QUEENSLAND UNIVERSITY OF TECHNOLOGY

IFN 701 – Project Plan

Road surface approximation with high-precise GPS tracks

Supervisor: Yanming Feng

Project Type: Research

Student Name: YIXI ZHOU

Student Number: n9599291

Contents

1. Introduction

1.1 Background

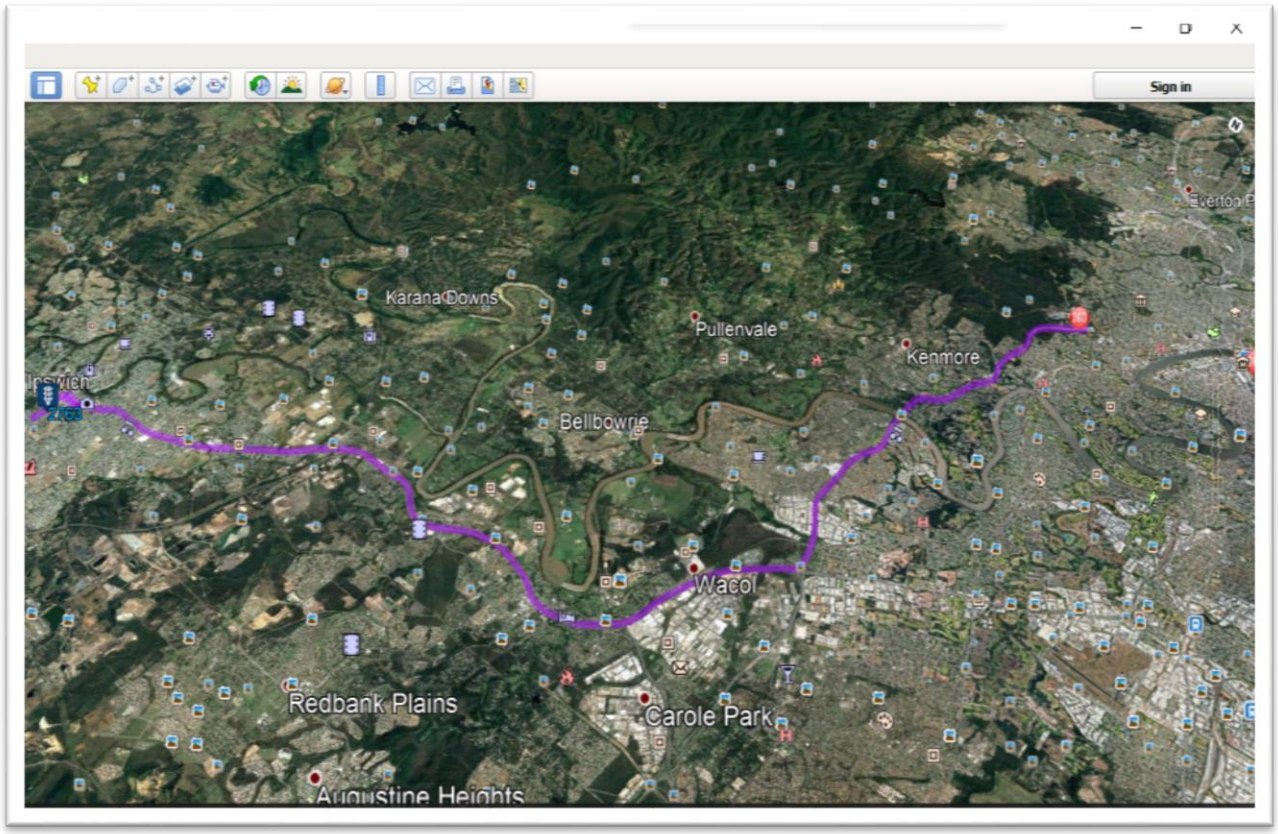
The digital map has become a significance industry area around world. Many big companies like Google and Baidu invest a great deal of capitals to build digital map, such as Google map the most widespread map application in the world. Through connecting with GPS (Global Positioning System), digital map has become the main tool to assist navigation of vehicles and pedestrians. At the beginning of digital map industry, there are two major methods to make digital map, containing digitised paper maps and aerial photographs via airplane or satellite. Lots of 2D maps are created and widely used, however, the requirement of high-precise digital map has continually grown up. The raising requirement of high-precise digital road map is caused by increasing of GPS precise. According to the declaration of semiconductor corporation Broadcom in ION GNSS meeting, a new chip are being tested which is able to provide mobile device for thirty centimetres navigation. The upgradation of GPS precision supply for researchers an original cheaper way compared with using satellites to produce digital map by GPS tracks. Thereby, many researchers have tried to exploit GPS receiver and vehicles for mapping. In prior work, (Jiménez, Aparicio, & Estrada, 2009)the data log vehicles are employed to collect roadway geometry information and develop curve-fitting algorithms to draw digital map for supporting advanced driver assistance systems (ADAS). Paola Di Mascio's team use GPS data to decide the geometry of road alignment(Di Mascio, Di Vito, Loprencipe, & Ragnoli, 2012). Dewang Chen's team utilise Practical Constraint K-Segment Principal Curve Algorithms to create Railway GPS digital map (Chen & Chen, 2013). As a result, some algorithms have already been used widely to describe straight alignments, circular and transition curves.

