Smart Mirror for Ambient Environment

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Abstract- *The purpose of this paper is to present a smart interactive mirror interface. In this paper, we describe the design and development of a futuristic mirror that offers simplified and customizable services. This thesis explores enhancing such mirrors with intelligence. The goal is to develop a user recognition system that is able to differentiate between the users of the system by using a camera hidden behind a two-way mirror. The Raspberry Pi(RPI) will be used as the embedded computational device for the intelligent mirror. This paper dictates the outline and improvement of a smart mirror that represents an interface for looking data for different individuals in a home situation.*

Keywords- Raspberry pi, IoT, Mobile Computing, OenCV

I. INTRODUCTION

A smart mirror is a mirror that has been enhanced by technology. It is a very simple concept that is illustrated in the given figure. A screen is placed behind a two-way mirror. By using a black and white graphical user interface (GUI) only the white colors will penetrate the mirror, resulting in an effect that makes it appear as if the mirror itself is a screen. The idea of an intelligent mirror is to further this enhancement to include artificial intelligence as well. The ideas as to what an intelligent mirror could encompass is vast. It could encompass anything related to intelligence. It could be a mirror that recognizes people, talk to people, learns a person's habits, it could be used as a component in activity recognition as part of a smart home. Or as it is ultimately a tool used by people to see their own reflection - it could be used to analyze the emotions of the person in question. This could further be used as input for a machine learning algorithm to predict the person's current level of happiness. Or even monitor his emotions over an extended period of time to detect mental illnesses. Because a mirror is naturally used by most people at least twice a day (morning and night), it would be able to continuously monitor people's faces without requiring any explicit input. The major advances done in the fields of computer vision in recent years makes the acts of facial recognition easily available to any software developer through frameworks. The aim is to build an intelligent mirror that can recognize people and use this to tailor the experience for each individual user. In this iteration of the project the goal is to create a user recognition system that will show a different user interface for each user. The Raspberry Pi will be used as an embedded device to capture video from a camera hidden behind the mirror. Further we will explore if it is possible to build a user recognition system that can run at a satisfactory level on the RPI.

II. LITERATURE SURVEY

Fit Mirror

Daniel Besserer et al. (2016) created a smart mirror for adding interactive fitness exercises to a person's morning routine. Their project utilizes the Microsoft Kinect v2 for tracking gestures and a Wii Balance Board for presence detection.

Interactive Mirror for Smart Home

Chidambaram Sethukkarasi et al. (2016) created an intelligent mirror that identifies users based on facial recognition, recognizes emotions, records health parameters and gives clothing advise. Their paper does not go in-depth on any of its subjects, but rather try to unite the ideas under the concept of an intelligent mirror. They use Viola & Jones for face detection and eigenfaces features for recognition. No results on the performance speed of neither detection or recognition was reported, but as shown in this thesis the speed of detecting faces with either haar-cascades, lbp-cascades or HOG classifiers can be greatly reduced by doing background substitution, as smaller image regions are faster to search. The experiments done in chapter 6 does however suggest that eigenfaces recognition method does not compare to newer neural network methods. Considering this paper is from 2016 it is a bit strange they opted for using eigen faces.

Wize Mirror

The most intelligent of the smart mirror projects is likely to be the research project Semeoticons. Its purpose is to analyze facial signs to measure the health level of the person in front of it. The paper by Franco Chiarugi et al. (2013) discusses the motivation and rationale behind the project. Their idea was to extract quantitative features of facial expressions related to stress, anxiety and fatigue and use those features to quantify an individual's well-being. The features would be extracted from data collected from multisensory devices. The data would be collected in the form of videos, images, 3D face scans and breath samples. The project is first and foremost a research project to digitalize semeiotics - the physical signs produced by diseases from facial images. As is evident from the title of their paper, the aim is to make the system non-intrusive to the user, but still being able to assess and monitor the individuals well-being. Because a mirror is a device most people use daily, either as part of their morning routine or bed routine, Franco Chiarugi et al. (2013) idea is to hide all sensory input devices in a mirror and provide the user with relevant feedback shown in the mirror.

