

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Кафедра аеронавігаційних систем

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри

«_» _____ 2017р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬО-КВАЛІФІКАЦІЙНОГО РІВНЯ
«МАГІСТР»

Тема: «Алгоритми обробки інформації навігаційних сенсорів
мобільних пристроїв користувача»

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Київ 2017

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

НН Інститут аеронавігації

Кафедра аеронавігаційних систем

Спеціальність: 8.07010203 « Системи аеронавігаційного обслуговування»

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« _ » _____ 2017р.

ЗАВДАННЯ

на виконання дипломної роботи

Ничака Михайла Васильовича

1. Тема дипломної роботи «Алгоритми обробки інформації навігаційних сенсорів мобільних пристроїв користувача» затверджена наказом ректора від 11 жовтня 2016р. №2600/ст.
2. Термін виконання роботи: 03.10.2016 по 20.01.2017.
3. Вихідні дані до роботи:
 - міжнародні стандартизуючі документи ICAO, Eurocontrol, IEEE;
 - Нормативна документація з обслуговування та розробки додатків під OS Android.
4. Зміст пояснювальної записки: аналіз електронних пристроїв користувачі та оглядовий аналіз характеристик датчиків, що можуть бути використані для ~~аеро~~навігації користувача, дослідження часової проблеми мультисенсорного пристрою та розробка структурної схеми інтегрованої системи.
5. Перелік обов'язкового графічного (ілюстративного) матеріалу: графіки,

таблиці, формули.

6. Календарний план-графік

№ п/п	Завдання	Термін виконання	Відмітка про виконання
1.	Підготовка та написання 1 розділу «Електронні пристрої та обробка даних»	03.10.16-15.11.16	виконано
2.	Підготовка та написання 3 розділу «Сенсори мобільного телефону кишенькового пристрою»	16.11.16-30.11.16	виконано
3.	Підготовка та написання 4 розділу « Пере ведення вимірів до єдиної шкали часу»	31.11.16-18.12.16	виконано
4.	Підготовка та написання 5 розділу « Вимірювання та обробка даних Зчитування даних »	19.12.16-14.01.17	виконано
5.	Підготовка презентації та доповіді	15.01.17-20.01.17	виконано

7. Дата видачі завдання: « 03 » жовтня 2016 р.

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(підпис студента) (П.І.Б.)

РЕФЕРАТ

Пояснювальна записка до дипломної роботи «Алгоритми обробки інформації навігаційних сенсорів мобільних пристроїв користувача»: 100 сторінок, 45 рисунків, 1 таблиця, 30 використаних джерел, 1 додаток.

Об'єкт дослідження – Процес обробки результатів вимірювання сенсорів мобільних пристроїв.

Предмет дослідження – Алгоритм обробки інформації навігаційних сенсорів.

Мета роботи – Розробка алгоритму обробки інформації навігаційних сенсорів мобільних пристроїв користувача та дослідження можливості використання дешевих навігаційних сенсорів на базі кишенькових пристроїв для виконання навігаційних вимірювань.

Метод дослідження – комп'ютерне моделювання та експериментальні випробування.

Наукова новизна полягає в наступному: за допомогою спеціально створеної програми здійснено аналіз даних сенсорів (акселерометра, гіроскопа, сенсора інтенсивності звуку, GPS приймача) з мобільного пристрою користувача. Інформація записана в текстовому форматі у спеціальній формі. Програма підтримує два типи обробки даних: інтерполяція поліномом та інтерполяція сплайном для різних часових вимірів.

Чому так важливо передавати інформацію з сенсорів до пристроїв обробки інформації. У наш час стрімко розвиваються безпілотні літальні апарати. Можливість швидкої і точної передачі даних від сенсорів літальних апаратів дасть багато переваг і можливостей. Тому значно дешевше і швидше буде розробити нові алгоритми роботи для даних типів передачі даних і обробки інформації, ніж впроваджувати абсолютно нові.

СЕНСОР, ДОСЛІДЖЕННЯ, МОБІЛЬНИЙ ПРИСТРІЙ, МЕТОД, ІНТЕРПОЛЯЦІЯ, ВИМІРЮВАННЯ, ПЕРЕДАЧА ДАНИХ, ГРАФІК, ОБРОБКА ДАНИХ, ОЦІНКА.

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY

Air Navigation System Department

PERMISSION TO DEFEND
GRANTED

Head of the Department

~~V. Yu. Larin~~

« _ » _____ 2017

MASTER'S DEGREE THESIS

Theme: «Information processing algorithm from navigation
sensors of user mobile devices»

Completed by:

Nychak M.V.

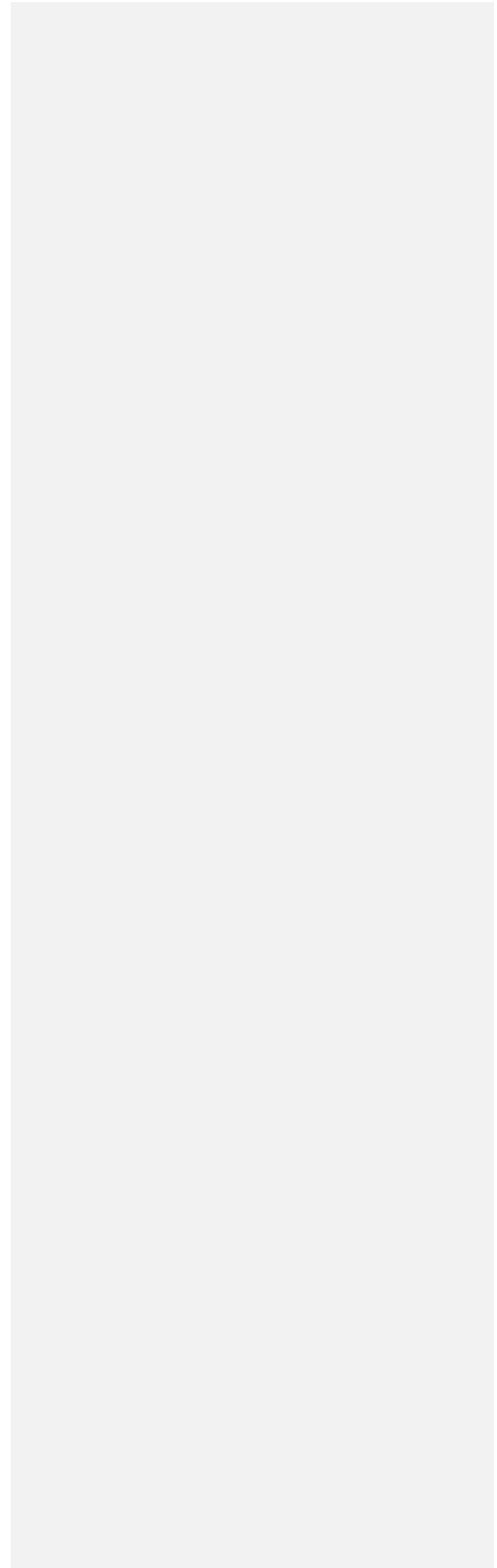
Supervisor:

Ostroumov I.V.