1.2 Significance

However, most of algorithms still focus on generating high accurate 2D maps. Therefore, in our research, this project purpose is to offer low- cost methodology to generate 3D road map for Brisbane. The first significant reason is the feature of Brisbane topography is to have lots of foothill area. When pedestrians employ google map to navigate walking, the 2D map is easily generate some error in distance because it difficult to compute up-down curve distance. As a Google map user, I usually feel the real distance in foothill area is longer than its calculation distance. Furthermore, the guarantee of higher traffic safety is another motivation, which the knowledge of road geometry could impact drive adapt their approach of driving cars. A good 3D digital road map will give drivers direct impression to show detail information like road gradient, which help drivers determine their driving strategies regard as different road topography. Moreover, we want to implement low- cost methodology for 3D mapping through GPS tracks. By publishing this mapping approach, it could help some medium-sized and small enterprises to generate map for rural area, which enrich the map information for customers.

1.3 Aims and Objectives

To develop our methodology, one road is chosen which from Ipswich to Brisbane city to become our target road (show below picture -1).



Pricture-1

For creating the target road map, we need to utilise high precise GPS to collect vehicle 3D coordinates track data, then draw 3D road surface via surface approximation algorithms. Thereby, three approaches including literature review, building artefact and quantitative analysis will be employed during whole project. There are four major aims for whole project. First of all, the mathematical model of each part of target road (Pricure-1) will be build and explained. Afterwards, we are going to design what kind of surface approximation algorithms are applied for target road. The third aim is to inspect how the experimental GPS data fit to the target surface road. Final aim is to generate the target road map artefact which produced by MATLAP programming code.

1.4 Project scope and target deliverables

Since it is a big project, we separate the project two parts. The first part is to utilize GPS data (longitude and latitude) to construct 2D mathematical model for different part of target road. Then, draw the 2D surface road via MATLAP. The second part is to employ GPS receiver to collect data and create 3D surface model base on the 2D surface model. My working scope is part 1.

In-scope

- Convert longitude and latitude value to kilometers
- Create local 2D coordinate for target road

- Divide target road to different part
- Construct mathematical model for each part of road
- Use MATLAP to draw the 2D surface road

Out-scope

- Use GPS receiver to collect data
- Convert KMZ files to txt files that record the longitude, latitude and altitude
- Build 3D mathematical model based on 2D math model
- Use MATLAP to draw the 3D surface road
- Use experimental data to fit the surface

Target deliverables

- Road Graph determined by longitude and latitude
- Local coordinator for target road (kilometers)
- Math equation for depicting 2D road
- Surface approximation algorithms to build 2D road artefact
- Essay to describe the whole methodology

