PROPOSAL OF NEW VERSATILES DEVICES FOR USES IN TRAFFIC ACCIDENT RECONSTRUCTION

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ABSTRACT:

The new technological advancements and increasing propagation of Windows mobile devices pose great opportunities for engineers and traffic accidents experts. These gadgets are compact hybrid devices integrating the capabilities of personal digital assistant (PDA), mobile phone, camera, music player, FM radio, Global Positioning System (GPS) and so on. They have standard computing facilities and advanced communication features including wireless and Bluetooth. Some of this embedded characteristics generating us a set of questions as the followings:

Can we obtain the confidence data using a simple windows mobile device (Smartphone)? How can we use these data into current traffic accident reconstruction activities? Which are the driver, car and road parameter logged by some current WM GPS and accelerometer-based application and how can we extend them?

These are simple questions which are trying to answer by research carried out by authors.

INTRODUCTION

Mobile phone is becoming a more and more indispensable tool in our daily life. Its main function was to make and receive phone calls when it was just invented. However, with the development of communication technology and other related technologies, a lot of new functions are integrated into this device.

The mobile market has during recent years expanded dramatically with high-end models featuring a lot of new technology and is capable of running more advanced applications than the conventional phones. These phones are often grouped into a category commonly known as smart phones". The smart phones are closing the gap between conventional mobile phones and portable computers as manufacturers are continuously making new models that replace the older ones with new technology and better performance.

The following list gives some examples of features that can be found in smart phones today:

- Wi-Fi - Enables fast Internet connections via wireless access points;
- Camera(s) - Resolution of up to 12 MP, video recording/editing, video calls.
- Push Email - Email are instantly sent to the phone as they arrive to the mail server;
- QWERTY keyboard - A keyboard makes typing easier;
- Touch/Multi-touch screen - For use with pen or finger(s);
- Accelerometer - Sensor for tilt of the device primarily used to switch between portrait and landscape layout.
- GPS - Can be very useful as a navigational aid when used with an application that provides maps.

This paper is based on development of the research for mobile phones uses in traffic accident reconstruction, research carried out on the Automotive and Engine department of Transilvania University of Brasov. The paper was primarily focus to assign adequate answers of the followings questions:

1. Can we obtain the confidence data using a simple windows mobile device (Smartphone)?

2. How can we use these data into current traffic accident reconstruction activities?

3. Which are the driver, car and road parameter logged by some current WM GPS and accelerometer-based application and how can we extend them?

EXPERIMENTAL RESEARCH

HARDWARE AND SOFTWARE EXPERIMENTAL FACILITIES

a. We use an **i900 Samsung Omnia** as Smartphone. The Samsung Omnia i900 is not the last Smartphone as technology and sensors capabilities, but this is a reliable proof and decent characteristics device. The Samsung SGH-i900 Omnia is a 3.5G cell phone. Samsung sells the Omnia with Windows Mobile pre-installed, but has shown a prototype running a LiMo (Linux Mobile) stack at Mobile World Congress 2009 [7].

As it seems, a lot of information is known about this device, mainly due to leaked service manuals.

- Hardware specs:
- Application Processor: 624MHz Marvell PXA312 with NAND (256MB) + DDR (128MB) in one package;
- GSM/UMTS Modem: Qualcomm MSM6281, interfaced via dual-ported RA;
- Wi-Fi: Marvell 8686;
- Bluetooth: CSR 41814;
- 8/16 GB external SD flash;
- Audio Codec / Touchscreen: Wolfson WM9713;
- Screen: 240x400 pixels, 3.2";
- 5MP Sony IMX034 camera with LED flash;
- Accelerometer Bosch Sensortec BMA020;
- Ambient light sensor.