Standarts Inspector:

Larin V.Yu.

Kyiv 2017



NATIONAL AVIATION UNIVERSITY

~~AS-Educational and Scientific~~ Institute of ~~air-Air navigation~~ Navigation

Air Navigation Systems Department

Specialty: 8.07010203 « Systems of Aeronavigation Service »

APPROVED BY

Head of the Department

V. Yu. Larin

« » 2017

Graduate Student's Degree Thesis Assignment

Mykhailo Nychak

1. The Project topic: «Information processing algorithm from navigation sensors of user mobile devices» approved by the Rector's order of « 11 » October 2016 № 2600/st
2. The Project to be completed between: 03.10.2016 – 20.01.2017.
3. Initial data to the project:
 - International standardizing documents ICAO, Eurocontro, FAA;
 - Android application maintenance and development normative documentation.
4. The content of the explanatory note (the list of problems to be considered):
User electronic devices analysis and viewing analysis of the characteristics of sensors that can be used for air navigation purposes. Multi-sensor devices time problem investigation and integrated system structural scheme development.

5. The list of mandatory graphic (illustrated) materials: graphs, tables, formulas.

6. Calendar timetable

№ п/п	Completion stages of Degree Project	Stage completion dates	Remarks
1	Preparation of chapter 1: « Custom devices and data processing »	03.10.16-15.11.16	completed
2	Preparation of chapter 3: « Sensors of smartphone »	16.11.16-30.11.16	completed
3	Preparation of chapter 4:« Calculation to unique time »	31.11.16-18.12.16	completed
4	Preparation of chapter 5: «Data measuring and processing»	19.12.16-14.01.17	completed
5	Preparation of report and graphic materials	15.01.17-20.01.17	completed

8. Assignment accepted for completion «03» October 2016

Supervisor _____ I.V.Ostroumov

Assignment accepted for completion _____ M.V. Nychak

ABSTRACT

Explanatory note to the master's thesis, « Information processing algorithm from navigation sensors of user mobile devices ~~Measurement and processing of data from electronic devices~~»: 100 pages, 45 figures, 1 table, 30 references, 1 appendix.

Investigation object – mobile device sensors measurement results processing.

Investigation subject – Navigation sensors information processing algorithm.

Purpose of the work – Information processing algorithm development from user mobile device navigation sensors and ~~invastigation~~ investigation of the possibility of using low-cost navigation sensors based on user pocket devices to perform navigation measurements.

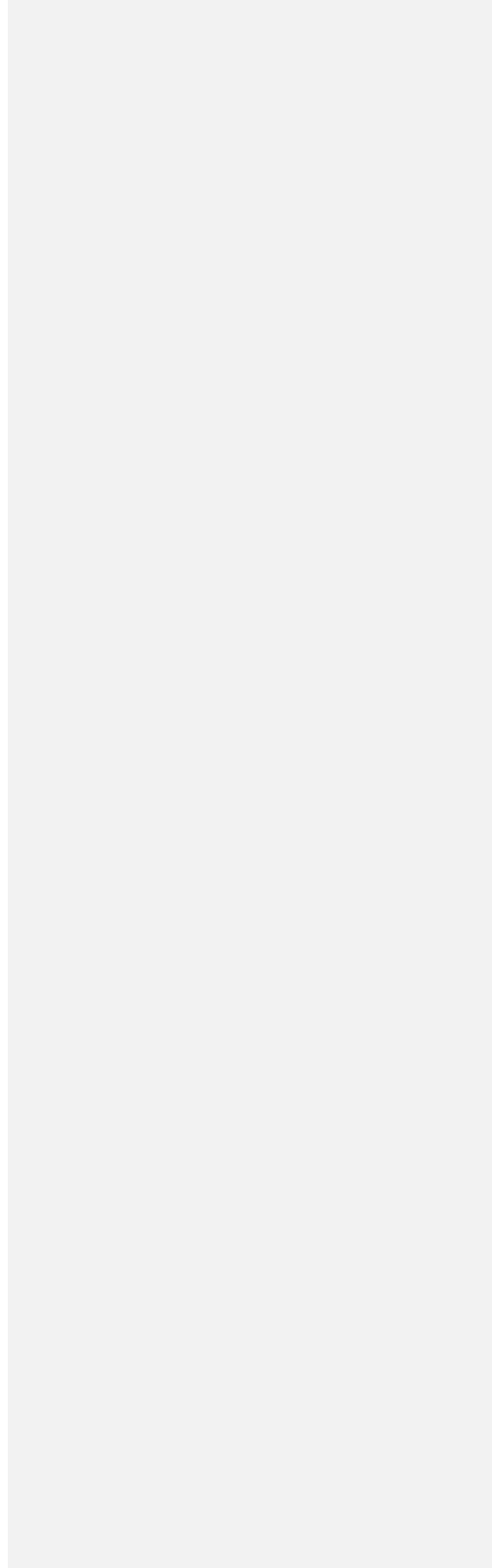
Investigation method – computer modeling and experimental researches.

Scientific innovation is in the following: using a specially created program was making analysis of data from sensors (accelerometer, gyroscope, sound intensity sensor, GPS receiver) of user pocket devices such as (smartphone, smart glasses, car din smart devices, tablets, etc.). Data is recorded in ~~txt~~ textual form in special format. Software supports two types of data processing: Polynomial interpolation and Spline interpolation ~~for unique time~~.

Why it is so important to transmit data online into MatLab. Nowadays rapidly are developing unmanned aerial vehicles. If we can transmit data from UAV sensors into MatLab, then we can process it and get the desired information about UAV. Of course we have to use the most chipiest way to data transfer.

SENSOR, RESEARCH, MOBILE DEVICE, METHOD, INTERPOLATION, MEASUREMENT, DATA, GRAPHS, DATA PROCESSING, EVALUATION.

