A Study of automated image capturing HDI environment using NAVIO 2

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***Abstract*—This paper presents a development of a low cost Human Drone Interaction (HDI) that is capable of taking images of scenes with people. Such a system will have many applications such as taking selfie images securely and detecting humans in rescue operations. We designed a HDI environment working with NAVIO 2 which is compatible with raspberry pi. OpenCV libraries gave additional speed to the system instead of using other image processing methods. Dynamic adaptation and the photography parallax were the main areas that we considered during the air-time of the drone. We constructed the proposed drone with the minimal designing architecture without all the additional building parts. After the initial design, the system was tested for HDI environment in different scenarios. Based on the test results, HDI environments parameters, such as stabilization, image quality, and speed, were tuned up . The results were quite impressive, compatibility between NAVIO 2 and Raspberry pi made this system a powerful HDI environment.**

***Index Terms*—Human Drone Interaction (HDI) , Photography Parallax, Dynamic Adaptation, Raspberry Pi, NAVIO 2**

I. Introduction

Few years ago, Drones were introduced to the robotic world as a smart gadget which can be used in different applications. Due to its trendiness and attractiveness Drones have become more popular among general community within a short period of time. Furthermore, researches on drones have considered as an emerging field in robotic industry as well. Thus far, these HDI environments has been used for several outdoor activities such as aerial photography [1] , film industry [2] , search and rescue people [3], monitor habitats exposed to risk of pollution [4] , agriculture and delivery [5] . It is also reported that drones have been tested on inspections of high-voltage electricity lines [6] in order to minimize the expensive power outages and risky climbs.In the recent future, it is expected that drones would become partly autonomous and will be modified to support humans to make their day today life easier [7]. Choosing automated drones over unmanned ground vehicles provide several advantages such as give an aerial view of the surroundings, easy establishment of the connection between user and drone and mostly, space is not a problem.

While, some of the research have been carried on the field of Human Drone Interaction (HDI), most of their feasibility have been limited by several factors. Cost of a drone can be considered as the major problematic area due to expensive drone segments and flight controlling systems. Furthermore, still it is not reported a standard drone platform with flight control and standard medium to carry out researches which makes it harder to test a drone.

Photography is one of the well-known primitive application of drones which it became famous for within last few years. Taking this into fact, Drones can be an excellent replacement for professional photographer and front selfie cameras of phones [8]. Annually, it is reported that a large number of deaths and critically injuries due to attempts of taking selfies in risky locations [9] around the world. Automated drones can be a decent alternative for taking photos with its less user controlled behavior and improved human drone interaction.

To design an autonomous drone with safe and controlled flight, a powerful brain is considered as a necessity. NAVIO 2 is known as a flight controller which offers all the I/O needed for a flight controller using the Raspberry Pi board [10]. Expanded processing power and video acquisition of NAVIO 2 enable higher capacity. With the combination of Raspberry pi and NAVIO 2 together, there is a higher chance of building powerful low cost HDI environment in drones.

In this work, we propose a low-cost automated image capturing HDI system, which is capable of detecting humans in a scene and taking images, as an alternative way of taking selfies in risky locations.

II. Related Works

Prior Studies on drones show that hand gestures, face poses and prop based interaction techniques provides the best support on controlling personal drones. Jessica et.al [11] show that high agreement score for gesture and voice interactions are more conveniences than other methods.

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Also, people prefer to interact with drones similar to the way they interact with another person or a pet. This concludes that, gestural interaction is good in a way, but may not be safe for close distance and may not be accurate enough for long distance. To have the best gestural interactions, drones will require some feature developments to interact with humans in a safer and accurate way in any distance.

Dan He and the team constructed a robot named as ”Flying buddy”, a mini unmanned aerial vehicle to extend human abilities such as flying above to see things/ obstacles and it will enhance the vision of the user [12]. It provide number of services such as flying to buy, flying to see, flying to report an accident and flying to take pictures. This drone is also capable of operating manually and autonomous. They have concluded that Flying buddy, deliver a significant output of improving human abilities as they expected. Florian Schaub and the group [13] studied the Privacy Interfaces of HDI environments and further discussed about three potential scenarios that demonstrate drone-based privacy interfaces in smart environments. The three potential scenarios are as follows: visualizing the information flow, displaying the gained information and getting Permission and Consent Requests. Finally, they concluded that in contrast to privacy interfaces on mobile or desktop devices, drones have the potential to provide a direct mapping between data practices and the physical environment.