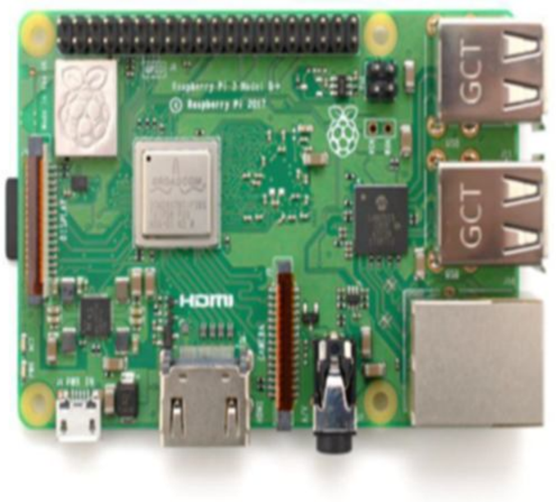
Toshiba Smart Mirror

At the 2014 International Consumer Electronics Show (CES)Toshiba showcased their smart mirror concept. Their smart mirror concept was similar to previous smart mirrors but utilized gesture control as an input method. Toshiba showcased their smart mirror in different home environments. Their idea was that the smart mirror would be customized for the purpose it would serve in each room. The bathroom smart mirror would show information such as weather forecast and a personal fitness monitor. Meanwhile the kitchen mirror would assist in cooking meals – in the form of finding, adjusting and preparing recipes. Since the convention in 2014 there have been few details on the future of the project and whether it will be commercialized.

Microsoft Smart Mirror

In 2016 Microsoft released details on the smart mirror they have been working on. Their intention does not seem to be to create a commercial smart mirror to sell to consumers, but rather they unveiled all the details on how to build one and made all the code publicly available at a github repository. Rather than selling a finished product consumers have the option to assemble their own mirror as a do-it-yourself project, without needing to do any explicit coding. However a certain knowledge of computers and technology is obviously needed to assemble the mirror. The interface can show such things as the weather, time and date, stocks, and traffic. It also supports facial recognition and will load customized interface profiles custom to each user. The mirror is run by a Raspberry Pi 3 with Windows 10 IoT Core that runs a hosted web app. This way the software is able to perform heavy tasks that would otherwise be unsuitable with the Raspberry Pi 3's hardware. Microsoft's solution shines some light on the situations on the state of smart mirrors as of 2017 - the major technology companies are yet to create smart mirrors where the trade-off between its appeal and its price is worthwhile.

III. RASPBERRY PI



A Raspberry Pi is a credit card-sized computer originally designed for education, in the field of IoT, robotics etc. which is inspired by the 1981 BBC Micro. The creator of Raspberry Pi was Eben Upton's whose goal was to create a low-cost device that would improve programming skills and hardware understanding at the pre-university level. But thanks to its small size and accessible price, it was quickly adopted by tinkerers, makers, and electronics enthusiasts for projects that require more than a basic microcontroller (such as Arduino devices).

The Raspberry Pi is slower than a modern laptop or desktop but is still a complete Linux computer and can provide all the expected abilities that implies, at a low-power consumption level. The Raspberry Pi is open hardware except the primary chip on the Raspberry Pi that is BroadcommSoC (System on a Chip), which operates all the main components of the board–CPU, graphics, memory, the USB controller, etc. Many of the projects made with a Raspberry Pi are open source having good documentation for the explanation and modification which can be useful for your project that you are building.

According to the Raspberry Pi Foundation, over 5 million Raspberry Pi's were sold by February 2015, making it the best-selling British computer. By November 2016 they had sold 11 million units, and 12.5m by March 2017, making it the third best-selling "general purpose computer". In July 2017, sales reached nearly 15 million. In March 2018, sales reached 19 million.

Ethernet: 10/100 BaseT Ethernet socket

Video Output: HDMI (rev 1.3 & 1.4) - Composite RCA (PAL and NTSC)
Audio Output: 3.5mm jack, HDMI
USB: 4 x USB 2.0 Connector
GPIO Connector: 40-pin 2.54 mm (100 mil) expansion header: 2x20 strip - Providing
27 GPIO pins as well as +3.3 V, +5 V and GND supply line.