The BMA020 Sensortec [8] is a tri-axial, low-g acceleration sensor with digital interfaces, aiming for low-power consumer market applications. The BMA020 has been designed to match a multitude of hardware requirements. Key features like g-range and filtering characteristics are programmable by the customer. Since the sensor has a very small package and very low power consumption it is a perfect fit for mobile applications. The BMA020 can be customer programmed to further optimize functionality and performance in all consumer applications. Especially the very low stand-by current and fast wake-up time underline the suitability for state-of-the-art mobile low-power designs. The BMA020 allows measurement of accelerations in 3 perpendicular axes. An evaluation circuitry converts the output of a three-channel micromechanical acceleration sensing structure that works according to the differential capacitance principle. The BMA020 senses tilt, motion, shock and vibration in cell phones, handhelds, computer peripherals, man-machine interfaces, virtual reality features and game controllers. The function and performance of the BMA020 can be programmed to match customer specific applications by means of parameter and control settings. The BMA020 provides a digital 10 bit output signal. Via serial interface command the full measurement range can be chosen to ±2g, ±4g or ±8g. A second-order filter with a pole-frequency of 1500 Hz is included to provide preconditioning of the measured acceleration signal. The maximum data conversion rate is 3 KHz. Additional digital filtering is possible to improve S/N ratio (down to 25Hz bandwidth). Typical noise level and quantization lead to a resolution of 4mg. The current consumption is typically 200 µA. In addition there are several features implemented to support the host system in reducing power consumption. Parallel to normal operation where acceleration values are provided to the output registers the BMA020 is capable to perform internal computations of the results. The customer is enabled to define specific criteria, for ex. high-g or low-g thresholds but also criteria for the recognition of smooth motion profiles. The sensor can inform the host system about the violation of one of these criteria via an interrupt pin. This feature can be used for many purposes, ex.. to wake-up the host system from a global sleep mode or to signalize a shock situation.

The main technical features of the BMA020 Sensortec accelerometer are presented in the Table 1.

Table 1

Sensitivity axes	x/y/z	
Measurement range	±2g, ±4g, ±8g (switchable via SPI/I2C)	
Sensitivity (calibrated)	2g 4g 8g	256LSB/g 128LSB/g 64LSB/g
Resolution	10bit - 4mg (±2g range)	
Nonlinearity	±0.5% FS	
Axes mixing	2%	
Zero-g offset (calibrated)	±220mg	
Zero-g offset temperature drift	1mg/K	
Noise	0.5mg/√Hz	
Bandwidth	25Hz … 1500 Hz (switchable via SPI/I²C)	
Digital input / output	SPI & I²C, Interrupt pin	
Supply voltage	2.0 … 3.6V, 1.62 … 3.6 V	
Current consumption	200µA	
Idle current	1µA	
Wake-up time	1ms	
Temperature range	-40°C … +85°C	

For claim the full of BMA020 i900 Omnia GPS and accelerometer capabilities the author has used **gPC (Performance Calculator based on g-forces) licensed software**, ver. 2.34, developed by MoisisV.

The main features of gPC (Performance Calculator based on g-forces) software are:

- Forward and lateral g forces measurements;
- Horsepower vehicle’s calculation using device's internal GPS receiver;
- Advanced processing methods of all calculated values, including g-forces (m/s^2), angles GPS data and calculated horsepower (HP), while being saved to a proper log file by the user;

- 0 - 100 Km/h or 0 - 60 miles/h acceleration times calculations;
- Calculation of time and horsepower for 0 - 402 meter or 1/4 of mile acceleration times, while in dragster mode;
- Log opportunity of any of the max horsepower, g-forces or angles values;
- Drawing 'circuit' capability according to the longitude and latitude values measured by the internal GPS receiver;
- Speed and horsepower graphs utility using the appropriate user's log files.

The figure 1 shows the screen configuration of gPC ver. 2.34 software and in the table 2 are presented an example of a ".xls" partial output of values file.

Another device[9] used to obtain professional acceleration data was the **Madge Tech UltraShock**. This device is a battery powered, stand alone 3 - axis shock recorder. The UltraShock measures and records shock at the peak acceleration levels over the user defined interval. The UltraShock is specifically designed for documenting dynamic environments such as moving vehicles, trucks, containers, ships, etc. The device is also valuable in characterizing environments such as production and assembly lines of delicate equipment, IC fabrication, communications and computer components. This is an all-in-one compact, portable, easy to use device that will measure and record up to 174,762 measurements per channel. The storage medium is non-volatile solid state memory, providing maximum data security even if the battery becomes discharged. The device can be started and stopped directly from your computer and it's small size allows it to fit almost anywhere.

Technical specifications of the Madge Tech UltraShock are visible the Table 3.

Figure 1. gPC (Performance Calculator based on g-forces) or gPC car edition screens configuration settings.

