous figures. Secondly, an interactive system would also provide an opportunity for individuals to engage with the information and cultural aspects documented and with each other within the system. In a direct way, the system will also facilitate intensional transformations as they make choices with regards to heritage engagement and cultural association. Currently, enthusiastic individuals and civil society groups are already undertaking this endeavor using social media tools such as Facebook and blogs (see figure 1 for an example).

However, such tools cannot and do not capture contextual cultural aspects of the cemetery. Nor are they designed to document important historical and cultural information. Although they can somewhat facilitate individual engagement with the heritage value of the cemetery, this is not done directly in the context of cultural information. As such, they are therefore insufficient to suffice as computing interventions, which we refer to as cultural systems in our paper. It is with this background and motivation that we began the design of our system.
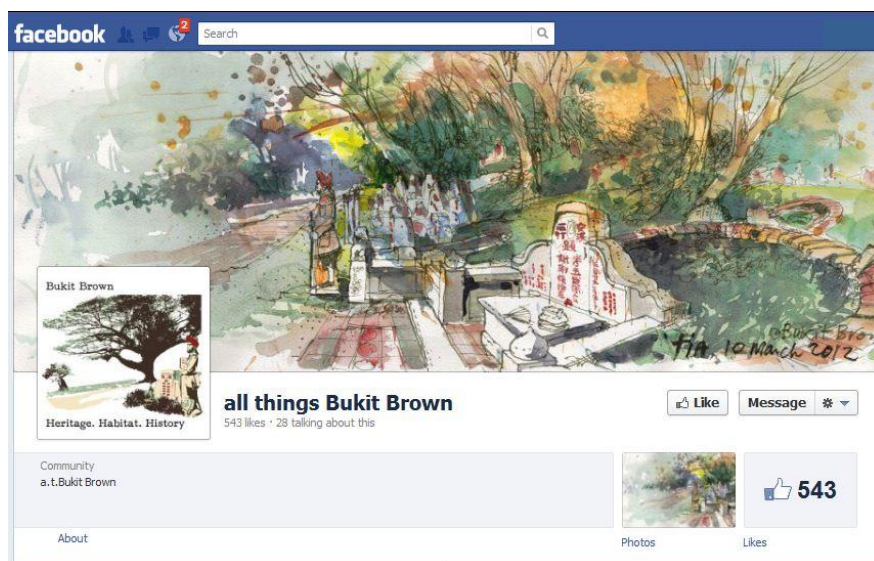
Figure 1: An example of a Facebook group to facilitate heritage engagement:
A type of intensional transformation

In recent years, the commonly conceptualised definition of augmented reality (AR) has incorporated Azuma's (Azuma, 1997) three characteristics. These characteristics assert that AR: combines the real and the virtual, is interactive and real time, and is registered in 3D. In this definition, mobile AR (Wagner and Schmalstieg, 2009) can be understood as an interaction technique for situated visualization of information. Given the potential of mobile AR to enable individuals to interact with physical artefacts in a rich and interactive media environment, we began exploring the use of mobile AR to develop a cultural system for BBC. The primary goals of this system were simple: to provide a navigational tool for visitors to BBC to find landmarks of significance, and at the same time, preserve important cultural content within the system to contribute to a meaningful engagement and interaction via the system.

A visit to BBC revealed a number of peculiarities of the cultural environment and practices surrounding. The first is an essential need to leave the environment untouched, even if digitally. The tombstones are very personal to their descendent families, and there are also many superstitions and rituals associated with them. For example, moving a tombstone to face one direction or the other may favour the 'luck' of a certain descendent. This also meant that using markers and other methods which required us to place certain modifications to the place to help with visual tracking was out of the question since it will violate the cultural beliefs and practices of the Chinese community. Because of the beliefs and practices around BBC, we also wanted to construct each graveyard in the AR system as close as possible to their natural appearances.

To do this we used the natural feature tracking technique (Neumann and You, 1999) instead of commonly used marker-based tracking (Zhang et al, 2002), which does not require any modifications to the physical place. This method would recognize specific landmarks using natural features of the place. Given that each tombstone is inscribed with a unique set of Chinese characters bearing the title(s), name, year deceased, and the names of their surviving children and grandchildren, we used them as the basis for visual recognition.

