Reliable and User Friendly U.S Banknote Recognition Application for Visually Impaired Users on Android Smartphones

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ABSTRACT

This paper introduces a reliable and user-friendly Android application that helps visually impaired users recognize U.S banknotes. The application relies only on an Android Smartphone and does not require any wireless data connection or back-end infrastructure. The application is proven to be robust and reliable under various environmental conditions which differ in lighting and background conditions. The overall banknote detection accuracy is over 94% in any lighting conditions (even in a dark room) or backgrounds with near real-time banknote detection time of 7 seconds. The main contribution of this paper is the use of a robust and reliable computer vision algorithm on the Android platform combined with a friendly “vision free” user interface.

Keywords: Android Application, Banknotes, Computer Vision, Technical Aid, Visually Impaired

INTRODUCTION

World Health Organization (WHO) approximates that there are 285 million visually impaired people worldwide (“World Health Organization Media Centre: Visual impaired and blindness”, 2013). Visually impaired people have been severely affected by losing the visual world, fact that can impede their daily lives. One particular problem they face is that they cannot distinguish between different U.S banknote denominations that have identical shape and size and no tactile features. According to the American Foundation for the Blind (“America Foundation for the Blind Keeping Track of Money”, 2013), one approach for the visually impaired to solve this problem is to fold the banknotes in different ways when they place the bills in their wallet. A $1 bill can be left unfolded, a $5 bill can be folded...
crosswise, and a $10 bill can be folded lengthwise and so on. This method works, but it relies on assistance and honesty of other people. There are a number of solutions for foreign banknote recognition as detailed in the next section. Most of these solutions (Hinwood, Preston, Suaning & Lovell, 2006; Mohamed, Ishak & Buniyamin, 2012; Sirikham, Chiracharit & Chamnongthai, 2009; Solymar, Stubendek, Radvanyi & Karacs, 2011) rely on special purpose devices which are expensive.

With the development of computer vision algorithms and increasing computing power of Smartphones with embedded accessibility features, it becomes possible to combine both technologies to help visually-impaired people recognize US banknotes. By leveraging these technologies, we developed an application, the Money Reader, that enables the visually impaired to independently and effectively recognize U.S banknotes just by using a Smartphone. To the best of our knowledge this is the first visually impaired accessible U.S banknote application on an Android platform which has been published in the literature.

According to the statistical data from the International Data Corporation Worldwide Quarterly Mobile Phone Tracker (“Worldwide Quarterly Mobile Phone Tracker”, 2013), Android is the top operating system in U.S and even globally for new smartphones sold in 2013. The market share in U.S rises to 81%. Many Android based applications for e-health have been developed and tested for usability (García-Gómez et al., 2014; Rodrigues, Pedro, Vardasca, de la Torre-Diez & Martins, 2013; Silva, Rodrigues, Lopes, Machado & Zhou, 2013; Rodrigues, Lopes, Silva & de la Torre-Diez, 2013).

In addition, Android platform has integrated accessibility features for the visually impaired population. For users with myopia which encounter challenges reading small print, Android accessibility settings enable the ‘Show Magnifier’ function which enlarges the font. Furthermore, Android allows users to use voice to control and interact with their Smartphones. The users can launch apps, make calls, write text messages and even take pictures with their voice. Also, Android integrated a virtual assistant that interacts with the user using voice commands (“Google Accessibility”, 2013). Moreover, there are a number of applications that were developed for the blind user such as Eyes-Free Keyboard, Text-to-Speech Extended and etc.

In addition to the accessibility features provided in the Android platform, an additional important consideration for choosing Android is the fact it provides an open software development environment which does not impose any limitations on the application privileges. On the other hand, the iPhone platform is closed and limits the application privileges. Many technique extensions can be applied in Android like changes in the launcher, automating routine tasks, different types of voice assistants, voice commands and voice-activated applications. A detailed description of Android operating system and its advantages can be found in (“Android operating system”, 2013).

Our approach uses Speeded up Robust Features (SURF) (Bay, Ess, Tuytelaars & Gool, 2008) features to achieve real-time, high accuracy, and stable performance in various environments. First, we open the app and capture the image, and then run it through the SURF algorithm which detects the interest points that generate the unique descriptor. Second, our program will calculate the matched points from the descriptor of the captured image with the pre-calculated descriptor of reference images. The banknote with the maximum number of matched points will be the final result. At last, our app will convey the user the denomination in an audio format.

The main contribution for this paper is the implementation of a robust and reliable computer vision algorithm, SURF, on an Android platform combined with a friendly “vision free” user interface. Using our solution the visually impaired can easily recognize same-sized tactile-free U.S currency.

The paper is organized as follows. In the next section we discuss the related work. The application overview is presented in Section 3 and Section 4 introduces the banknote
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