Handheld devices for Educational Purposes

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Abstract: *The paper discusses the opportunity of using handheld devices in educational process. The functional characteristics of mobile devices are explained. Two examples for using smart phones as sensor data source are described. The first one concerns navigation systems, the second - 3D scene reconstruction. The possible problems are listed and commented.*

Key words: *Handheld devices, Education.*

INTRODUCTION

Today handheld devices conquer the world. Almost every one of citizens of the our planet has one or more handheld device. But what is the meaning of this catchword? The Wikipedia definition [1] for handheld device is: "A mobile device is a small computing device, typically small enough to be handheld (and hence also commonly known as a handheld computer or simply handheld) having a display screen with touch input and/or a miniature keyboard and weighing less than 2 pounds (0.91 kg)." In another Internet definition [2] a handheld computer is regarded "as a computer that can conveniently be stored in a pocket (of sufficient size) and used while you're holding it".

The both definitions does not describe functional characteristics of handheld devices. The big variety of designed mobile devices perplexes correct description. Here is a list of the most popular handheld devices like notebooks, smart phones, tablet computers, wearable computers, smart watches, head-mounted displays, personal digital assistants, calculators, game consoles, media players, digital photo/still and video cameras, navigation devices, etc. The brightest representative of mobile devices is the smart phone. It has not only the biggest market share, but it acquires quickly functionality of all other devices and becomes an indispensible device for everyone of us. Since that point and further it will be considered that smartphones are mosly handheld devices and after that all other mentioned above devices.

The main aim of this work is to describe the basic functional characteristics of handheld devices in the next chapter, to discuss the applications of these devices in educational process in the third chapter and to outline the possible problems to be solved. At the end of the paper a summary is given

FUNCTIONAL CHARACTERISTICS OF HANDHELD DEVICES

As a computing device the most important characteristic of handheld device is its **computing power**. The big player here are Qualcomm, Nvidia, Apple, Samsung and Intel. Qualcomm dominates in the field of mobile processors and its latest SnapDragon processors have clock speed of 2.3 GHz. The newest processors have multicore architectures (up to 8 cores), 64 bit processors and graphics chip. In the case of Nvidia Tegra there are 256 GPU cores. Usually the power consumption is limited up to 10 W, but all of them have more power efficient rate with a little companion core.

Computing power without enough **memory** could not be used effectively. Memory stores many applications, hundreds of photos and videos, songs and other information on handheld device. Two types of memory are used - internal and memory cards. Internal memory usually counts several GB but in the most expensive models it is 128 GB. Memory cards extend mobile device memory. To be used memory cards the handheld device have to have memory slot. Pushing memory card in memory slot let you increase memory and allows to share information between different devices. The size of memory cards on the market varies from 2 GB to 64 GB.

Battery is also very important for normal functioning of mobile device. Fast processors, large screens, communications and lots of power hungry applications requires batteries with largest possible capacity. All of them are using the lightest and the most robust power sources based on Li Ion technology. Nevertheless their constantly increasing capacity (today up to 4 - 5 Ah) there is not a device with busy time more than 24 hours.

The **operating system** (OS) of handheld devices hardly can be considered as next step of development of OS originally designed for bigger stationary personal desktop computers. Due to limited processing power, the mobile OS has lighten architecture, but simultaneously possesses other features useful for mobile or handheld use like Bluetooth, Wi-Fi or other near field communication, GPS and inertial navigation, video camera in addition to WEB camera, speech recognition and voice recorder, touch-screen interface, etc. The most popular mobile OS are Google Android (81.2%), Apple iOS (15.0%), Nokia's Symbian, BlackBerry (0.4%), Hewlett-Packard's webOS (formerly Palm OS) and Microsoft's Windows Phone OS (3.0%). The last note about OS is the great difference between computers and smart phones. In computers it is appropriate to change the OS, but the smart phones usually could not change their OS, only upgrade it.

The **application software** is the most important for users. The availability of plenty of excellent application gives the owners an unique possibility to tune the handheld device according his needs, to specialize it. There are low cost application software and amazing quantity of totally free applications. According to estimation of Gartner Inc. in 2013 about 102 billion applications were downloaded. 91% of them were free. Usually the applications are OS dependent. The biggest application software stores are controlled by OS producers.

The biggest application repository is Google Play for Android. It was opened in October 2008. After six years, there were more than 1.3 million applications for Android. The applications were 40 billion times downloaded. Apple's App Store for iOS is on the second place with several hundreds of thousands applications. Other smaller application repositories are Amazon Appstore (for Android and BlackBerry), native BlackBerry World application store for BlackBerry 10, Ovi (Nokia Store) for Nokia phones, Windows Phone Store for Windows Phone platform, Samsung Apps, etc.