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INTRODUCTION

Thesis actuality. Sensor it is the most powerful part of any system. Aviation industry is the plase where millions of sensors is be used for difetrent purposes. Other very important task of avionics equipment is data transfer between sensors to processing equipment. Why it is so important to transmit data online into MatLab? Nowadays rapidly are developing unmanned aerial vehicles. If we can transmit data from unmanned aerial vehicle (UAV) sensors into MatLab, then we can process it and get the desired information about UAV. Of course we have to use the most chipiest way to data transfer.

Today everyone in the world has such kind of mobile phoneporked electric device. Many of them has different sensors, such as: pressure sensor, temperature sensor, gravity sensor, gyroscope, rotation vector sensor, proximity sensor, light sensor, orientation sensor, magnetic field sensor, accelerometer, GPS receiver and so on. It will be grate step to use cool if we can use real time data from cell phone sensors inside porket device for some navigation tasks.

Thesis relation with scientific research programs, schedules and themes

Scientific research was done in the framework of international fundamental researches of IEEE.

Investigation object – mobile device sensors measurement results processing.

Investigation subject – Navigation–navigation sensors information processing algorithm.

Purpose of the work – Information processing algorithm development from user mobile device navigation sensors and invastigation of the possibility of using low-cost navigation sensors based on user pocket devices to perform navigation measurements.

Investigation method – computer modeling and experimental researches.

Science research novelty is in using a specially created soft program for data processing from remote sensors of pocket device and recorded data in txt form in special format. Software support two types of data processing for unique time.

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Practical results of science research. The result of simulation are shown on special graphs for trajectory is 3D graph and for other parameters in relation to time.

Results were published in scientific conferences and has got a patent.

LIST OF ABBREVIATIONS AND EXPLANATION OF TERMS

CPU – Central Processing Unit

PC – Personal Computer

NFC – Near Field Communication

AC – Alternative Current

PDA's – Personal Digital Assistants

PSTN – Public Switched Telephone Network

MMS – Multimedia Messaging Service

FM – Frequency Modulation

USB – Universal Serial Bus

LCD – Liquid Cristal Display

OLED – Organic Light Emitting Diode

GPS – Global Positioning System

SD – Secure Digital

OHMD – Optical Head-Mounted Display

HUD – Heads-UP Display

AR – Augmented Reality

DIN – Deutsches Institut Normung

DVD – Digital Versatile Disk

LAN – Local Area Network

WLAN – Wireless Local Area Network

SHF – Super High Frequency

ISM – Industrial, Scientific and Medical

IEEE – Institute of Electrical and Electronics Engineers

WPS – Wi-Fi Protected Setup

WPA – Wi-Fi Protected Access

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UHF – Ultra High Frequency

PANs – Personal Area Networks

SIG – Special Interest Group

GFSK – Gaussian Frequency-Shift Keying

DQPSK – Differential Quadrature Phase Shift Keying

BR – Basic Rate

EDR – Enhanced Data Rate

SMS - Short Message Service

EDGE – Enhanced Data Rates for GSM Evolution

OS – Operation System

PIDs – Process Identifiers

FS – File System

IR – Infrared

LED – Light Emitting Diode

DOP – Delusion Of Precision

CMG – Control Moment Gyroscope

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CHAPTER 5. DATA MEASURING AND PROCESSING

5.1. Algorithms of data processing

—Very important task ~~of~~ ~~of~~ this work is data transfer between sensors and processing equipment. We have three main parts of equipment which are interact between each other. Those three parts are: mobile phone; personal computer, laptop or other machine; Wi-Fi, Bluetooth router or other transferring device. In our case we use cell phone (with special application), wi-fi router and personal computer (with special software).

—The detailed structural scheme of the data transferring and processing is represented on the figure 5.1. In this scheme we can see three main blocs and internal structure of two of them. Cell phone block consist of: block of sensors, microcontroller, memory, display, wi-fi module and touch screen.

—While working of mobile device sensors all information from these sensors is transfer to data bus and process in microcontroller. After microcontroller thru the same data bus it can be transferred by wi-fi module (ip address 192.168.1.2) or visualized on the display. From wi-fi module of the call phone information goes to wi-fi router (ip address 192.168.1.1) which redirect our sensors information to the wi-fi module of the personal computer (ip address 192.168.1.3).

—Personal computer block consist of hardware part and software part. In hardware part receiving information goes to the data bus, then to central processing unit and to from data bus to software block. In software block we use “Android sensor support” adding to MatLAB.

—Why it is so important to transmit data online into MatLab? If we can transmit data from mobile device sensors into MatLab, then we can process it and get the desired information. We use MatLab for recording and decoding data. Also we use spline interpolation and polynomial interpolation methods (which are described in chapter 4) to process data and get corresponding calculations and graphs.

—All MatLab working results can be displayed on the screen in real time and all information will be updated during each second. Also all results can be saved on the hard drive disk.

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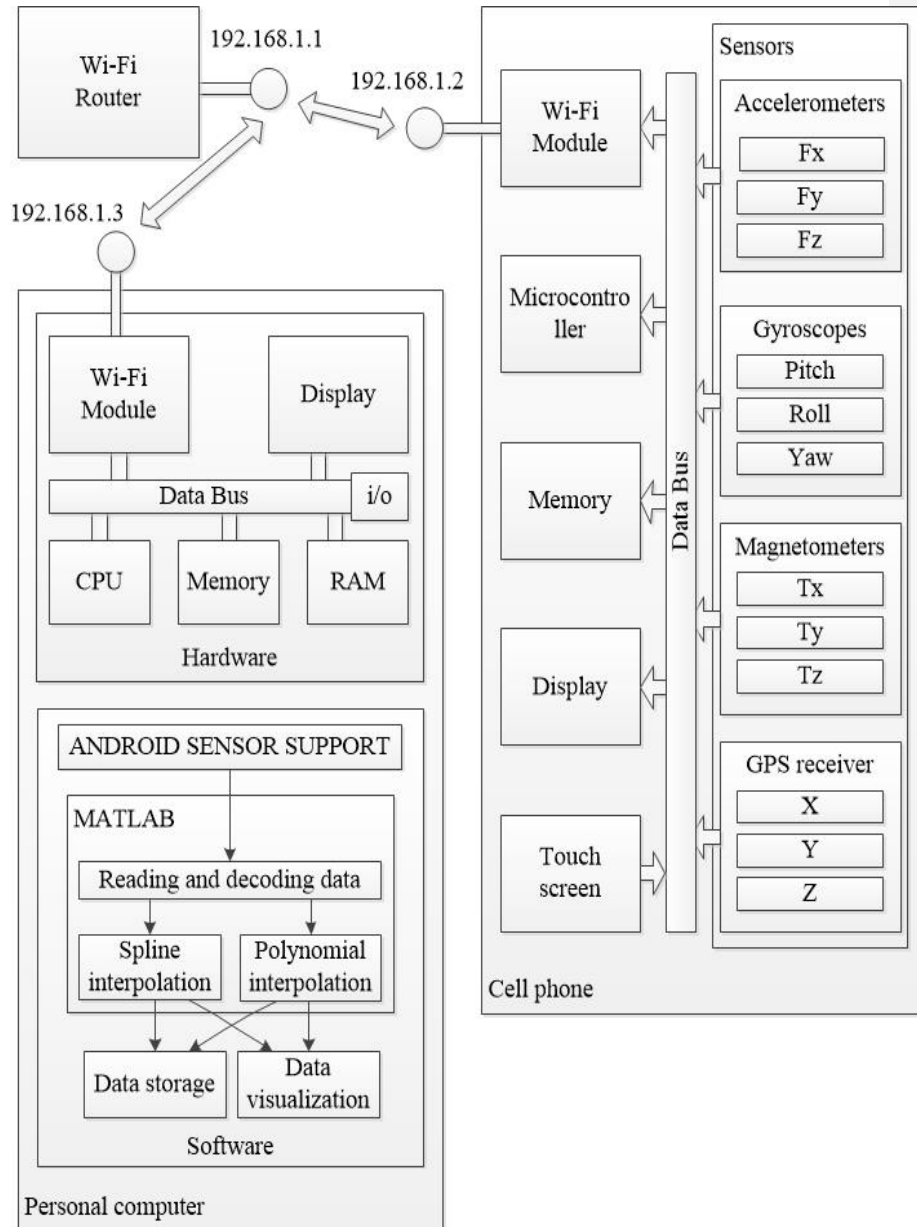


