A Novel Smartphone-based Vision-Aware mHealth Framework Applied to a Breast Cancer Awareness Application

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Abstract: There is currently a growing research interest mobile health (mHealth) application development which attempts to capitalize on the exponential growth of mobile technologies for the benefit of public health. This paper presents an implementation of a novel smartphone-based development framework for prototyping vision-aware native mHealth applications, in the design and development of an mHealth educational application, 'Dibdib Advocacy App', for raising breast cancer awareness in the Philippines.

Key Words: mHealth; breast cancer awareness; application development; framework; mobile application; feature-driven development

1. INTRODUCTION

Mobile health (mHealth) is defined by the World Health Organization as “the practice of medical and public health through the usage of mobile devices” (WHO, 2011). Recently, there are over 7 billion wireless subscribers worldwide according to the International Telecommunication Union, corresponding to a penetration rate of 97 % (ITU, 2015). This scenario offers an enormous potential for positive impact especially in low- and middle income countries, leading to an increasing trend of mHealth application development. Thus, there is currently a growing research interest in developing open tools and frameworks addressing specific mHealth issues and challenges, including a complex interplay of various fields, i.e. health science, software engineering, and informatics.

Recently, many mHealth applications (apps) for smartphones have been developed and utilized by health professionals, patients, and the general public (Mosa, 2012). Some of these mHealth apps are targeted towards healthcare professionals focusing on disease diagnosis, drug reference, medical calculators, cell counting (Thurman, 2015), literature search, clinical communication, Hospital Information System (HIS) client applications, Electronic Medical Record (EMR) (Abel, 2015), medical training and general healthcare applications; for medical or nursing students and general public focusing on medical education; and for patients focusing on disease management with chronic illness, ENT-related, fall-related, and other conditions, i.e. hypertension (Mann, 2014) and electrocardiogram (ECG) monitoring (Choo2015). However, a few studies suggest that some of the current mHealth apps lack the necessary regulation (Cuenca, 2014). In fact, a number of mHealth apps have no medical expert participation during its development (Pereira-Azevedo, 2015). Furthermore, with the current surge of mHealth apps available today, it is also increasingly more difficult to determine which apps are trustworthy and effective (Shapiro, 2014). Some mHealth apps have no validation for diagnostic accuracy, utility, or safety using established research methods (Kassianos, 2015). These challenges and the lack of standard mHealth development framework make the mHealth field an open research area.

In this paper, we present the design and development of an mHealth educational application, 'Dibdib Advocacy App', for raising breast cancer awareness, developed utilizing the novel vision-aware mHealth framework in Android platform. The main goal of Diddib Advocacy App is spreading awareness and helping Filipino women fight against the breast cancer disease with information guidance and regular breast examination with tools based on the smartphone's built-in camera. Breast cancer (BC) is the most common cancer affecting women worldwide. Philippines is among the countries with highest trends in incidence of the disease, according to the GLOBOCAN research data (IARC-WHO, 2012). Majority of BC deaths occur in low- and middle-income countries, where most women are diagnosed in late stages, due mainly to lack of awareness on early detection, and barriers to health services.

This paper is organized as follows: Section 2 discusses the methodology, followed by results and discussion in Section 3. Finally, the paper is concluded in Section 4.

2. METHODOLOGY

In the development of our vision-aware native mHealth framework, we utilized one of the principal agile methodologies - Feature-Driven Development (FDD). FDD was originally introduced by Jeff De Luca and Peter Coad in their book, "Java Modeling in color with UML" (Coad, 1999), where FDD was proposed as the solution to the problem of accommodating shorter and shorter business cycles. FDD is a model-driven short-iteration process, which begins with establishing an overall domain model from consultation with domain experts, e.x. breast cancer specialists, then it continues with a series of two-week "design by feature, build by feature" (DBF-BBF) iterations (Figure 1). In particular, FDD is composed of five core processes, namely: (1) Develop an overall model; (2) Build a features list; (3) Plan by feature; (4) Design by feature; and (5) Build by feature (De Luca, 2008).

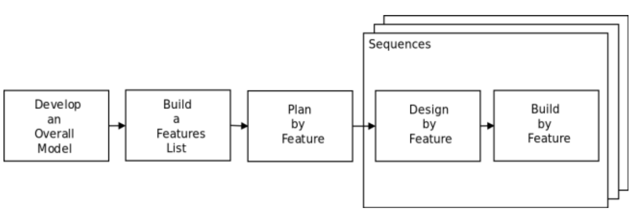


Fig. 1. FDD Methodology

3. RESULTS AND DISCUSSION

In this research, we define the term 'vision-awareness' as the capability of an mHealth application to process the smartphone's built-in camera frames, both static or image sequences, to provide any form of measurement or knowledge inference for the user, whether it is another module within the same application or other associated applications. In other words, our proposed vision-aware mHealth framework (Fig. 2) is a software abstraction middle layer that attempts to formally integrate the computer vision capability to an mHealth application giving it the capability to 'see', while considering the general requirements of an mHealth system.