The natural feature tracking method entails collecting and storing natural feature information within the system, and such information are later used to track objects. As a first step we had to capture images of every tomb that needed to be tracked. Thereafter, feature information is extracted and stored locally in the system. Two types of natural features information were collected: unique inscriptions on the tombstone, and the unique design features of the whole grave. Figure 2 provides an illustration.

In this way the natural features of BBC can be reconstructed digitally using AR. Other than the advantage of eliminating the need to do physical modifications to each grave, the method also makes it possible to locate each grave even when a grave is partially visible. This is not possible in other tracking techniques like marker based tracking.
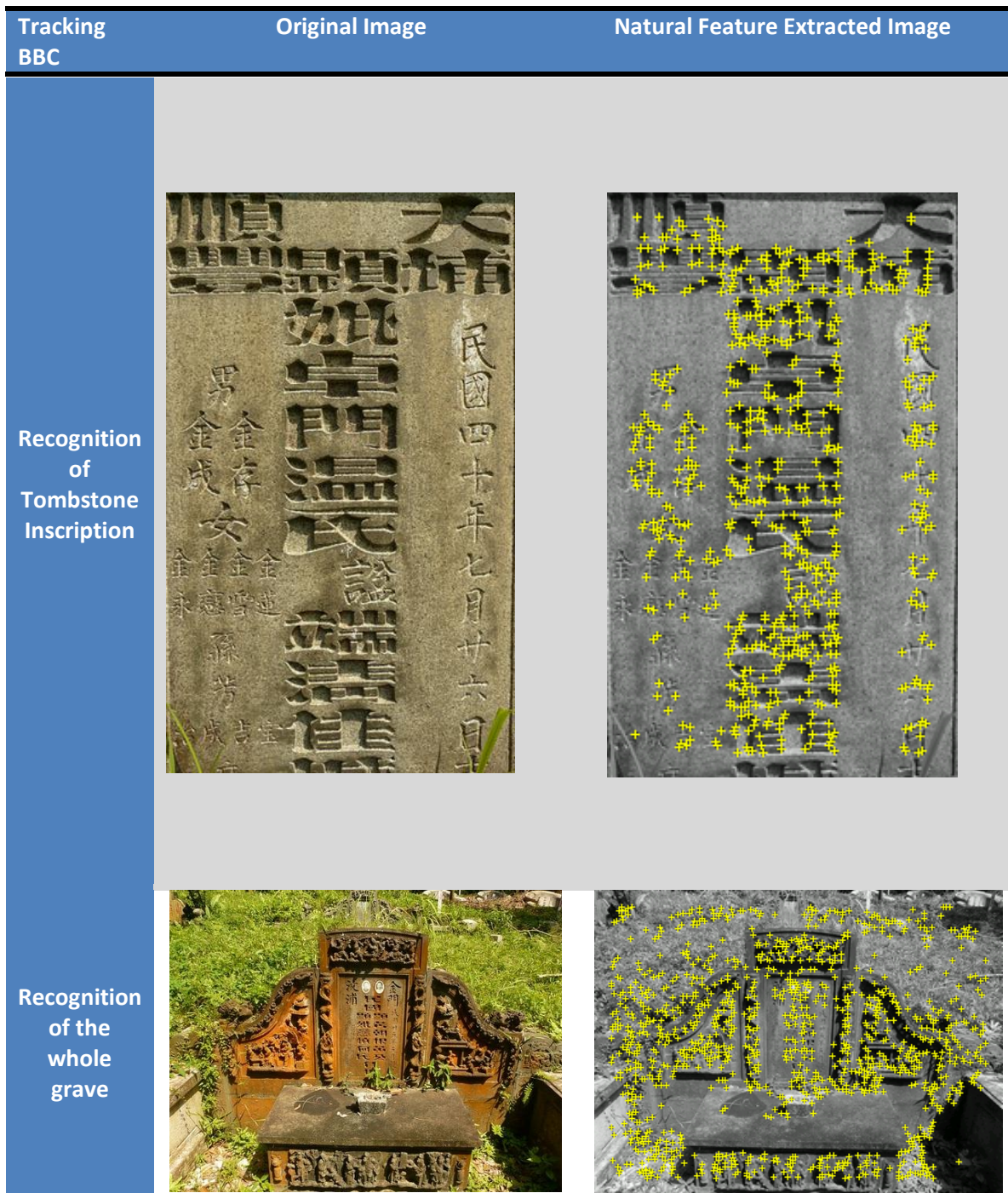
Tracking BBC	Original Image	Natural Feature Extracted Image
Recognition of Tombstone Inscription		
Recognition of the whole grave		