There are various generations of Raspberry Pi's released till date.

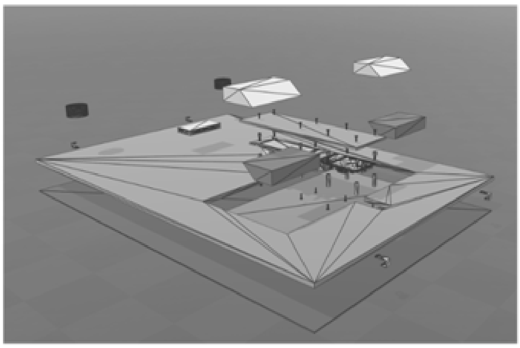
All models feature a Broadcom system on a chip(SOC) with an integrated ARM compatible central processing unit (CPU) and on-chip graphics processing unit (GPU).

Processor speed ranges from 700 MHz to 1.4 GHz for the Pi 3; on-board memory ranges from 256 MB to 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory in either SDHC or Micro SDHC sizes.

The boards have one to four USB ports. For video, output, HDMI and composite video are supported, with a standard 3.5 mm phono jack for audio output. Lower-level output is provided by a number of GPIO pins which support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3 and Pi Zero W have on-board Wi-Fi 802.11n and Bluetooth.

IV. PROPOSED SYSTEM

The proposed design of the smart mirror can be discussed in terms of two perspectives. One is in relation to the mirror's interface while the other is related to the mirror's underlying features by which services are provided. The two-way mirror has a thin reflective coating that allows passage to an amount of light while reflecting the rest as shown in Fig. 3.



It is partly reflective from one side, and is glass transparent from the other. The reflective side is lighter in shade with a darker transparent side to prevent the reflection of light. This enables users facing the dark side of the mirror to see through, unlike the vision from the reflective (lighter) side of the mirror, through which the users can only see their reflection. We use such a mirror with a television screen for the user-personalized profile display through the connected smart phone with the dedicated mobile application. To ensure the clarity of the displayed content, we utilize a television screen with a light emitting diode technology. The screen is located behind the mirror where the light rays from the television pass through the mirror since the mirror is transparent. Hence, while the user can see himself/herself via the smart mirror's regular mirror functionality, the user can still view the profile as per the proposed system. Moreover, to handle noise and enhance display quality, we employ a real time sigma filter for noise reduction in digital TV signals. In order to assemble the proposed system and set it up, we designed and built a shadow box, or a wooden box container. The shadow box has enough depth allowing it to hold the television screen, with the front facing side of the box being hollow to fix the mirror in it. The box also has small holes in its back to provide access to the various connectors needed such as the power chord of the television screen, as well as for the ventilation purposes to prevent overheating. Furthermore, the design of the shadow box consists of a wide base for maximum stability, and wheels for ease of setup regardless of the location. This further adds to the customizability and interactivity features that our proposed system fosters. More importantly, the design adheres to safety measures in terms of protection of the mirror and the complete proposed system interface. One key use of the smart

mirror is addressing the need to maintain a healthy lifestyle and medication plan for diabetes patients. Designing custom services allows us to integrate the mirror to medicine tracking mobile applications to remind patients of the importance of following theirdiabetes control plan. Fitness trackers collect other readings such as weight, heart rate, sleep quality, blood pressure, and glucose levels. An m-Health widget showing a graph of these readings provides an opportunity to create a needed feedback loop to help users lead a healthy lifestyle. The centralized server used to store user profiles along with the uniqueness of the identification of smart phones means that a user can continue to carry their custom smart mirror design everywhere a participating mirror exists. This is similar to the centralized storage of user extensions in browsers.

V. SENSORS

A sensor is a transducer device to detect events or changes in its environment, and then provide a corresponding electrical output. The most important characteristics of a sensor are precision, resolution, linearity, and speed. Sensor calibration improves the sensor performance. The performance can be enhanced by removing structural errors in the sensor outputs. Structural errors can be find out by taking difference between sensor's measured output and its expected output. Above repeatable errors calculated during calibration are compensated in real time during measurements carried out by sensors.

