MAVI: Mobility Assistant for Visually Impaired

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Abstract
Mobility in an outdoor environment has been always a challenge for visually impaired people. Traditional solutions like white cane or guide dogs suffer from many limitations. Many electronic aids have been developed to assist the visually impaired people with various mobility needs. However, the specification of such aids has primarily assumed a structured environment, typical of many developed nations. Unstructured infrastructures in developing countries pose unique challenges in outdoor mobility of visually impaired people. We describe these unique challenges for mobility of visually impaired, the specification of a mobility aid to address these challenges, and subsequently our efforts in developing an electronic solution towards it. This solution complements a smart cane and is named MAVI. MAVI addresses three primary areas in mobility: safety, navigation and social inclusion. We use a mix of real-time computer vision and cloud technology for its implementation.

Keywords
Mobility; visually impaired; assistive technology; computer vision; embedded systems.

Introduction
World Health Organization (WHO) fact sheet [1] states that globally 285 million people are visually impaired. 90% of this visually impaired population stays in developing countries in low income settings. Thus, low cost and affordable solutions must be developed to assist them in their mobility. Outdoor mobility for visually impaired people is important to enable an inclusive society for them. Traditional mobility aids like white cane have a very short range of detection while guide dogs are expensive to maintain. Electronic aids developed in recent past like Smartcane [2] help to improve the detection distance, but cannot support navigation and object classification. Other solutions like Microsoft's seeing AI [5] use only a cloud server to do the computations, limiting their usability in areas with limited wireless connectivity, typical of rural environment in developing countries. Various other limitations of existing aids and the needs for a developing countries are highlighted in [3]. Mobility aids proposed by Ye et al. [4], and Apostolopoulos et al. [6] are limited to an indoor environment only. However, outdoor environment present a different set of challenges than indoors. A detailed survey of various mobility aids was presented by Elmannai et al. [7]. None of these solutions address the unique needs of mobility for unstructured environments in developing countries like India.

MAVI Specifications:

Safety:

- Animal detection (cow and dog)
- Pothole detection

Navigation:

- Signboard detection and OCR
- Localization

Social Inclusion:

- Face detection and face recognition

MAVI Design Plan:

Compute: Mix of CPU, accelerators, and cloud.

Sensors: Fusion of RGB, Ultrasonic, Sound and GPS + IMU

HCI: A mix of beep, vibrate, and speech

Metrics: Accuracy, battery life, form factor, and weight

Current Prototype:

- Two prototypes based on Raspberry Pi 3B for local and cloud
- RGB camera mounted on spectacle frame
- Supports SBD, FDR, and AD
- Interface to user through speech

Based on a detailed user survey of visually impaired people, the specification of a new mobility device was proposed. The device uses intelligent computer vision techniques to identify certain objects of interest in the walking path and conveys to the user as per the chosen mode of communication. We name this device as MAVI (Mobility Assistant for Visually Impaired) [10].

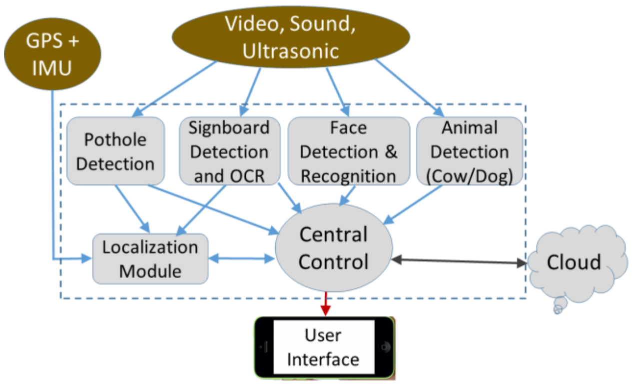

Figure 1: Block diagram of MAVI: A mixture of Video, Sound, Ultrasonic and GPS sensors is used to execute different tasks

MAVI Development

MAVI has been developed as an embedded system, using algorithms proven effective by the computer vision researchers. A major challenge has been to efficiently port these algorithms to a portable system. In view of that, we used Raspberry Pi 3B (R-Pi) [8] board as the platform along with a Pivothead wireless camera [9]. We currently support face detection and recognition (FDR), Animal detection (cow/dog) (AD) and signboard detection (SBD) and OCR in our prototype implementation. A control system is developed to capture the image from the camera and then run different tasks on the R-Pi platform. The output is conveyed to the user using a mobile phone, connected to the device using Bluetooth. The feedback can be given as speech, beep or vibrations. The Android app also provides certain control to configure the tasks which are enabled in the system.

Future Work

An initial prototype for MAVI has been developed based on state-of-the-art object detection techniques which utilize deep neural networks for detecting objects of interest. Optimization of the system to make it smarter and energy efficient is an ongoing work. We plan to conduct early user trials to seek feedback on the usability of the system and incorporate the deficiencies based on these trials.

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