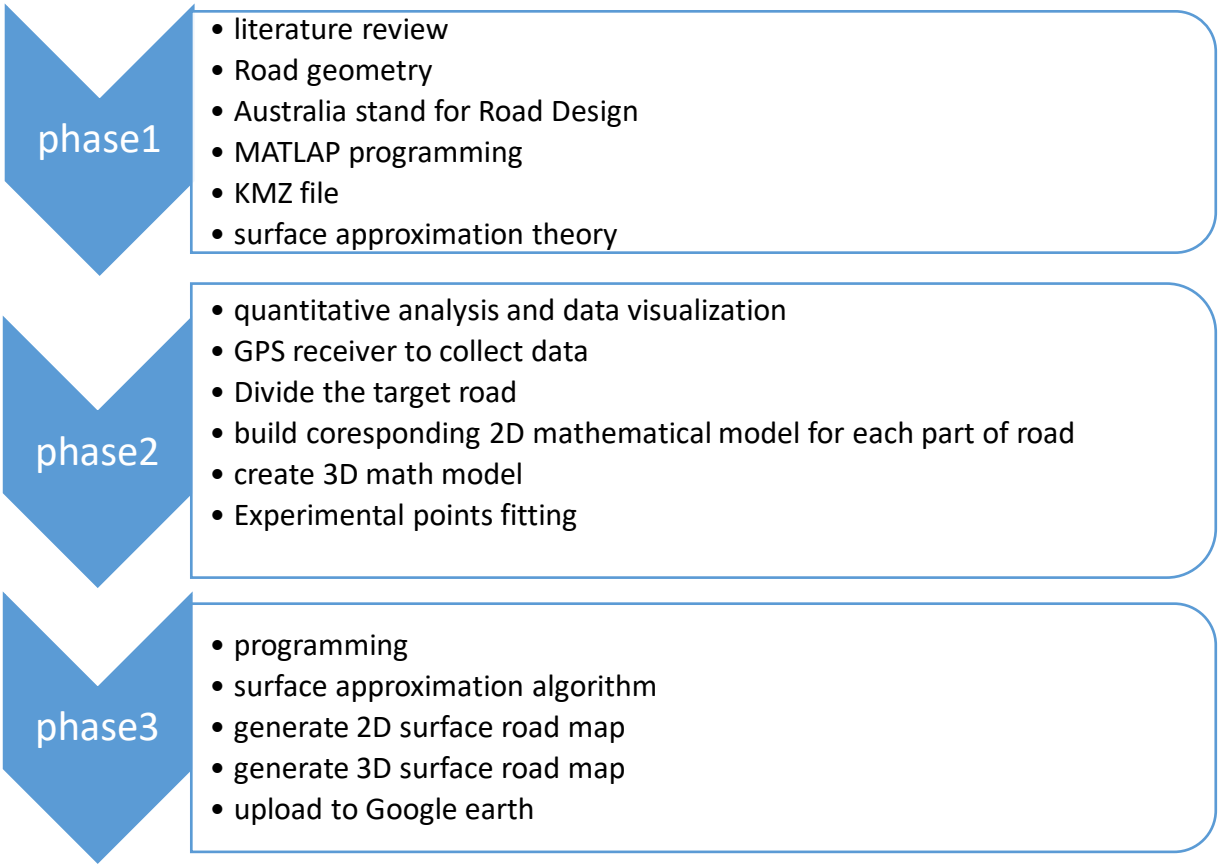
2. Project Methodology

Since the tools, technology and theory is still not familiar to me, literature review will be utilized in the first phase of the project to learn skills that need for the project. Through literature review, I can learn road geometry and global surface approximation theory like smooth surface fitting. It would help me implement the mathematical knowledge to build math model for target road. Also, the MATLAP programming language are desperate for constructing 2D and 3D road surface map. Hence, the MATLAP book and teaching video are going to be read and watched to learn the syntax of MATLAP language. Some other reference, such as Australia stand for road design, are important for me to ensure the width of road. Moreover, I need to study how to use Google earth and KMZ file, these tools can assist us to analyse the collected GPS data. Above all, the first phase are supplied to acquire the knowledge which can solve the issue.