Image Sensor

The image sensor module is a small chip which consists of a sensor that can detect images and send the relevant information to the system. The sensor uses matching algorithms and preloaded images stored in the SD card to has its own frequency and variable attenuation which the image sensor takes advantage of. This kind of image matching using the difference in color frequencies to determine the type of object is called RGB imaging. These lights are determine the type of object the user is facing. Every color of light converted into signals or small bursts of current which are then converted into the required information I.e.; the object characteristics. Image sensors are used in electronic imaging devices of both analog and digital types, which include digital cameras, camera modules, medical imaging equipment, night vision equipment such as thermal imaging devices, radar, sonar, and others.

GPS

GPS (global positioning system) module in the system is used to guide the user to its destination on command from the user. it is a small electronic circuit that allows connecting to the Rasp- berry Pi microcontroller to get position and altitude, as well as speed, date and time on UTC (Universal Time Coordinated). It uses the standard NMEA protocol to transmit the position data via serial port.GPS TTL Mini is a high gain GPS Receiver. It has an entirely compact and simple design with the ultimate tracking performances. It is also ideal for plug-and-play GPS receiver module into their small form factor design as in the proposed system which requires minimal design. It can be directly connected to Microcontroller's UART. The GPS concept is based on time and the known position of GPS specialized satellites. The satellites carry very stable atomic clocks that are synchronized with one another and with the ground clocks. Any drift from true time maintained on the ground is corrected daily.

VI. SOFTWARE TOOLS

A. Linux Operating System

Linux is a family of free and open-source software operating systems built around the Linux kernel. Typically, Linux is packaged in a form known as a Linux distribution (or distro for short) for both desktop and server use. The defining component of a Linux distribution is the Linux kernel, an operating system kernel.

B. Python Language

Python is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, and a syntax that allows programmers to express concepts in fewer lines of code, notably using significant whitespace. It provides constructs that enable clear programming on both small and large scales. Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library. Python interpreters are available for many operating systems. C Python, the reference implementation of Python, is open source software and has a community-based development model, as do nearly all of its variant implementations.

C. Open CV

OpenCV (Open Source Computer Vision Library) is an open-source BSD-licensed library that includes several hundreds of computer vision algorithms.

OpenCV has a modular structure, which means that the package includes several shared or static libraries. The following modules are available:

Core functionality - a compact module defining basic data structures, including the dense multi-dimensional array Mat and basic functions used by all other modules.

Image processing - an image processing module that includes linear and non-linear image filtering, geometrical image transformations (resize, affine and perspective warping, generic table-based remapping), color space conversion, histograms, and so on.

Video - a video analysis module that includes motion estimation, background ubtraction, and object tracking algorithms.

Video I/O - an easy-to-use interface to video capturing and video codecs.

GPU - GPU-accelerated algorithms from different OpenCV modules.

VII. CONCLUSION

This paper proposes a futuristic smart mirror system that provides users with an easy-to-use mirror interface, allowing users access to customizable services in a highly interactive manner, while performing other tasks simultaneously. This facilitates the vision of ubiquitous and pervasive computing, as well as paves the way towards instilling the paradigm of Ambient Intelligence and smart environment concepts in our everyday lives. The proposed system allows users to utilize a commonly found household object as an interactive interface for displaying a variety of information services and regular updates from different domains of social media and news outlets. These can be customized by utilizing a dedicated mobile application, which allows users to create and manage their profiles based on what they wish to display on the smart interactive mirror. The personalized profile is then stored in the database server, from which it is retrieved by the mobile application connected to the television screen within the two-way mirror. This happens in an automated manner as soon as a new device is detected in the close proximity to the mirror. In the event of multiple nearby devices to the smart mirror, the profile of the closest device is displayed, based on the measurement of the RSSI strength. Overall, the proposed smart mirror system incorporates various functionalities to grant users access to personalized information services and a control of household smart appliances.

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