TWO EXAMPLES OF APPLICATION OF HANDHELD DEVICES IN EDUCATION

There are many examples of usage handheld devices in education. How to record person life by keeping personal diaries is described in [4]. There a Narrative Clip camera was used to make a record for 68 days period. In [5] the concept of e-textbooks in the classroom was discussed and authors suggested some improvements to the e-textbook. The location based mobile application for educational process support was proposed in [6]. In [7,8] virtual labs were suggested as a good practice in education.

Here we propose the usage of handheld device as a real measurement device. It can be used for solving and training on different tasks in navigation and 3D scene restoration. The first example concerns navigation. Contemporary smart phones are equipped with entire set of inertial sensors. The sensors are divided in two groups: gyro sensors and accelerometers. Gyro sensor measures rotation rate of the body. Accelerometer provides information about linear acceleration of the body. Usually description of 3D motion of a body is given by 3 orthogonally placed accelerometers giving transition dynamic of the body and 3 orthogonally placed gyro sensors determining the orientation/attitude of the body. The axes of the both types of sensors normally coincide – e.g. in a 3D orthogonal coordinate system there are sensors to measure linear accelerations on each of the axes and rotation rate of the same axes. In smart phones usually the strapdown gyro sensor is implemented. It is fixed tightly on the body and provides measurement of rate of rotation of the body. For this class of sensors, the body orientation is received through the integration of gyro measurements in respect to a priori known body orientation. Usually the strapdown sensors are produced as a MEM device with extremely high robustness and low power consumption. In this paper such a type of devices will be considered. The Inertial

Navigation System (INS) is a system that relies entirely on inertial measurements for determination of dynamical body position and orientation.

Having a smart phone in hand, the student have a real (not virtual) laboratory for inertial sensor testing and development of dead reckoning algorithms for tracking and attitude estimation. There are many applications freely available to support educational process like Sensor Box for Android, GPS & Sensors, Barometer, Compass Pro, Multi Measures, Ultra GPS Logger, GPS Test Plus, GPS Doctor, Wireless IMU, Motion Sensor, Sensor stream, etc. There are several ways to receive sensor data on a remote computer. The first one is to save data in phone memory and after experiment connect phone with desktop computer by USB cable. The second is more complex but assures data transition in real time. The server has to be laptop with WiFi and has to be configured as WiFi server. The phone is configured as WiFi client and transmits data trough UDP protocol. This protocol is chosen to maximize transmition rate. The third way again consider data recording on the phone. The application Dropbox is activated. Dropbox automatically syncs files between your desktop computer and phone. When data files are saved in the Dropbox folder on your mobile device, it immediately downloads information to the Dropbox directory on the desktop computer.

The inertial sensor data may be used for development inertial navigation systems. The biggest advantage of these systems is that they depend only from sensor information and initial alignment. The position and attitude are calculated through integration of sensor data. Due to inaccuracy of sensing elements, the errors are accumulated and soon after the start of algorithm the results become compromised. To avoid such a situation the more accurate sensor are required. For the case of phone sensor set, where all sensors are budget variant (low cost) the more expensive sensor could not be implemented. The more suitable solution is to use other sensor and to develop so called aided navigation system. The appropriate sensors are GPS, pressure sensor, video/camera sensor. The algorithms process simultaneously data from inertial sensors and additional sensors. This organization of calculations is often called data fusion. A realization using Sensor stream application is given on fig.1 (option panel).

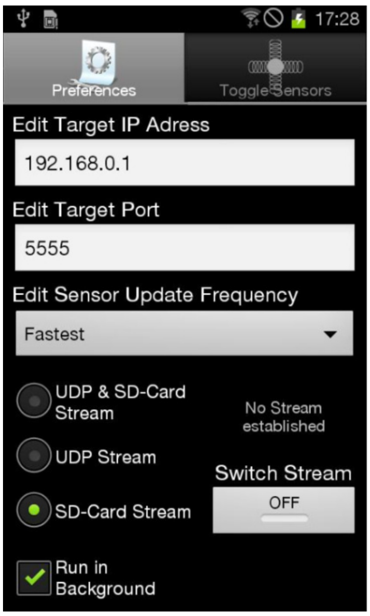

Fig. 1 Option panel of sensor stream application

Fig. 2 Sensor panel of sensor stream application

The next two figures (fig.3 and fig.4) plot the received sensor data.