Figure 2: Feature extraction: Grave description (top-right) and Complete Grave (bottom-right)

The BBC cultural system currently runs on android platform. Natural features of graves and accompanying cultural content are stored locally in mobile phones. The mobile system extracts frames from the camera in real-time and compares with the natural feature database in order to recognize particular graves. Vuforia sdk from qualcomm[1] was used for natural feature tracking and Android SDK was used for 2D and 3D rendering[2]. The system architecture is depicted in figure 3.

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[1] http://www.qualcomm.com/solutions/augmented-reality

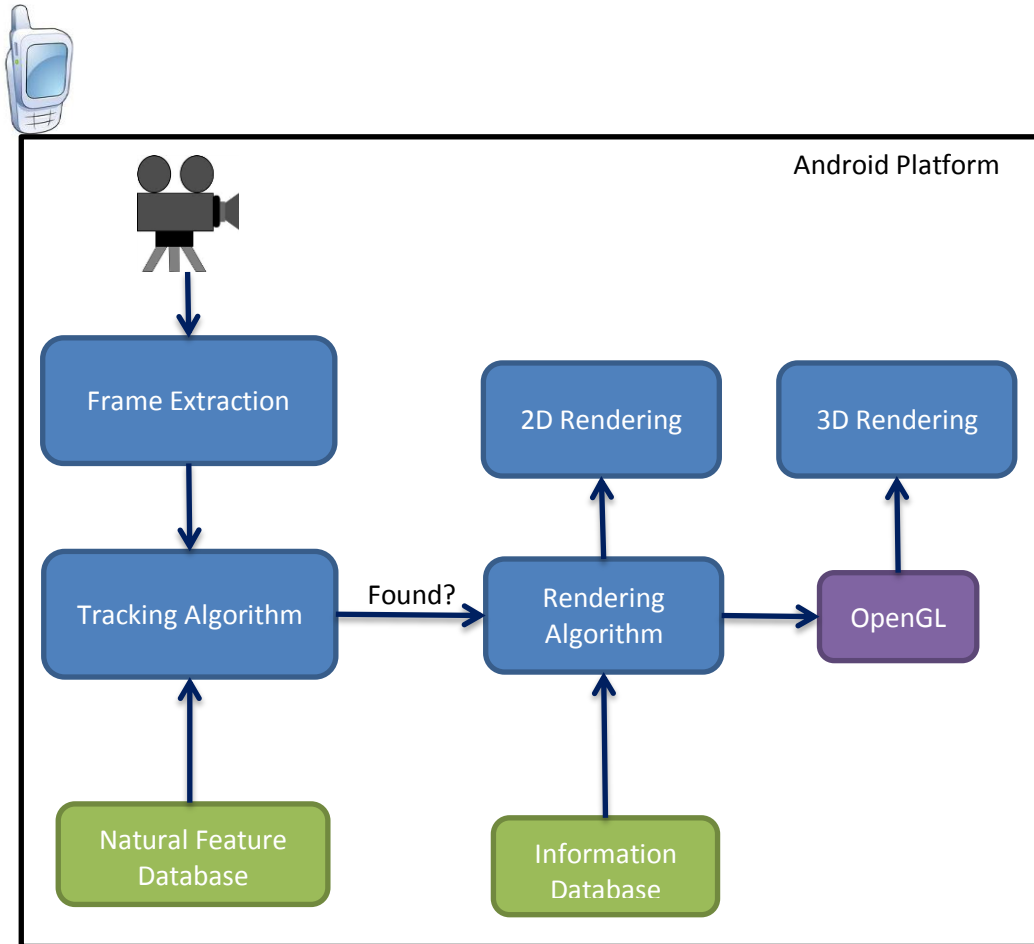[2] http://developer.android.com/sdk/index.html

Figure 3: System Architecture

The BBC cultural system is developed in tandem with an ongoing documentation project of the cemetery. In the documentation project, various information are collected: oral histories collected from caretakers and descendent families, photographs of each tomb, information about the flora and fauna in the area, video documentaries of exhumations and other rituals carried out at BBC, as well as textual historical information. As such, the system is designed to render both 2D and 3D information, to be listed as text, images, videos, 3D models, and web links.