Figure 5.1 - Structural scheme of data processing

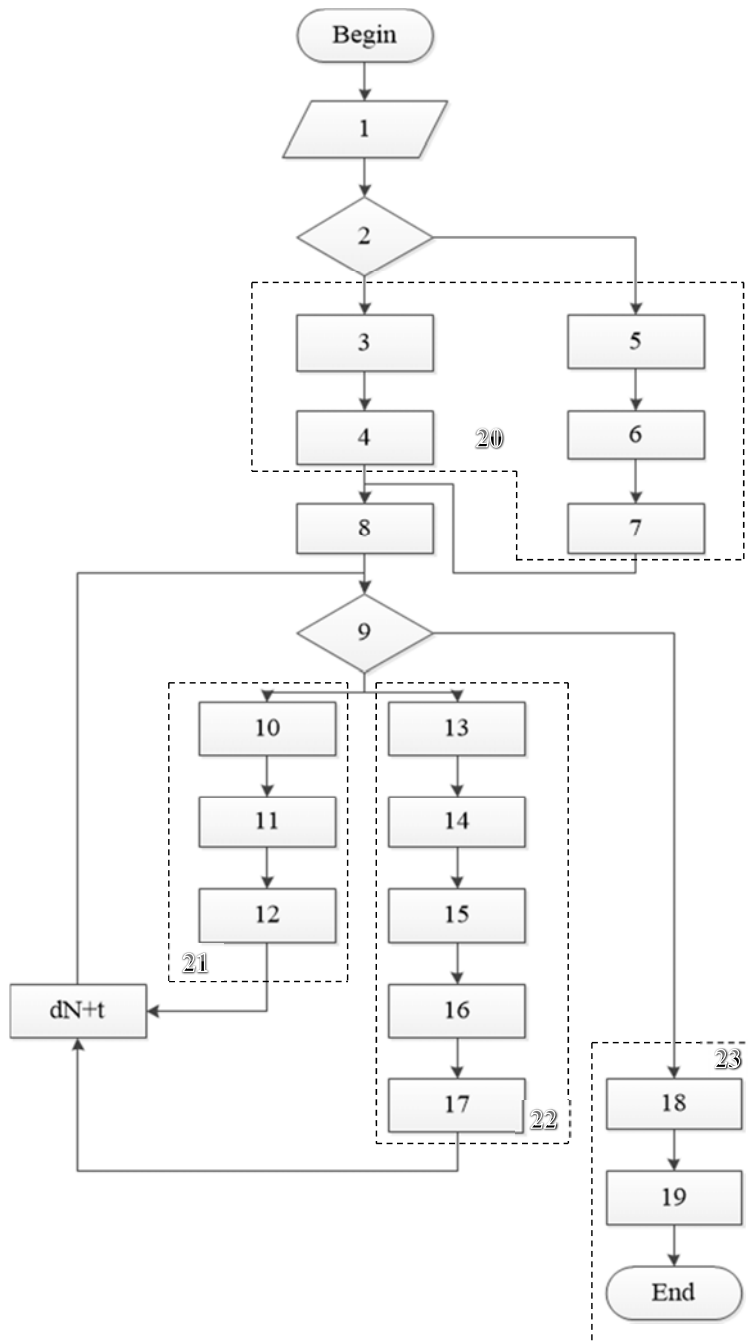


Figure 5.18 - Block scheme of data processing

Algorithm of data processing of information from sensors of mobile phone is represented in figure 5.18. Meaning of block numbers on the scheme:

1. Input data.
2. Desiding block.
3. Reading data from IP host.
4. Data storage in matrixes.
5. Reading data from “*.txt” file.
6. Starting to int. convertation.
7. Data storage.
8. Sensor measurement parameter changing $dN=1$.
9. Comparison of dN with maximal number of parameters.
10. Calculation of Polynomial coefficient (description in chapter 4.4).
11. Calculation of parameters in single time scale.
12. Saving of results.
13. Calculation of the spline node points (description in chapter 4.5).
14. Calculatio of “Coux de Bour function”.
15. Calculation of Spline function coefficients.
16. Calculation of parameters in single time scale.
17. Saving of results.
18. Moving trajectory 3D visualization.
19. Plot of parameters depending from time.
20. Data receiving block.
21. Block of calculation to the single time scale with the help of Polynomial interpolation.
22. Block of calculation to the single time scale with the help of Spline interpolation.
23. Plot of graphs and 3D visualization data block.

[This alghoritm has been used to developed specific software in MATLAB for data transfer and anaisis. Some basic codes of this software has been represented in Apendix A. Also, software received authorship lisence \(Apendix B\).](#)

5.2. Data measurement

—To make data measurements possible online we enable MATLAB to access onboard sensors on Android mobile devices. With this method, we can access a mobile device's accelerometer, magnetometer, location, orientation and compass information directly from MATLAB running on your computer. It is possible to access current and logged sensor data, and you can use MATLAB to visualize and analyze the mobile sensor data or make decisions based on the acquired data.