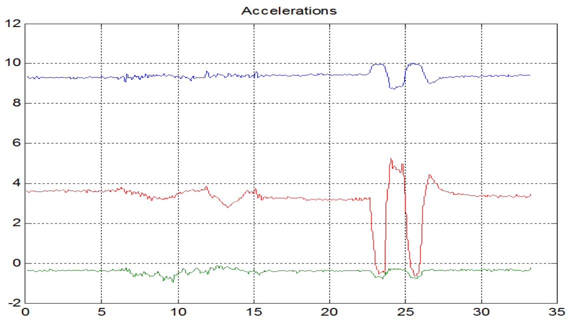

Fig. 3 Accelerometers data

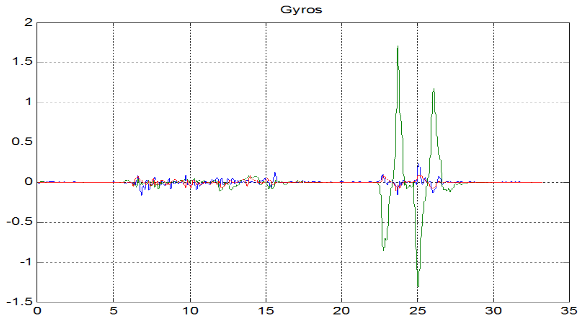

Fig. 4 Gyro data

On the fig. 5 the estimates of phone position is displayed and on the fig. 6 the attitude of phone is depicted.

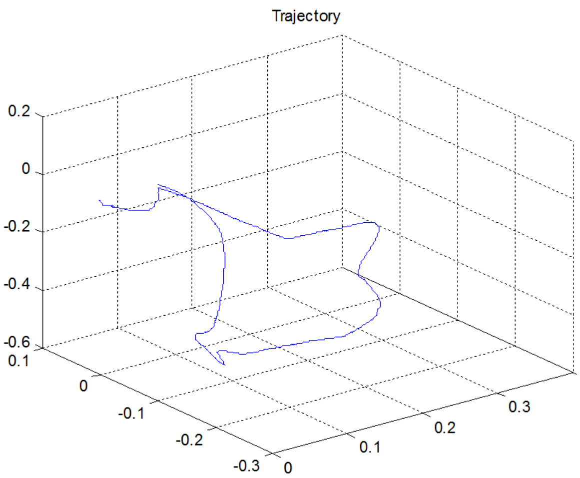

Fig. 5 Phone position

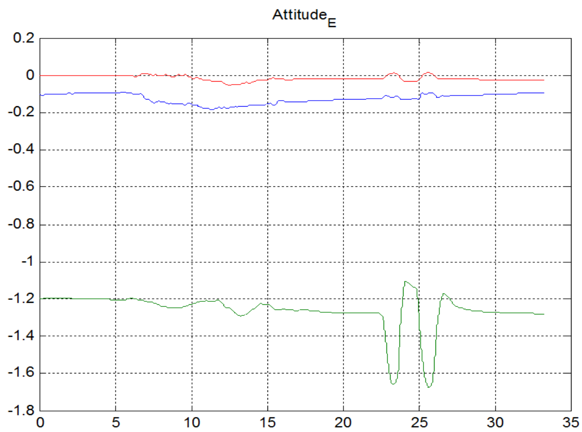

Fig. 6 Phone attitude

The second example concerns 3D scene reconstruction using several photos on one and the same scene, taken from different positions. Usually the camera gives a 2D projection of 3D scene. The depth of scene in this projection is lost. The question is to reconstruct 3D scene from multiple images. The problem is theoretically solved [9] and well-studied, but practical results are disappointing. The modern smart phone has several navigation sensors. If their data are recorded and used to be calculated camera position and attitude when the photos are taken the poorly conditioned task will be easily resolved and the solution will be stable. The global algorithm includes the following steps:

1) Take simultaneously picture and camera coordinates (position) and attitude;
2) Move the camera slightly and repeat the step 1;
3) The step 2 is committed several times (depends on scene);
4) Application of SURF or SIFT algorithms for dense feature set selection;
5) Features registration;
6) Triangulation and depth calculation;
7) 3D scene reconstruction.

The smart phone again serves as a source of all sensor information. Different algorithm realizations may be tested and their accuracy estimated.

THE MOST IMPORTANT PROBLEMS FOR IMPLEMENTATION OF HANDHELD DEVICES IN EDUCATION

The latest smart phones have powerful processors, fast memory, a plenty of sensors. They easily can serve as a real sensor data source to support education in navigation, computational photography, 3D scene restoration, etc. The main drawback of contemporary systems is the low quality of available hardware. To reduce the price of handheld devices often the developers go to solutions with low accuracy sensors. But the progress in the field is very big and soon the enhanced sensor sets find place in the mobile devices.

CONCLUSIONS

The research presented in this paper gives a proposal for using handheld devices as a real data acquisition devices and substantially extend the place of smart phones in education. The authors themselves extensively used the smart phones in the pointed examples and are deeply concerned in the usefulness of mobile devices in education process.

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The paper has been reviewed.