Dario Floreano [14] has mentioned about small autonomous drones and mainly focused about the design and manufacturing challenges in his review. The challenges he discussed were the practical issues that arise when scaling a vehicle down, such as reduce the power of motors and transmission efficiency. Jose Luis Sanchez-Lopez and the team [15] created a HDI environment that provided answers for the two known issues which was level of autonomy and versatility. For these issues they have proposed a HDI environment architecture that integrates both a deliberative and reactive approaches, and tested three years through research projects and exhibitions.

Nagi et. al [16] report have developed a drone for detection of face pose and hand gestures. This approach was recognized as a successful method of face detection using OpenCV implementation of the Viola-Jones face detector [17] . Additionally, this system offers mobile robots the ability of localizing human operators and provides HDIs with a better perception of the environment around the human. Furthermore, the robot controller of the drone collects the feedback information from the user to measure the accuracy of estimation.

Although these approaches provide some useful features, they contain some major disadvantages such as high cost, Complex architecture and consuming high energy for the flight time. Theses lead drawbacks inspired us to design a HDI environment with a simple hardware architecture and Low cost environment.

III. Methodology

A. System Architecture

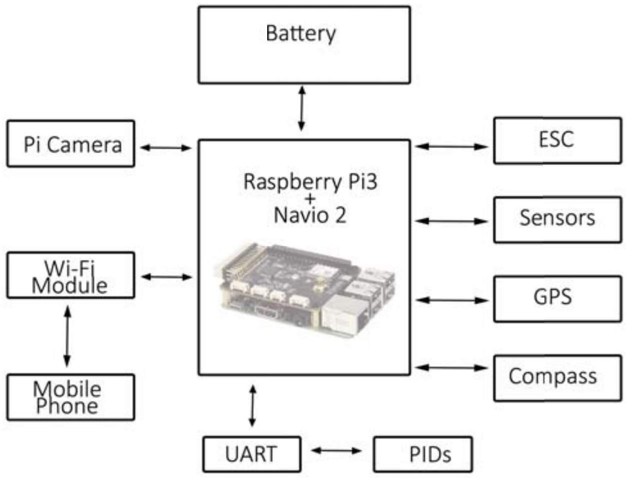

Fig. 1. Basic Hardware architecture of the HDI environment

As shown in the Fig. 1, the proposed system mainly consists of a drone kit, a Raspberry pi single-board computer, a NAVIO 2 flight control module, and an ESP-8266 Wi-fi module. The drone flight control is handled by the Raspberry Pi and its shield called NAVIO 2. The software suit running on Raspberry pi which is called ardupilot controls the navigation of the drone. During the development phases radio transmitter and receiver are used for manually operations of the drone.

Drone has one sensor unit to measure gravity using three accelerometers and rotation rate using three gyroscopes. In this research we used Mission Planner software to tune and stabilize the drone using these sensors.To transmit and receive signal with drone and device which has PID (Proportional-Integral-Derivative controller) to calibrate the drone we used Dual TTL 3D Radio Telemetry Kit module with 915 MHz. PID is the software glue that connects commands and sensors inputs together to control the power to the motors. Here we used Mission Planner software as PID [18]. Drone is powered by LiPo (Lithium Polymer) battery which has a huge power to weight ratio for the amount of power they can deliver with light weight [19]. ESC (Electronic Speed Controller) that has a microcontroller in its core. It takes a single signal from Navio 2 flight controller and converts that to high power pulses to the motor [20] .

The Wi-fi module is used to send user commands via a smartphone to take pictures. It communicates with the Raspberry pi through UART protocol. The smart phone can be configured as a Wi-fi hotspot, and establishes a wireless communication link with the Wifi module attached to the Raspberry pi.

Raspberry pi performs another important operation in this system, in addition to the flight control operations with NAVIO 2. That is detecting humans in the scene, before taking a picture. Open CV image processing algorithms run on the Raspberry pi performs the human detection of the camera image. After only detecting human, the images are saved.