A key idea in vision-aware mHealth approach is that the camera is utilized not simply for taking images or videos, but can be considered now as a sensor measuring objectively a certain parameter or property from the real-world user (or patient) scene. Among the major advantages of this approach is its ubiquity in access and non-invasiveness. With the current advancement of technology, majority of smartphones now have a built-in camera, thus, making a vision-aware mHealth approach highly accessible to many people. Furthermore, a camera-based approach is unobstrusive and simply watches the scene from a particular distance, thus, non-invasive to the user as shown in the conceptual diagram in Fig 4.

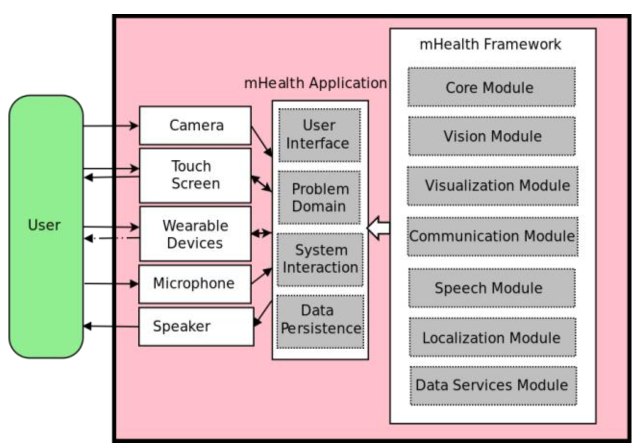


Fig. 2. Vision-aware mHealth Framework

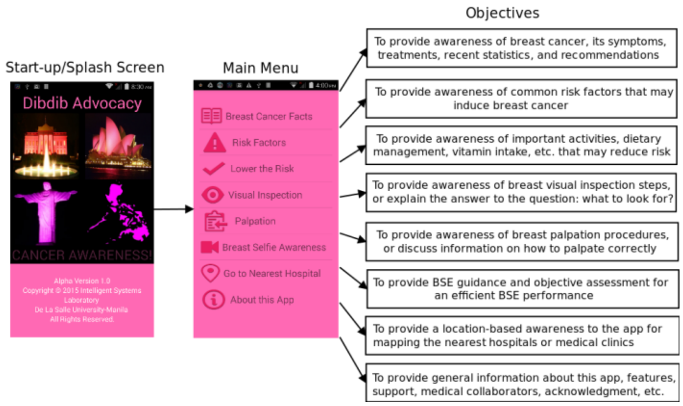


Fig. 3. Dibdib App Main menu and their corresponding Objectives

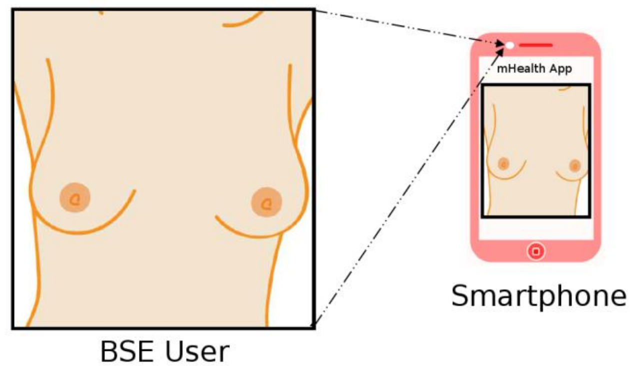
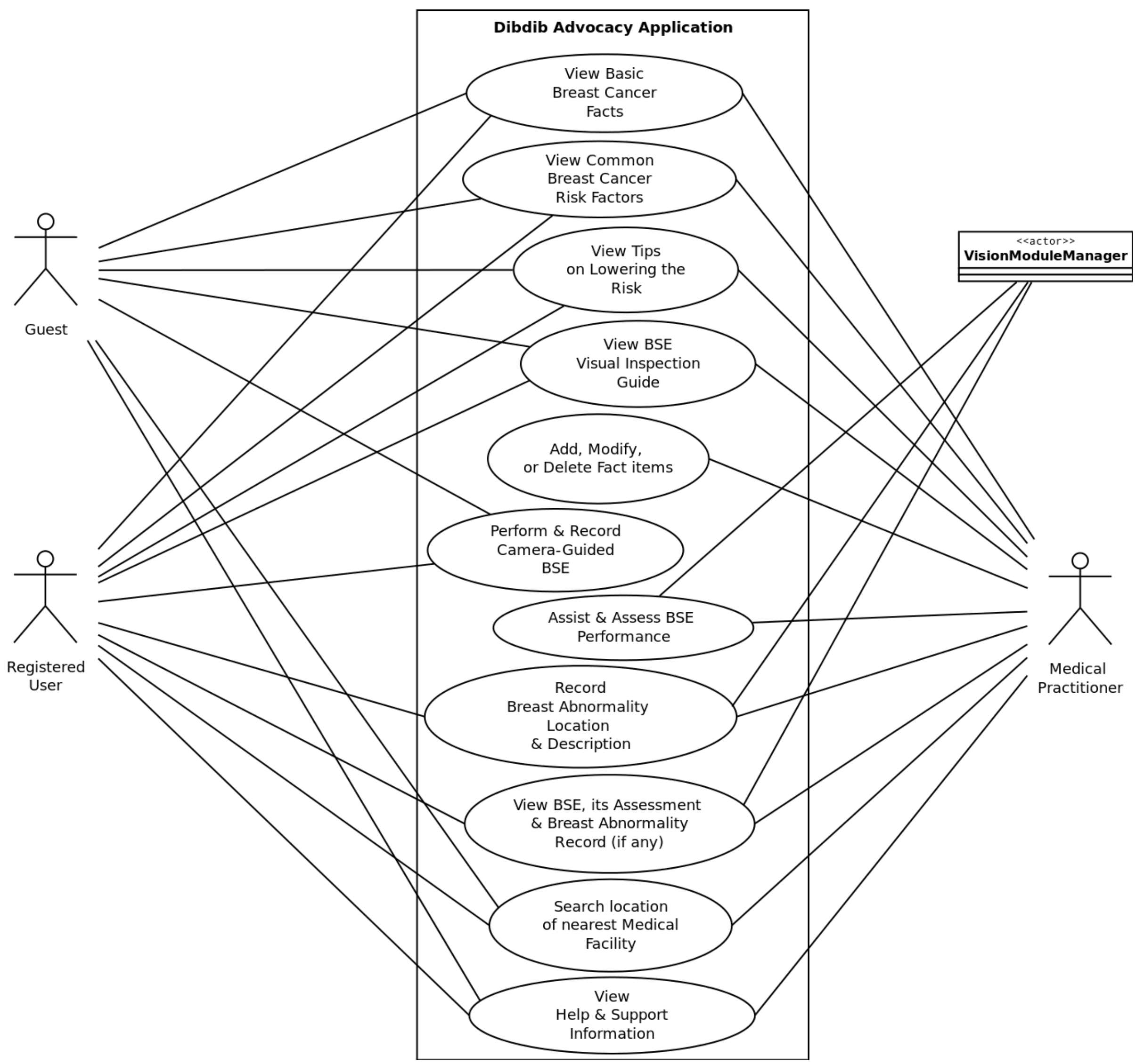


Fig. 4. BSE Guidance Conceptual Diagram

Fig. 5. Dibdib App Use Case Diagram



A prototype smartphone mHealth application called Dibdib Advocacy App or simply Dibdib App was developed utilizing our proposed vision-aware mHealth framework (Fig. 3). It should be noted however that the intended purpose of Dibdib App is generally educational or breast self-examination (BSE) user assistance rather than diagnosis of Breast cancer, cure, mitigation, treatment, nor a means of prevention. However, public education is a key first step because early detection cannot be successful if the public is unaware of the problem or has adverse misconceptions about the value of early detection (Ozmen, 2008).