After phase 1, the quantitative analysis and data visualization method will be exploited in phase 2. Initially, a high precise GPS receiver is installed in an automobile. Then, the car travels between Ipswich and Brisbane city to collected GPS data. Because this road is long and the shape is complex, the target road is divided into many parts, which are able to describe by simple and classic mathematical model. For each part of road, there is a mathematical model to depict its features such as length, width and gradient. During this progress, initially, the 2D road math model will be established. Next, at the foundation of preceding 2D math model, we will create 3D math model for the road surface. Subsequently, the experimental will be fitted to mathematical model to check the accuracy through MATLAP graph. Finally, the whole road mathematical model are obtained via combining each math model.

The last phase is to establish an artefact for map. According to the phase 2 mathematical model equation, the surface approximation algorithm will be supplied in MATLAP to generate 2D surface road map firstly. Then, Z-axis will be added to the local coordinator. The 3D mathematical model is going to be constructed basing on 2D model. Finally, we will apply

MATLAP to produce 2D and 3D road surface model. Furthermore, we can upload our map to Google earth to evaluate the precision of 3D map artefact. The below graph show the process of project.



3. Project management approach

To manage IF701 project, Scrum framework has been picked from agile management method. Since there are many individual delivery (different math model) during the project, the Scrum framework contribute numerous sprint review to get the feedback from product owner (academic supervisor). Therefore, we can maximize the value of deliverables via iterative developing(da Silva & Lovato, 2016). Furthermore, this is a research type of project, the artefact features and 2D and 3D mapping methodology are not fixed, however the time is fixed, which due at week 13 semester1. So, this project is suitable to adapt Scum framework management approach. According to the Cynefin leadership framework, the complex method, including probe, sense and respond, is selected in the project(Burman & Aphane, 2016). The reason is that there are many unknown knowledge during research. We need to provide new methodology on mapping. Also, I do not familiar with mapping and GPS area, so I must learn new skills and communicate with product owner in high frequency. During whole project, we utilize the empirical process control approach to manage the project, which contain Transparency, Inspection and adaption.

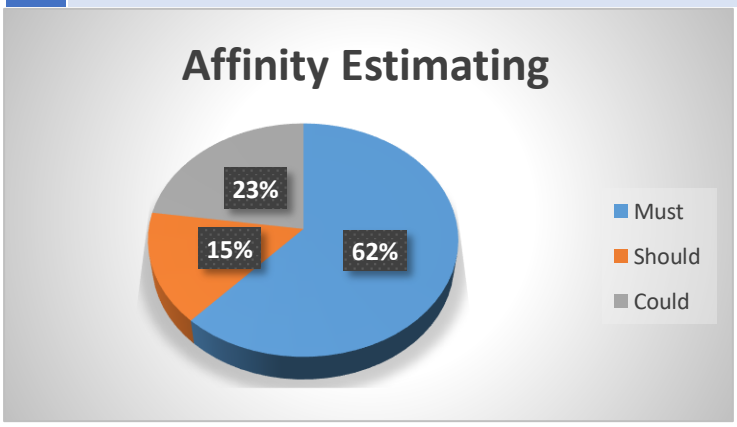
Transparency	• Create product backlog to show what I need to do • Make weekly time planning schedule • Prioritize the item • Meet academic supervisor every week
Inspection	• Collect feedback form academic supervisor in regular week meeting • Academic supervisor check the deliverables at sprint review and sprint retrospective
Adaption	• According to academic supervisor advice, start to achieve 2D surface. • Change the product backlog in project meeting on the basis of product owner opinion

Roles		
Product owner	Development team	Scum master
Yanming feng (academic supervisor)	Yixi Zhou	Yixi Zhou