B. Interaction between User and Drone

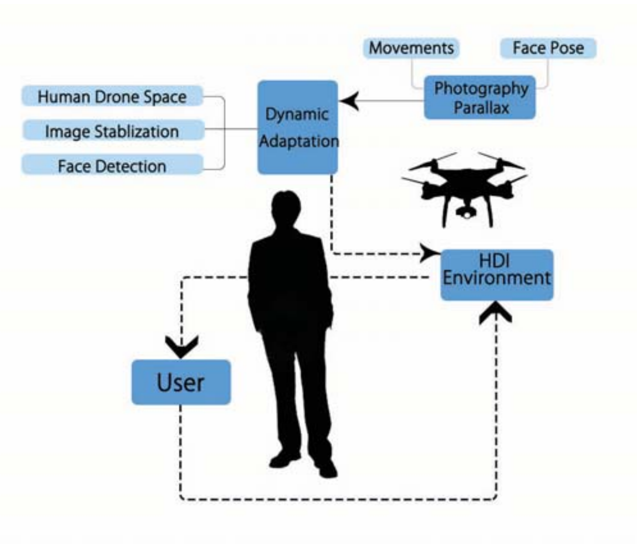

Fig. 2. Interaction between Human and the Drone

We also focused to building the strong communication between the HDI environment and User. As shown in the block diagram of Fig. 2, Dynamic Adaptation [21] and Photography Parallax [22] are the two main facts that we considered when planning the interaction. Considering dynamic adaptation, it requires frequent observations of sensors and the behavior of users. We used three major factors to dynamic adaptation. They were human drone space, Image stabilization, and Face detection. Human drone space was measured by a raspberry-Pi camera with IR sensor and Image stabilization was accomplished by tuning up the hardware of the drone using NAVIO 2 controller. For detecting face pose and movements we used OpenCV libraries, which can be implemented in Raspberry pi. Considering Photography parallax, it requires collecting movements and face poses to gathering best photographs for further analysis. Detecting movements and face pose can also be achieved by using OpenCv libraries.

Architecture shown in the diagram of Fig. 2 made us easy to tune up the HDI environment and gathering data for further studies.

IV. Results

Images of the drone system is shown in Fig. 3. It is capable of detecting humans in the scene and take pictures. When it is launched, it moves to the distance controlled by the radio transmitter. Image capturing commands can be sent to the drone by using a smartphone. Once the drone receives a command to capture images, it automatically detects humans in the scene before recording images. As shown in Fig. 3 we made the drone with a minimalize hardware architecture. The HDI environment was tested in order to fine tune the output. Testing procedure was helped to adjust parameters of the calibration and focused more to the stabilization of the drone.

The system works in the limited distance where the Wi-Fi signal strength is good to receive user commands through Wi-fi. However, this limitation is not a problem in applications such as taking selfie images.

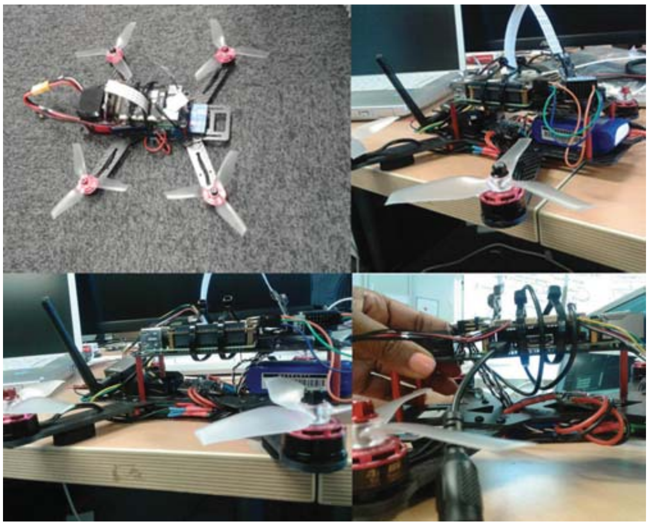

Fig. 3. Images of the proposed Drone

Fig. 4 shows real-time images captured by the system, which executes human recognition algorithm written in Python using the OpenCV libraries. The results are quite impressive although it uses low end processor in Raspberry-pi.

Fig. 4. Sample images captured by the system

V. Conclusion

Personal drones are becoming popular since they are being explored in various applications. In this paper, we explained the development of a low-cost image capturing HDI system, which can be used to take selfies, avoiding accidents when they are operated in risky situations. The system consists of a Raspberry pi single-board computer with NAVIO 2 flight controller module, and a Wi-fi module. It automatically detects humans in the scene before recording images. One limitation of the proposed system is that it requires manual operation of the drone using a radio transmitter. To overcome this limitation, autonomous controlling feature will be added to the system in future studies.

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