Difference to Convergence: More than preservation

The discussion on the design of our system has so far illustrated two points. The first lies in how cultural practices and beliefs of the community around the Chinese cemetery of BBC informed our design, leading to a convincing proposition to use information from natural features as a basis for tracking specific tombstones in BBC. The second, and forms a key component of our future work, is how the system may potentially shape cultural practices in the long run. Understanding that both points are recursive and dialogical is imperative to understanding the convergence of cultural systems (such as the one mentioned in this paper) with socio-cultural practices. In other words, designing cultural systems with the socio-cultural practices in mind can shape the very same socio-

cultural practices, and in the long run, lead to sustainability of both the practices and technologies in use.

The development of our cultural system also presents immediate and long term implications. One advantage is that important information about each grave can be captured in context, together with viewing them in real-time. For example, an individual was able to read about the historical background of the person buried there, rationale and functions of certain 'guards' carved into the grave and other design aesthetics of each graveyard. This provides an enriching user experience, and collectively, also serves as a way to preserve important heritage information about BBC.

At this point, we want to raise several questions which are imminent in our minds, which should also present important issues to be discussed through further scholarly work. The first is associated with the growing body of work on the digital archival and preservation of cultural artifacts. Cultural institutions, government and international agencies, academics and technical enterprises alike have been concerned with the potential and challenges posed by digital preservation. Digital preservation, we argue, is not and should not be seen as a one-off activity, and should be an ongoing activity that is part of cultural practice. Additionally, the recognition that social systems (such as the BBC cultural system) are shaped by, and shape cultural practices (Orlikowski and Robey, 1991) suggests that the cultural system will contribute a certain trajectory of changes to the cultural practices around BBC. In other words, even as important cultural content is preserved via the system, it promotes ongoing use and accumulation of content which can come directly from users. In the long run, it provides a mechanism to ensure that digital preservation is a process rather than a one-off event.

The second and somewhat related proposition suggests that interactive cultural systems promotes and facilitates active citizenry, a long term effect which can only be observed over time. Towards this aspect, longitudinal studies tracking the impacts of how individuals use new cultural systems are of interest to us.

Future Work and Conclusion

As the system is at the first stage of development as a proof of concept, it has yet to be introduced to many users with the exception of a few key informants in the community. Immediate future work would involve a series of user studies, to understand the potential impacts and implications for users, especially in terms of how it would shape their socio-cultural practices of engaging with BBC, and visiting the graves as a ritual.

In terms of technical development, the system can potentially be optimised with terrain paging techniques to recognize a larger number of graves. The terrain of the grave yard will be paged to several pages as each page containing maximum of sixty graves. Our approach is to combine visual tracking with GPS techniques (Honkamaa et al., 2007) to create an accurate localization system. The system will be using GPS locations of the graves for such paging. The large gap in available GPS accuracy versus required accuracy for initialization can be overcome through paging techniques. Based on the GPS locations of each user, the system will load the natural feature contents and information dynamically to the system. With this technique, the system will be able to do continuous tracking which will support a larger number of graves to be tracked. Combination of GPS with vision tracking algorithms can provide a very good accuracy for navigation which enhances location-based interactions (Dow et al., 2005) at BBC.

The paper has presented a case of Bukit Brown Cemetery at the brink of partial disappearance due to the impacts of modernity. The erosion of the physical land is not the only aspect that is at risk – but more importantly, the socio-cultural practices as well as community ties. With this context, we designed and developed a system to address the imminent challenges of disappearing cultural records, and to also provide a mechanism to promote cultural engagement. We also present technical novelties that are made possible by the unique design aesthetics of the cemetery. Some future work is immediate, namely in the form of user studies and further system improvements are also relevant and of interest to us.

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