Dibdib App includes basic facts, risk factors, visual inspection guide, breast palpation video demonstration supervised by a medical professional, Google Maps/Places integration, Android's Text-to-Speech API and image processing, providing a fully integrated app experience. It is available in Google's Play store and has been chosen by Google Developer Group (GDG) Philippines as among the most innovative Apps in the 1st HackFair Philippines 2015 event. (Google Developer's Group (GDG) Philippines, Hackfair 2015; http://blog.gdgph.org; accessed January 1, 2016).

Fig. 5 depicts the Use Case diagram of Dibdib App under the vision-aware mHealth Platform as a result of FDD overall model development process. A use case is an activity the system carries out to accomplish some goal of the user of the system (Satzinger, 2012). Firstly, the principal actors of the Dibdib App system where identified as guest, registered user, medical practitioner, and vision module manager. Secondly, the goals or tasks performed by each actor towards the system were determined. A Registered user role can perform almost all functionalities of the system, i.e. view Fact items consisting of basic breast cancer facts, common risk factors, tips on lowering the risk, and BSE visual inspection guide; perform and record camera-guided BSE; record breast abnormality location & description; view BSE & its assessment with breast abnormality record (if any); search & map location of nearest medical facility; and view help & support information. However, the user cannot add, modify, or delete Fact items, nor assess the BSE performance which will be done by the Medical practitioner role or the Vision module. The Medical practitioner role can execute almost all capabilities of the user except the performance & recording of camera-guided BSE. The Guest role also has capabilities similar to the User except the recording of breast abnormality location, and description. Finally, the Vision module role (non-human actor) is to assist & assess BSE performance, record breast abnormality location & description, and view BSE & its assessment with breast abnormality record (if any).