—To use this method, the computer and mobile device must be on the same network. The method includes the necessary MATLAB files and a read me document for initial setup. In order to use this, we installed the "Sensor UDP" mobile application.

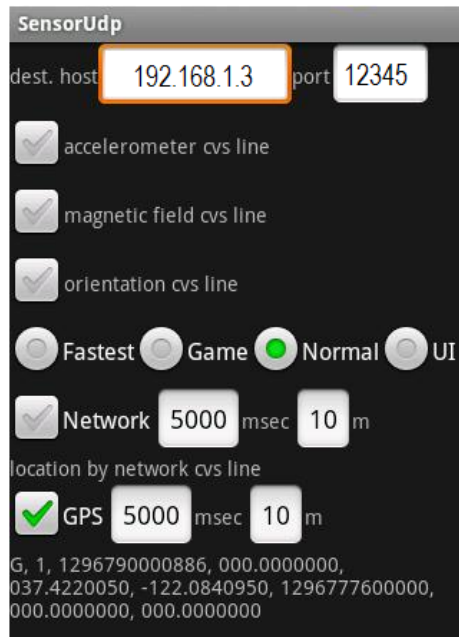


Figure 5.2 - "Sensor UDP" application screen

—This app (fig. 5.2) sends sensor and location information as CVS lines via UDP packet. Netcat is convenient for a receiver. Sensor information includes values

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from accelerometer, magnetic field meter and orientation. You can select network and/or GPS as location provider(s).

5.3. Experimental data

—During the experimental part of this work the data from sensors of mobile phone was measured, transferred to personal computer and processed into corresponding plots (figures 5.3 – 5.17). Those figures represent the recorded data from sensors by orange color and circles; different methods of interpolation by red and blue colors and stars.

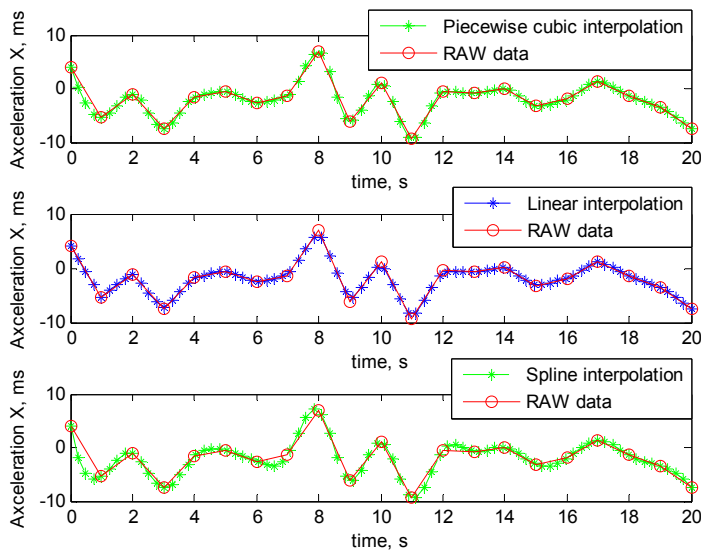


Figure 5.3 – Plot of Raw data from Accelerometer X and Piecewise cubic, Linear, Spline interpolations

—In plots 5.3 – 5.13 I have used Piecewise cubic interpolation, Linear interpolation and Spline interpolation methods. For better detailing of the graphs I have chosen only 20 points of raw data.

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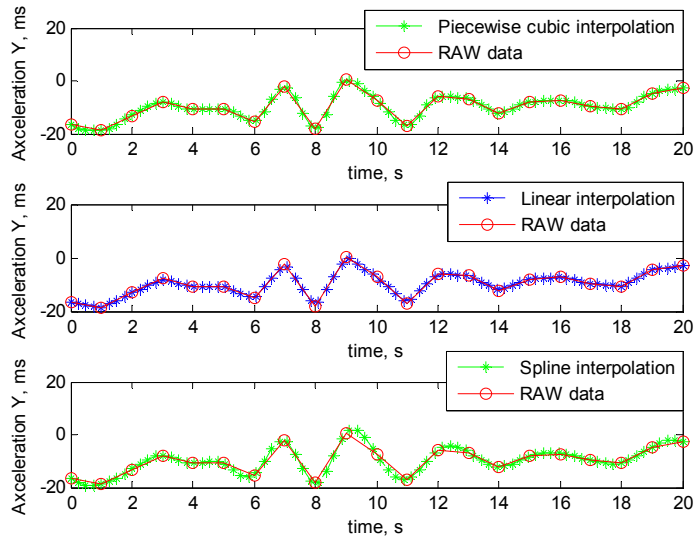


Figure 5.4 – Plot of Raw data from Accelerometer Y and Piecewise cubic, Linear, Spline interpolations

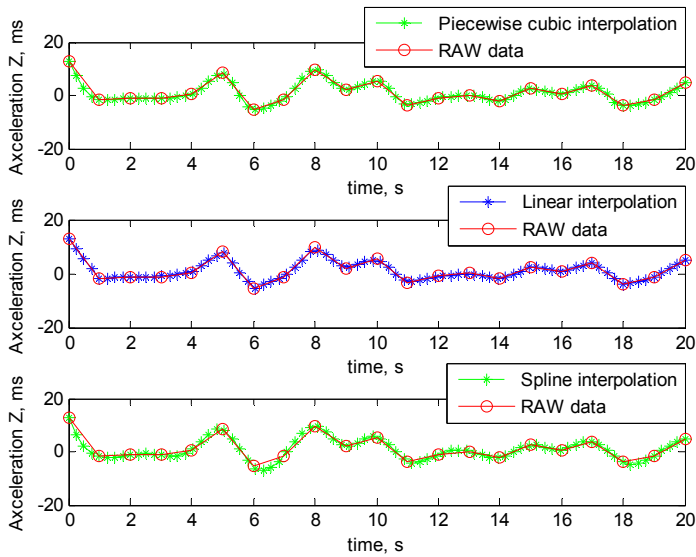


Figure 5.5 – Plot of Raw data from Accelerometer Z and Piecewise cubic, Linear, Spline interpolations

Also I have built the 3D plot (figure 5.6) of the Acceleration X,Y,Z and Spline interpolation.