Table 2

gPC Car Edition Log File
www.extreme-apps.com
Car Weight 1740 Car Cd 30 Frontal Area 2240
gZ -9,8654317855835
g-Sensor Scale Calibration it's VALID

Date Time	X (m/s^2) [or /10 for g]	Y (m/s^2) [or /10 for g]	Z (m/s^2) [or /10 for g]	YZ (m/s^2) [or /10 for g]	GPS Position (Latitude)	GPS Position (Longitude)
28-05-2010 14:18:57	0.5690154000	-0.1142442000	0.0000000000	-0.1118834000	45.7453084833	25.7041875167
28-05-2010 14:18:57	0.5690154000	-0.1142442000	-0.0808649100	-0.1161438000	45.7453084833	25.7041875167
28-05-2010 14:18:57	0.6069498000	-0.0380813500	0.0000000000	-0.0770503400	45.7453080667	25.7041886000
28-05-2010 14:18:58	0.5690154000	-0.0380813500	0.0000000000	-0.0575035900	45.7453080667	25.7041886000

Table 3

UTLRASHOCK SPECIFICATIONS

TEMPERATURE				
Sensor:	Semiconductor			
Range:	-20 to +60°C			
Resolution:	0.1 °C			
Accuracy:	±0.5°C (0 to +50°C)			
HUMIDITY	Capacitive Polymer			
Sensor:	0 to 95%RH			
Range:	0.1%RH			
Resolution:	±3%RH (±2%RH typical at 25°C)			
Accuracy:	+10 to +40°C; 10 to 80%RH			
Specified Accuracy Range:				
PRESSURE				
Sensor:				
Range:				
Resolution:				
Calibrated Accuracy:				
	Semiconductor Strain Gage 0 to 30PSIA 0.002PSIA ±1.0%FSR at 25°C; ±0.2% typical			
SHOCK				
Accelerometer Type:	MEMS Semiconductor			
Acceleration Range (g):	±5	±50	±100	±250
Acceleration Resolution (g):	0.01	0.03	0.05	0.2
Calibrated Accuracy(g):	±0.2	±1.0	±2.0	±4.0
Sampling Rate:	1.953 millisecond (512Hz)			
Accelerometer Freq. Resp.:	0Hz to approx. 400Hz			
Reading Rate:	64Hz to 5 minutes for shock, selectable in software. Temperature, pressure & humidity sampled approx. every 2 seconds at intervals shorter than 2 seconds. Otherwise, sampled at the reading rate.			

Memory:	1 74,762 readings per channel; 1,572,858 total readings
Start modes:	Software programmable immediate start or delay start, up to 6 months in advance
Real Time Recording:	May be used with PC to monitor and record instantaneous measurements in real time
Password Protection:	
	An optional password may be programmed into the device to restrict access to configuration options. Data may be read out with the password.
Calibration:	
	Digital calibration through software
Calibration Date:	Automatically recorded within device
Battery Type:	9V lithium or alkaline battery included; user replaceable
Battery Life:	7 days typical with lithium battery, 1 min. reading rate @ 25°C
Data Format:	Date and time stamped °C, °F, K, °R ; %RH, mg/ml water vapor concentration; PSIA, inHg, mmHg, bar, atm, Torr, Pa, kPa, MPa, altitude; g
Time Accuracy:	±1 minute/month (at 2 to 30°C)
Computer Interface:	PC serial or USB (interface cable required); 115,200 baud
Software:	Windows 95/98/ME/NT/2000/XP/Vista based software
Operating Environment:	-20 to +60°C, 0 to 95%RH non-condensing
Dimensions::	3.5" x 4.4" x 1.0" (89mm x 111mm x 26mm)
Weight:	12 oz (341 g)
Enclosure:	Anodized aluminum
Approvals:	CE

The **Racelogic VBox**100 [10] a GPS based high performance device was used in the experimental research. Car speed, accelerations and GPS car position (with sampling rate of 20 or 100 Hz) can be stored by high precision by VBox 100 [2].

For some of the real life tests performed was presented the condition showed in figure 2.

For satellites visibility, the Smartphone was placed on the car dashboard, below the car windscreen. The “Y” axe of the phone was the same as the car longitudinal axe and the horizontal position of device was calibrated to be parallel of the car floor (fig. 2).

For operating reasons, the Madge Tech UltraShock device was mounted on the car floor, rearwards of the driver chair, with “Y” axe parallel to the car longitudinal axe.

In the same position as Madge Tech UltraShock, was placed to the Raceologic VBox 100 device, together two outside GPS antennas. The VBox GPS antennas were mounted on car roof approximately in the car center of gravity vertical plan [3].