3.1 Sprint Backlog

ID	Requirement	Priority	Estimate points
1	learn Road geometry	Must	8
2	Learn Australia stand for Road Design	Must	3
3	Study Global surface approximation theory	Must	8
4	Learn MATLAP programming	Must	8
5	Understand KMZ file and Google Earth	Should	2
6	Using GPS receiver to collect more data	Should	5
7	Experimental points will be fitted to mathematical model	Should	3
8	Create local 2D coordinate (x, y)	Must	2
9	Convert KMZ files to txt files that record the longitude, latitude and altitude	Must	3
10	Convert longitude and latitude value to kilometers	Must	5
11	Divide the target road into many parts	Must	3
12	Build math model to describe 2D road	Must	8
13	Use MATLAP to program and show the graph for road	Must	5
14	8.Generate the 2D road surface artefact map	Should	8
15	Build 3D mathematical model to depict surface road (x,y,z).	Could	8
16	Generate 3D surface by MATLAP	Could	8
17	upload to google earth to check the accuracy	Could	1

18	Write the final essay	Must	8
19	Do presentation for research outcome	Must	5
20	Add other information to map	Could	8



3.2 Task breakdown structure and weekly plan

Time	Product Backlog	Deliverables
	Sprint planning	
Week 1	**Find proper project and academic supervisor (project settlement) Meet academic supervisor**	**Know basic project goal Understand project scope**
Week 2	**Sign the project agreement Meet with academic supervisor to acquire detail information for project**	**Submit agreement**
Week 3	**Do literature review to know correlative knowledge about project and prepare Presentation about project plan**	**PowerPoint for project plan Get presentation feedback from teacher**
Week4	**Do literature review Meet with supervisor to discuss project plan and get signature Write the project plan**	**Submit Project plan**

	Sprint 1	
Week 5	**Literature review 1(Sprint Backlog)**	**Understand math knowledge for project**
Week 6	**Learn MATLAP and tools 4,5(Sprint Backlog)**	**Know how to use MATLAP programming and Google earth**
Week 7	**Learn surface approximation algorithms 3(Sprint Backlog)**	**Under take basic knowledge about global parametrizations for surface triangulations, smooth surface fitting**
Week 8	**Study other knowledge and tools**	**Understand KMZ files Know how to use Google earth**

	Which need to use 2,5(Sprint Backlog)	**Review previous knowledge**
Sprint review	**The sprint 1 is focus on phase 1, which I need to learn the skills and knowledge to do the project. In the sprint review, check I understand these basic knowledge. Then, make plan for next sprint**	

Sprint 2		
Week 9	**Data preparation 9,10 (Sprint Backlog)**	**1. The csv file for GPS data (longitude and latitude) 2.csv file show the difference for longitude and latitude (convert to meters value).**
Week 10	**Mathematical model preparation for 2D surface model 8,11(Sprint Backlog)**	**1. local 2D coordinate (x, y) 2. divide target road several parts**
Week 11	**Build 2D math model for each part of target road 12 (Sprint Backlog)**	**Many math equation to describe the feature like length and width of target road**
Week 12	**Generate road surface graph and prepare presentation 13,19(Sprint Backlog)**	**MATLAP programming code The 2D surface road artefact graph Presentation for project research**
Week 13	**Check 2D map accuracy and write final essay 17,18(Sprint Backlog)**	**Report for whole project including mapping methodology and map artefact.**
Sprint review	**Review whole progress for this project. Find the deficiency during the progress for researching. Then, prepare the project in semester 2 to build 3D map based on 2D map.**	

3.3 Communication Plan

channel	Frequency	Participant	Purpose
Regular Week meeting	One a week Every Thursday afternoon 2.00 to 4.00	Academic supervisor Student	1. Check project progress every week and give feedback for deliverables. 2. Ask question for project. 3. Sprint review and retrospective
E-mail	Anytime	Academic supervisor Student	1.aquire GPS data and other required information 2.ask detail question during project 3.send the result and deliverables
Appointment	Book appointment time by E-mail, during Monday to Friday	Academic supervisor Student	1. If I have some sudden problem which cannot solve, I will make appointment for consulting it. 2.demostrate delay deliverables to academic supervisor