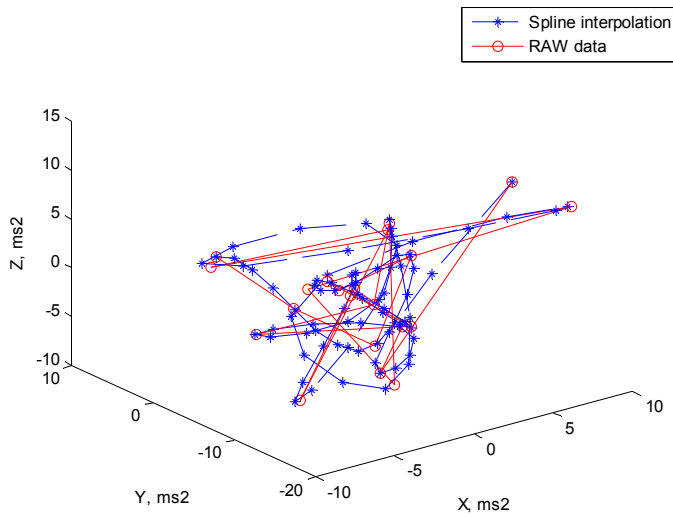


Figure 5.6 – 3D plot of Acceleration X, Y, Z and Spline interpolation.

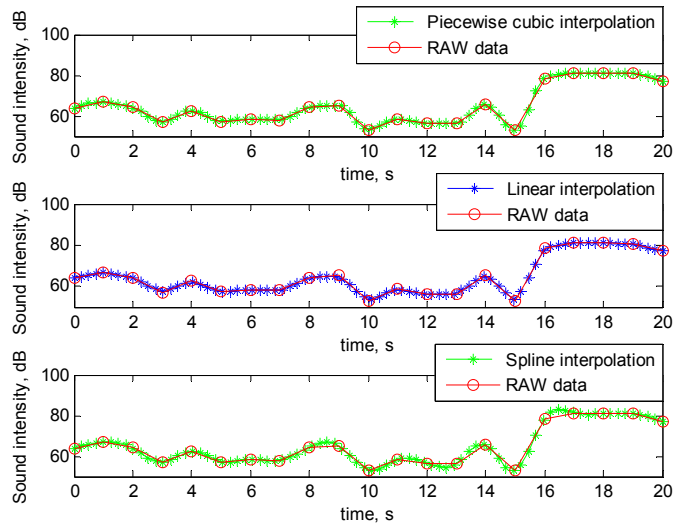


Figure 5.7 – Plot of Raw data from Sound intensity sensor and Piecewise cubic, Linear, Spline interpolations

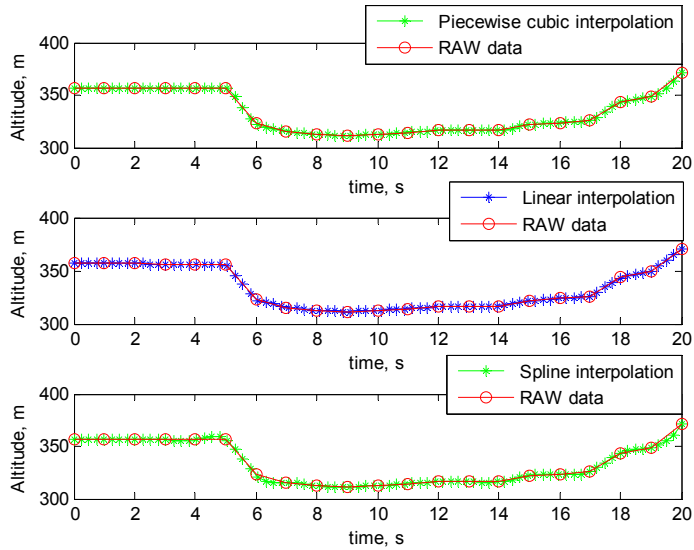


Figure 5.8 – Plot of Raw data from GPS Altitude and Piecewise cubic, Linear, Spline interpolations

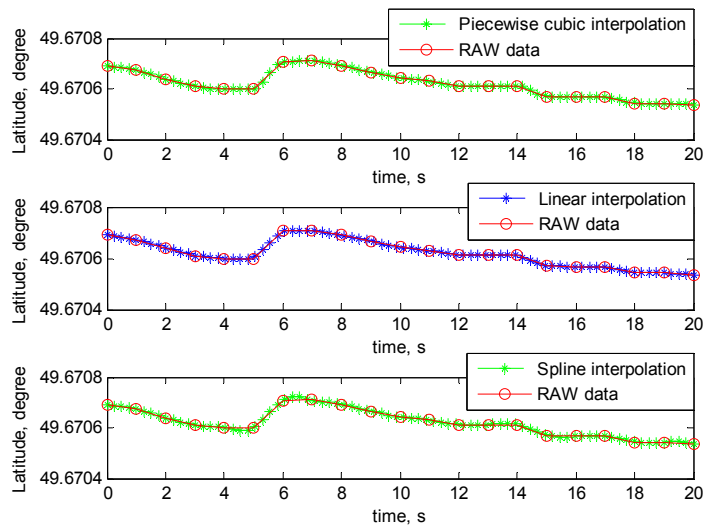


Figure 5.9 – Plot of Raw data from GPS Latitude and Piecewise cubic, Linear, Spline interpolations

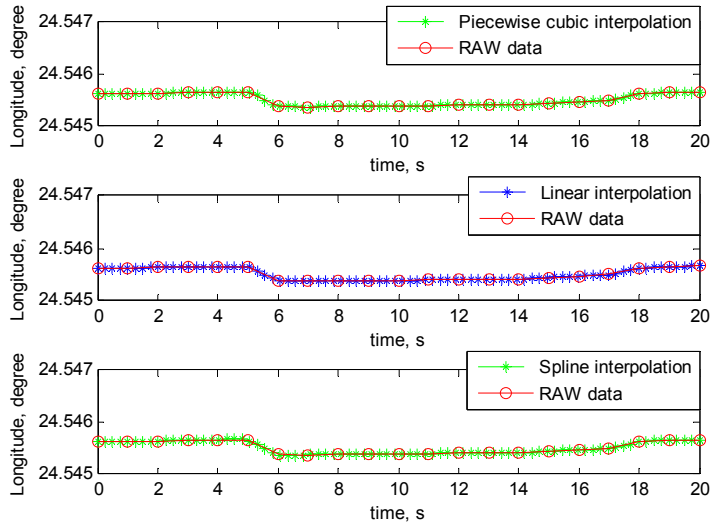


Figure 5.10 – Plot of Raw data from GPS Longitude and Piecwise cubic, Linear, Spline interpolations