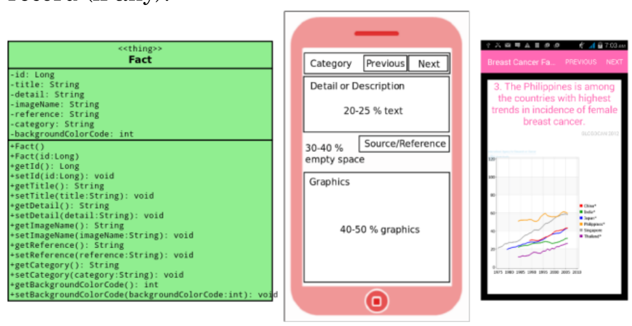


Fig. 7. Fact UML Class diagram (left), Fact detail activity design (middle), and its actual implementation in Dibdib App (right)

In poster design, the International Association of Clinical Research Nurses (IACRN) suggests a balance black and white spaces consisting of 20-25 % text, 40-50 % graphics, and 30-40 % empty space (IACRN, 2011). Following a similar approach, the Dibdib app fact-based detail presentation activity was designed as shown in the middle of Fig. 7, and implemented in the rightmost screencapture. Core Module Management is responsible for the Fact detail activity presentation, in which, it utilizes a ViewPager object to present the Fact objects in a simple swipe view. Furthermore, the Data Services Module is responsible for management and persistence of Fact objects. The Data Services Module uses a SQLite database for persistent storage and query of Fact objects during start-up of the application to populate the top-level menu titles, and detail activity items.

For breast detection, we employed the widely known Viola and Jones algorithm (Viola, 2001) in Open Computer Vision (OpenCV), which is an open-source and highly-efficient library for computer vision. The dataset B1000 utilized in the algorithm development is composed of 1120 frontal breast images, which is an augmentation of datasets from (Eman, 2014; Masilang, 2014; Jose, 2015); and T100 testing images composed of 100 selected image frames from BSE videos produced under CHED-PHERNet Breast Cancer Research Project. In B1000 dataset, there are 2072 ground truth values, comprised of the bounding boxes for the left and right breasts, annotated using the standard annotation tool that comes with OpenCV. Consequently, the ground truth values (positive) were parsed into the OpenCV data vector, then, applied to OpenCV cascade classification training tool which produces the object model in an xml file. Among the most important training parameter is the type of feature to apply, e.x. Haar wavelet or Local Binary Pattern (LBP) features. Haar wavelet-based object models are reported to provide higher accuracy but LBP features is faster in training and detection due to integer calculations instead of floating point calculations in Haar wavelet-based models (Puttemans, 2015). In Dibdib App development, we trained in both LBP and Haar wavelet-based model as shown in Figure 8. Haar wavelet-based model took more than 94 % more time than the LBP model, but with lower accuracy at 70 % while the LBP model is at about 91 % as tested on T100 dataset, a test set composed of randomly selected BSE images taken from BSE video frames.

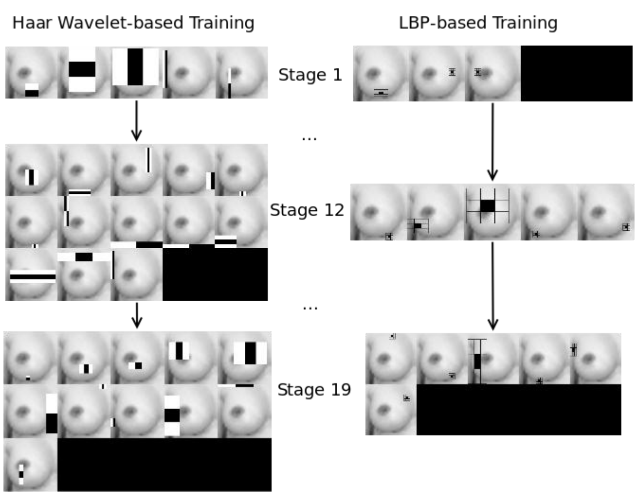


Fig. 8. Comparison between Haar wavelet-based and LBP-based cascade breast detection training

4. CONCLUSIONS

The main contributions of this paper were as follows: (1) a proposed novel smartphone-based framework for vision-aware native mHealth applications; and (2) presentation of an example prototype application, Diddib App, for breast cancer awareness, BSE guidance, and Assessment. For future research, more testing are needed i.e. Usability and App Quality assessment. Furthermore, some features were not discussed due to the limited scope of this paper.

5. ACKNOWLEDGMENTS

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