3.4 Potential project risks and risk mitigation strategies

Risk	Impact	Possibility of Risk	Severity of Risk	Overall Risk	Mitigation strategies
The learning phase is delayed or not finished	Since I am not familiar with mapping area, studying knowledge, tools and technology that is used in the project is really essential. The delay of learning phase can cause the whole project failed.	Likely	High	High	Regular week sprint meeting ensure the studying planning is on the track. Furthermore, ask many questions to supervisor to solve issues. Use the middle break and weekend time to study project knowledge.
Data quality strictly depend on GPS receiver	Because the math model is based on the GPS data, poor quality data could cause us build wrong mathematical model. It will decrease the artefact road surface precision.	unlikely	High	low	Collect more GPS data to improve the data quality. And Choose a good weather to do the road trip.
Accidental and systematic errors due to the imprecision of satellites	The errors of satellites absolute time and refraction phenomena can cause the track position has 10 meters mistake.	Rare	High	Very low	We will accept this risk, which allow our surface road artefact have 10 meters error.
The mathematical model is not precise enough	Since we divide target road into several parts and employ classic model to express it, the number of dividing parts decide the accuracy of math model. Splitting too much will cause lots of workload. Conversely, it may cause impression of math model, which could generate poor quality map.	Moderate	Low	Medium	Use experimental data to fit the mathematical model, which can check the accuracy of our math model.
Academic supervisor is too busy for regular meeting	It will lead to less feedback for deliverables, and reduce the quality of final artefact. Also, it will accumulate the questions for project, which may delay the project plan each week.	Moderate	Low	Low	Use other communication channel to reduce risk such as E-mail and phone.

4. Reference

Burman, C. J., & Aphane, M. A. (2016). Leadership emergence: the application of the Cynefin framework during a bio-social HIV/AIDS risk-reduction pilot. *African Journal of AIDS Research, 15*(3), 249-260. doi: 10.2989/16085906.2016.1198821