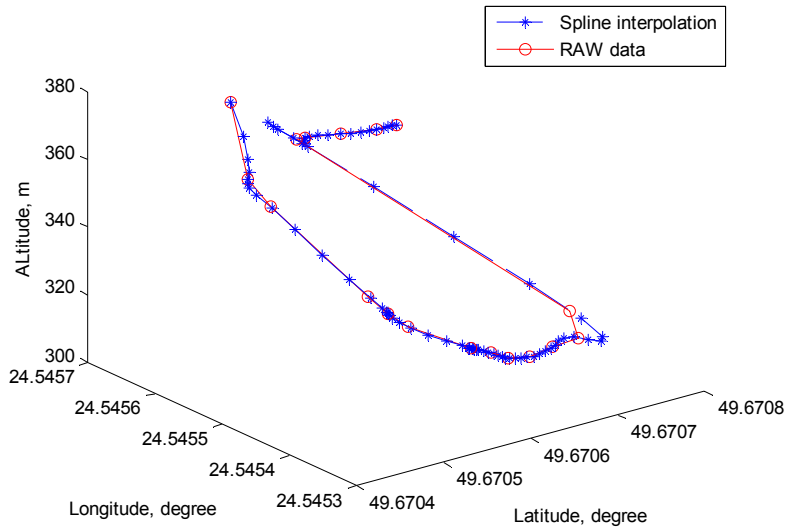


Figure 5.11 – 3D plot of GPS data and Spline interpolation.

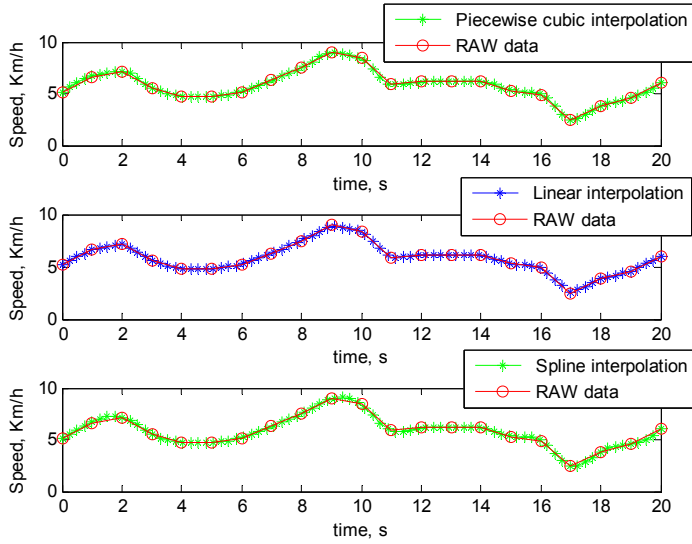


Figure 5.12 – Plot of Raw data from GPS Speed and Piecewise cubic, Linear, Spline interpolations

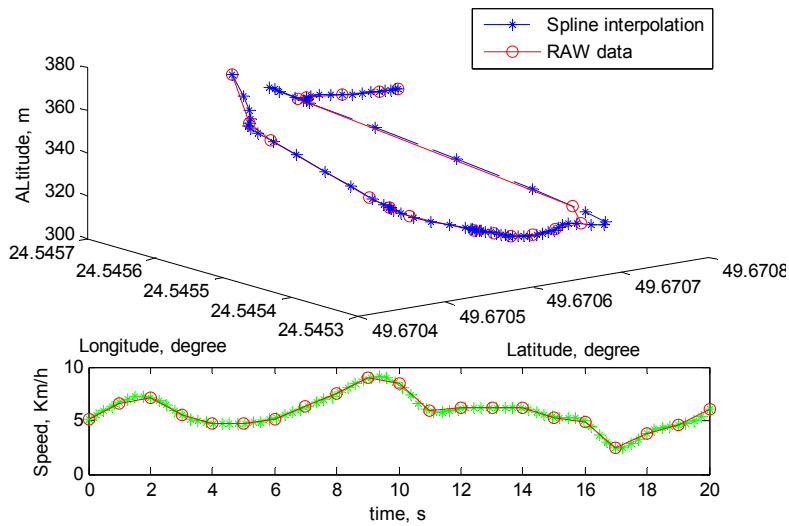


Figure 5.13 – 3D plot of GPS data with Speed and Spline interpolation.

— The other method which was used in this work is Polynomial interpolation. This method in details is described in Chapter 4. Two parameters were investigated by this method: Acceleration X from Accelerometer and Altitude from GPS. Corresponding plots are 5.14 – 5.17.

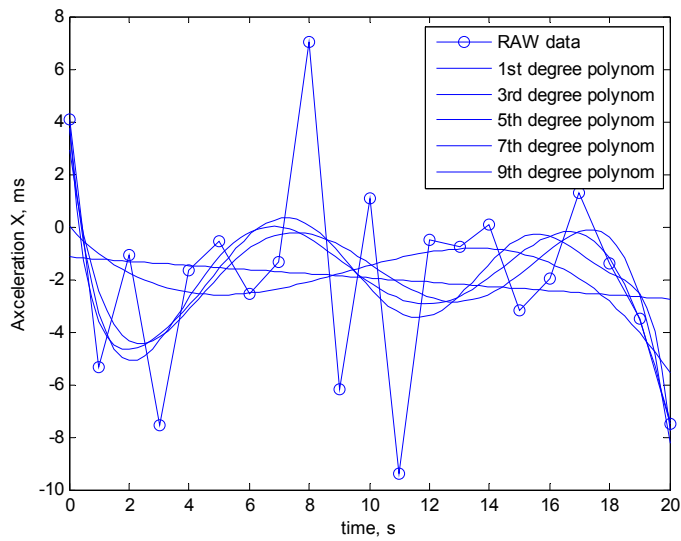


Figure 5.14 – Polynomial interpolation with different degree of polynomial.

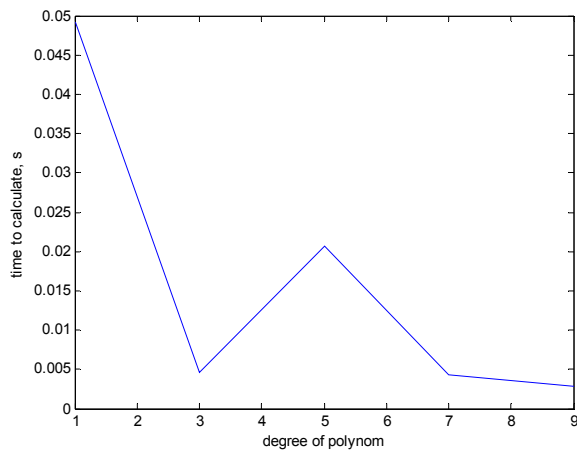


Figure 5.15 – Dependence of time to calculation and degree of polynomial.