RESULTS AND DISCUTION

Many tests were performed using the devices above presented mounted in different cars. Specified apparatus were controlled by using a notebook, via USB ports and characteristic software. GPS (UTC) time and Windows notebook calibrated time was the parameter used to triggering and synchronize all the devices.

Fig. 2 Experimental research facilities example.

Because gPC (Performance Calculator based on g-forces) software, running on Samsung Omnia i900, has parameters outputs controlled by a variable (4 Hz or 5 Hz or 6 Hz or 7 Hz) GPS refresh rate, the time steeps of Samsung Omnia results diagrams were not equal (figure 3 and figure 4).

That is reason which was imposing us to use same total time interval for both Samsung Omnia and twin device used in the tests performed.

On the other hand, the gPC (Performance Calculator based on g-forces) software needs as inputs car weight, car frontal area and drag aerodynamic coefficient for more precise results outputs. Approximate values of these parameters provided us poor results outputs.

Also, longitudinal accelerations and GPS car velocities represented as results in tests performed depends of devices mounted positions relative of the car center of gravity or/and of GPS antenna position. Different position can get us different results.

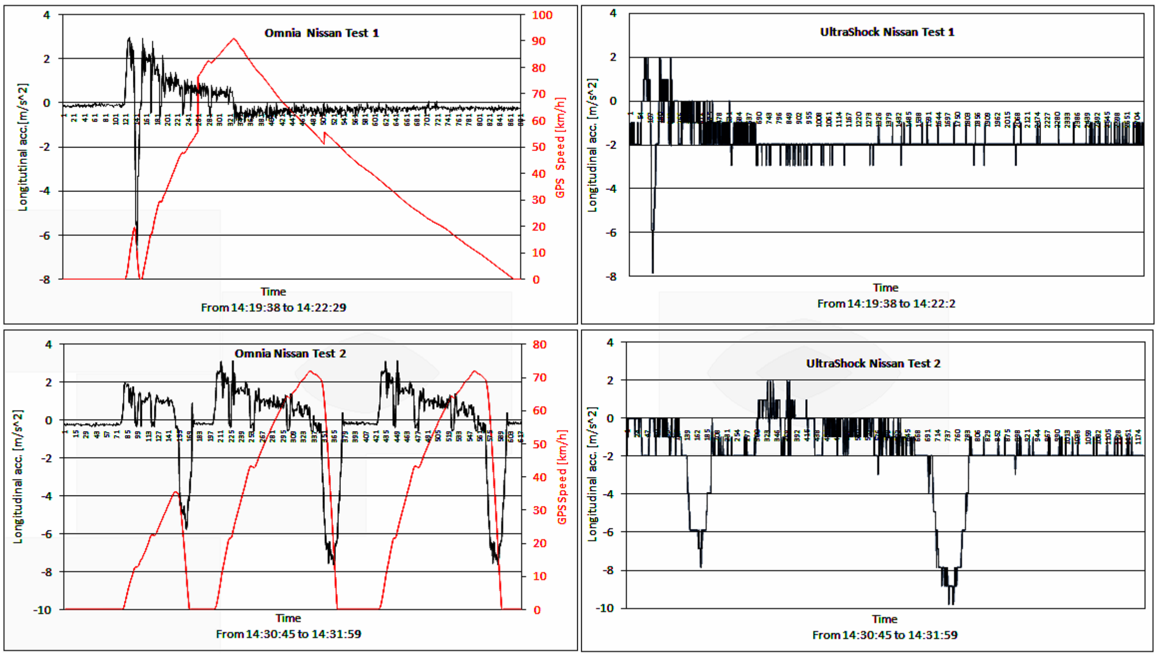

Fig. 3 Results obtained with Samsung Omnia and Madge Tech UltraShock mounted into Nissan Primera car