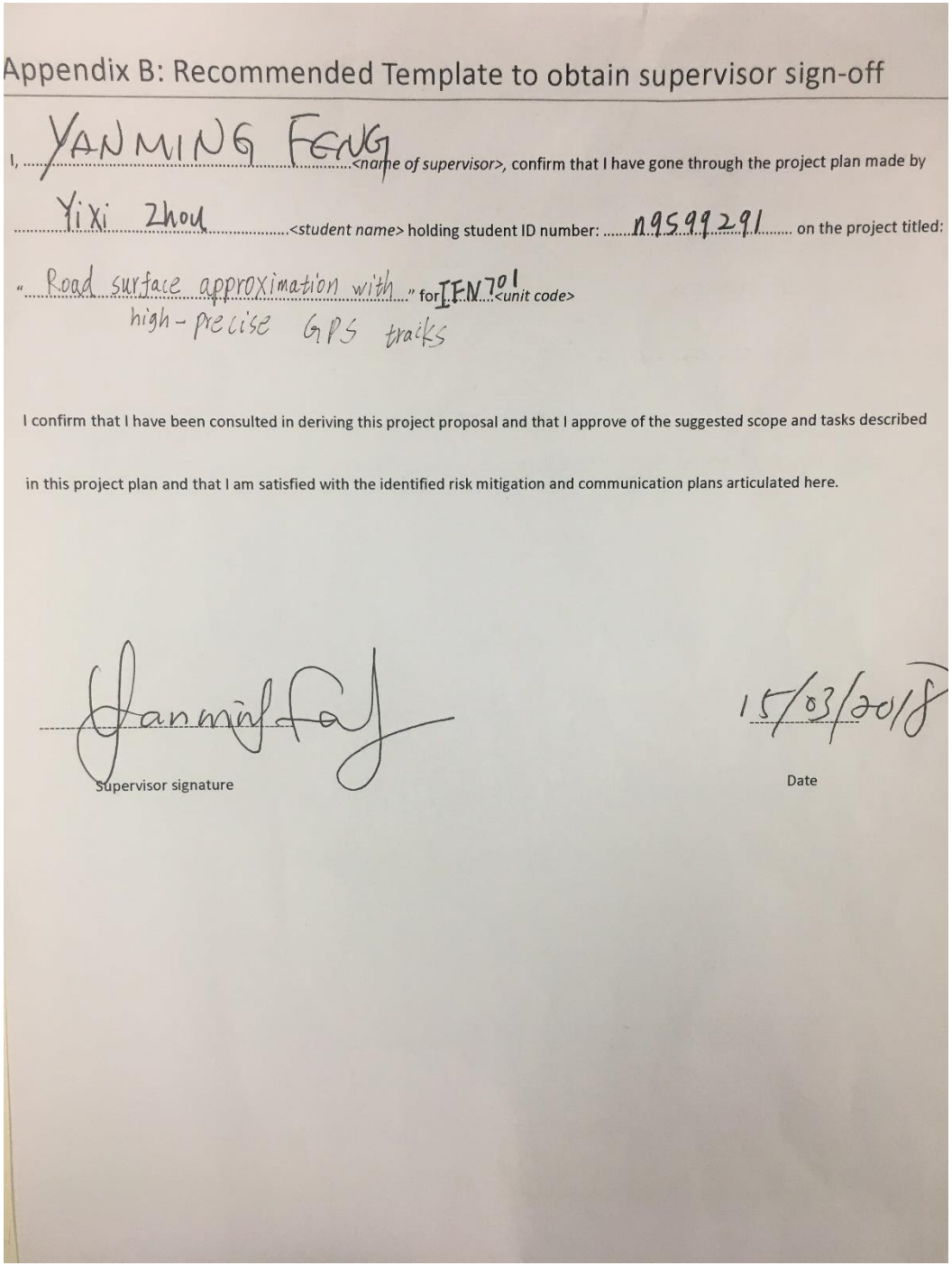
Chen, D. W., & Chen, L. (2013). Practical Constraint K-Segment Principal Curve Algorithms for Generating Railway GPS Digital Map. *MATHEMATICAL PROBLEMS IN ENGINEERING, 2013*, 1-11. doi: 10.1155/2013/258694

da Silva, E. C., & Lovato, L. A. (2016). Scrum framework: efficiency in software projects/Framework scrum: eficiencia em projetos de software. *Revista de Gestao e Projetos, 7*(2), 1. doi: 10.5585/gep.v7i2.330

Di Mascio, P., Di Vito, M., Loprencipe, G., & Ragnoli, A. (2012). Procedure to Determine the Geometry of Road Alignment Using GPS Data. *Procedia - Social and Behavioral Sciences, 53*, 1202-1215. doi: 10.1016/j.sbspro.2012.09.969

Jiménez, F., Aparicio, F., & Estrada, G. (2009). Measurement uncertainty determination and curve-fitting algorithms for development of accurate digital maps for advanced driver assistance systems. *Transportation Research Part C, 17*(3), 225-239. doi: 10.1016/j.trc.2008.10.004

5. Appendix B



Appendix B: Recommended Template to obtain supervisor sign-off

I, YANMING FENG <name of supervisor>, confirm that I have gone through the project plan made by

Yixi Zhou <student name> holding student ID number: n9599291 on the project titled:

"Road surface approximation with high-precise GPS tracks" for IFN701 <unit code>

I confirm that I have been consulted in deriving this project proposal and that I approve of the suggested scope and tasks described in this project plan and that I am satisfied with the identified risk mitigation and communication plans articulated here.

Yanming Feng

Supervisor signature

15/03/2018

Date