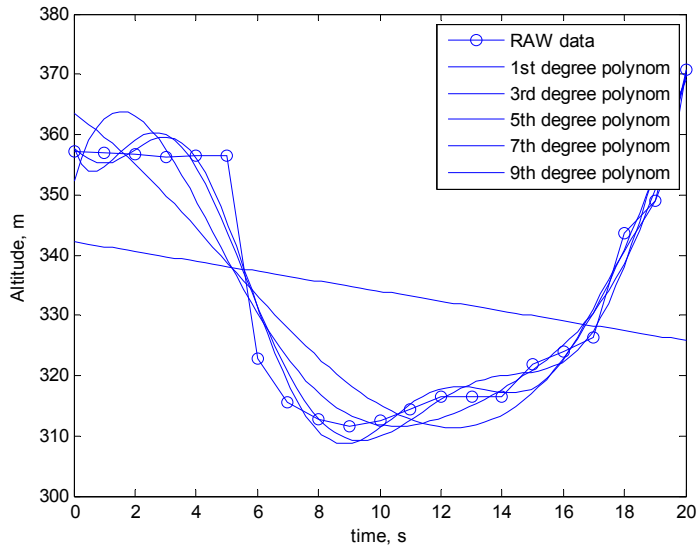


Figure 5.16 – Polynomial interpolation of Altitude with different degree of polynomial.

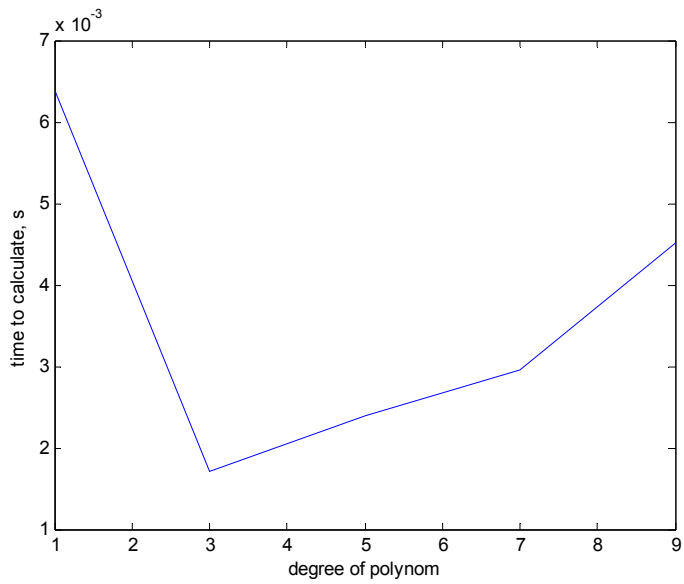


Figure 5.17 – Dependence of time to calculation and degree of polynomial.

Conclusions to the chapter 5

—The fifth chapter of the work include all final result of research. This results represented in figures. In this chapter were presented algorithms of data processing and detailed structural scheme of the data transferring and processing.

—Information which was recorded from three sensors: Accelerometer, GPS receiver and Sound intensity sensor. Received information represented in graphs of raw data, Piecewise cubic interpolation, Linear Interpolation and Spline interpolations. Also for Acceleration X and Altitude were built Polynomial Interpolation with different degree of polynom.

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CONCLUSIONS

Detailed analysis of the theoretical base and the results of practical part of work have allowed making the following conclusions.

Due to the analysis of trends in the aviation industry – aviation industry is the place where millions of sensors is be used for difetrent purposes. Other very important task of avionics equipment is data transfer between sensors to processing equipment. ~~Why it is so important to transmit data online into MatLab?~~ Nowadays rapidly are developing unmanned aerial vehicles. If we can transmit data from UAV sensors into MatLab, then we can process it and get the desired information about UAV. Of course we have to use the most chipiest way to data transfer.

The result of a scientific research paper are a special graphs, for trajectory in 3D graph and for other parameters in relation to time. Was described inside and outside structure of modern devices, there functions and possibilities. Adduce structural schemes of devices hardwere and describe there components.

Has been examined the basic principles of sensors measurement nature. Each sensor measures in some specific time scale and it could be a huge problem while data processing. There are different methods with the help of which we can solve this problem and those methods were described.

Received information represented in graphs of raw data, Piecewise cubic interpolation, Linear Interpolation and Spline interpolations. Also for Acceleration X and Altitude were built Polynomial Interpolation with different degree of polynom.

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Appendix A

Listing of program in MATLAB software

```

clear all; close all; clc
load sensor.mat

ACCELEROMETERXms(1)=[];
ACCELEROMETERYms(1)=[];
ACCELEROMETERZms(1)=[];
LIGHTlux(1)=[];
LOCATIONAccuracym(1)=[];
LOCATIONAltitudem(1)=[];
LOCATIONLatitude(1)=[];
LOCATIONLongitude(1)=[];
LOCATIONORIENTATION(1)=[];
LOCATIONSPEEDKmh(1)=[];
PROXIMITYm(1)=[];
SOUNDLEVELdB(1)=[];
Timesincestartinms(1)=[];

%range cutting
a=20;b=40
AXms=ACCELEROMETERXms(a:b);
AYms=ACCELEROMETERYms(a:b);
AZms=ACCELEROMETERZms(a:b);
L=LIGHTlux(a:b);
LAccuracym=LOCATIONAccuracym(a:b);
LAltitudem=LOCATIONAltitudem(a:b);
LLatitude=LOCATIONLatitude(a:b);
LLongitude=LOCATIONLongitude(a:b);
LORIENTATION=LOCATIONORIENTATION(a:b);
LSPEEDKmh=LOCATIONSPEEDKmh(a:b);
P=PROXIMITYm(a:b);
SdB=SOUNDLEVELdB(a:b);
Timestartinms=Timesincestartinms(a:b);

time=(Timestartinms-Timestartinms(1))*1e-3; %s

num=80
timeint = linspace(0,time(end), num);
AXi=interp1(time,AXms,timeint, 'pchip');
AYi=interp1(time,AYms,timeint, 'pchip');
AZi=interp1(time,AZms,timeint, 'pchip');
Soundi=interp1(time,SdB,timeint, 'pchip');
LOCALi=interp1(time,LAltitudem,timeint, 'pchip');
LOCLATI=interp1(time,LLatitude,timeint, 'pchip');
LOCLONI=interp1(time,LLongitude,timeint, 'pchip');
Speedi=interp1(time,LSPEEDKmh,timeint, 'pchip');

figure(1)

```

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