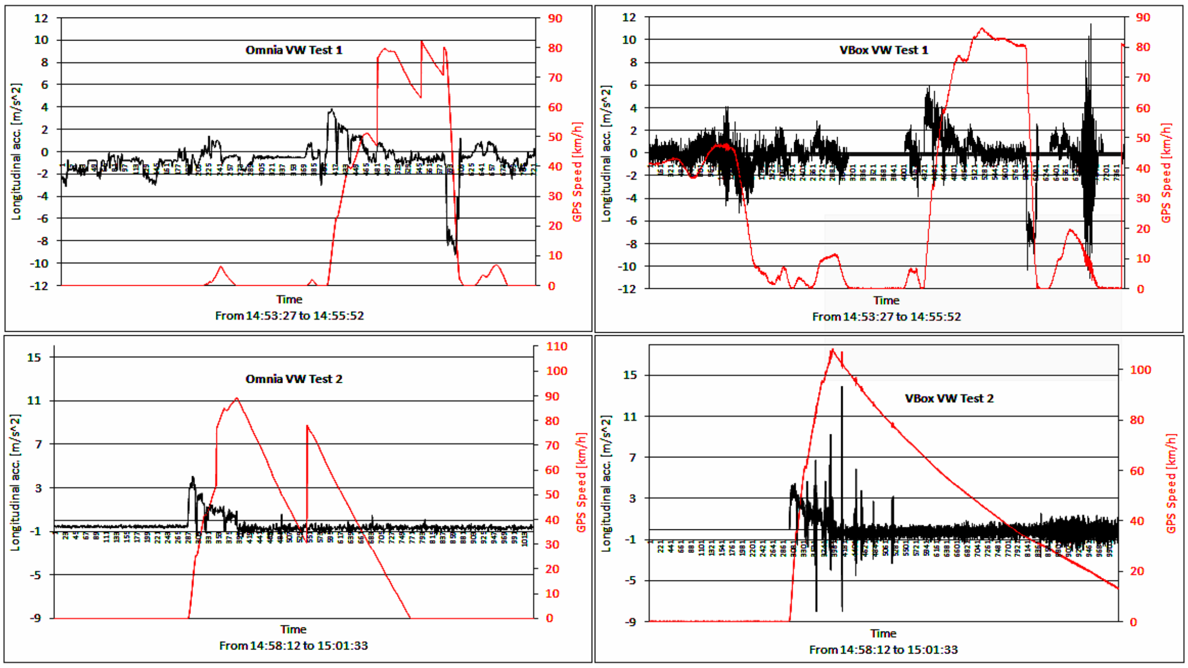

Fig. 4 Results obtained with Samsung Omnia and Racelogic VBox 100 device mounted into VW Golf car

CONCLUSION

This paper was based on development and the research for mobile phones used in traffic accident reconstruction, research carried out on the Automotive and Engine Department of Transilvania University of Brasov. The paper main goals were to assign adequate answers of the followings questions:

1. Can we obtain the confidence data using a simple windows mobile device (Smartphone)?

2. How can we use these data into current traffic accident reconstruction activities?

3. Which are the driver, car and road parameter logged by some current WM GPS and accelerometer-based application and how can we extend them?

1. Data obtaining by using an actual quality Windows Mobile Smartphone are difficult to compare with others achieved with professional research devices. Outputs accelerometer parameters are functions of time steeps variable depending of the GPS refresh rate. As result, poor satellites GPS visibilities induce more long time steeps and poor accelerations and velocity digital output. Other issues is provided by incorrect in car devices mounted position and/or axes alignment. God quality of the actual Smartphone accelerometers needs specific software that can claim all of capabilities. Using the specific API Smartphone knowledge we intend to develop new software that will exclude the influence of the GPS refresh rate issues.

2. Many vehicle dynamic parameters obtaining using software like gPC (Performance Calculator based on g-forces) can be used into Traffic Accident Reconstruction activities. Accelerations and specific vehicle speed can be used to calculate road profile, tire-road friction coefficient, on wheel power, specific drag coefficient and others. Other applications and Smartphone facilities can work, for example, as road transversal and longitudinal clinometers or, using high definition phone photo camera, we can take picture and make notes or sketch directly on the traffic accident picture using Smartphone touch screen.

3. The driver, car and road parameter logged by actual Windows Mobile, Android and iPhone GPS and accelerometer-based application can be:

- Forward, vertical and lateral accelerations;
- Data for horsepower vehicle’s calculation using device's internal GPS receiver;
- Data inputs for possible calculated values, including g-forces, angles GPS data and calculated horsepower (HP), while being saved to a proper log file by the user;
- Data for 0 - 100 Km/h or 0 - 60 miles/h acceleration times calculations;
- Data for calculation of time and horsepower for 0 - 402 meter or 1/4 of mile acceleration times, while in dragster mode.

In some circumstances, peak acceleration values characteristic for a car crash accident, can be used for automated call of emergency services.

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