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BUMPY

for the Cycling Advocacy of the Zagreb Cyclists' Union

Final Project Report

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1. Introduction

1.1 Purpose of the Document

The purpose of this document is to summarize work experience related to the Cycling advocacy project with respect to project work and results.

1.2 Document Organization

- Section 1, *Introduction*, describes the contents of this guide, used documentation during developing process, etc.
- Section 2, *Background*, describes the customer as well as the purpose and objectives of the project
- Section 3, *Project results*, describes the results of the project such as produced deliverables, fulfilled requirements, etc.
- Section 4, *Project work*, describes the project organization, executed routines, project effort and worked hours, etc.

1.3 Intended Audience

- The customer
- The project's team
- Project supervisors
- All other project stakeholders

1.4 Definition and Acronyms

1.4.1 Definitions

Keyword	Definition
Collected data	Data collected bt Android during cycling, consists of Location and Motion data.
Location data	Location data collected by Android. Each GNSS point has a timestamp, latitude, longitude, elevation, speed and accuracy.
Motion data	Sensors data collected by Android. Each motion data acquisition consists of a timestamp, and three floats (one per each axis) for each sensor (accelerometer, magnetometer and gyroscope).
Trip	All the synthetic information about a trip (including path and issues).
Road Quality	It is a signed float measuring the quality of the road. It can be assigned both to segments and bumpy issues.
Road Quality Map	It is a collection of paths and represents all the roads which have been ridden by the users. It can be plotted over a world map (e.g. OpenStreetMap).
FixMyStreet	An external platform for reporting road issues to authorities
FixMyStreet Issue	An issue pointed out by users. For example, a tree that fell over a street or a damaged semaphore.
Bumpy Issue	An issue automatically detected by the system. Only hard bumps can be identified at the moment.
Heat Map	A map plotting different level of colours (green to red) over a city map to indicate the road quality

1.4.2 Acronyms and Abbreviations

Acronym or Abbreviation	*Definition*
POLIMI	Politecnico di Milano (Polytechnic University of Milan)
FER	Fakultet Elektrotehnike i Računarstva (Faculty of Electrical Engineering and Computing)
UUID	Universally Unique Identifier
UI	User interface
REST	Representational State Transfer
API	Application Program Interface
ID	Identifier
GNSS	Global Navigation Satellite System
CSV	Comma Separated Values (file format)
AT	Android Test
WT	Web Test

1.5 References

Cyclist's Union: http://sindikatbiciklista.hr/en/
Fakultet elektrotehnike i računarstva: https://www.fer.unizg.hr/en
Politecnico di Milano: https://www.polimi.it/en/
FixMyStreet: https://www.fixmystreet.org/
Web application: http://161.53.67.132:3000/

2. Background

The customer of the project is the Cyclist's Union, a volunteer association founded in 2011 and located in Zagreb, Croatia. Their goal is to promote cycling as an efficient, sustainable and healthy way of transport in order to have a clean, safe and pleasant green cities.

In accordance with their goal of getting more people to use cycling as a means of transportation, the Cyclist's Union wishes to develop a technological solution for the reporting of road conditions with the goal of monitoring and improvement. More specifically, the solution should be able to detect rough roads and road bumps, collect that information and visualize it. The basic idea is to rely on today's widespread usage of smartphones, namely Android phones, and utilize their various sensors to obtain road surface data. The data obtained by such means can then be analyzed by some algorithm in order to identify road issues like bumps and abrupt breaks, and then used to visualize and locate all potential road issues and encourage local administrations to intervene, which in turn will result in better road conditions that will incentivize people to turn to cycling.

The project team consists of four students from FER and four students from POLIMI, with one supervisor from each university.

3. Project Results

The end result of our project is an application for android and web and a backend service to support the frontend apps.

Mobile app provides the following features:

- view the Road Quality map with detected bumps
- start and end trip
- see distance, speed, vibration level and duration during the trip
- bumps detection
- view trip statistics
- view the list of past trips
- get achievements during the trips and view the achievements list
- manage the trip data upload process
- export trip as CSV file
- delete trip

Web application provides the following features:

- view the Road Quality map with detected bumps
- log in with the unique identifier
- view the list of previous trips
- view detailed trip information
- export trip as CSV file
- delete trip

Backend service is responsible for and enables the following:

- Collecting and storing user's trip data
- Calculating and storing statistics for the uploaded trips
- Calculating road quality data from the stored trips.
- Calculating bumps from the stored trips

3.1 Produced deliverables

Deliverables produced during the course of this project, along with various revisions, are as follows:

- Documentation
    - Project Plan document
    - Requirements Definition document
    - Design Description document
    - Bumpy API document
    - Acceptance Test Plan document
    - Final Project Report document
    - Installation manual

- 8 Sprint reports
- 26 Minutes of Meeting documents
- Presentations
    - Project vision and plan presentation
    - Requirements definition and design description presentation
    - Project status presentation
    - Alpha prototype presentation
    - Beta prototype presentation
    - Final presentation
- Software
    - “Bumpy” Android application
    - Web application
    - Backend service

3.2 Fulfilled requirements

Out of the 24 core functional requirements defined by the Requirements Definition document, all 24 were completed. Out of the 14 non-functional core requirements defined by the same document, all 14 were completed. Finally, Out of the 5 optional requirements, only 3 were completed due to the fact that the issue reporting feature and FixMyStreet module integration were dropped from the project. In total, out of 43 requirements defined by the Requirements definition document, 41 were completed.

3.3 Missing functionalities and possible improvements

Generally, most of the functionalities defined by the Requirements definition document were successfully completed. Out of 43 requirements, only 2 were not completed. There is also room for possible improvements to the system.

3.3.1 Missing functionalities

While there are two requirements not fulfilled during the course of this project, only one functionality remains unimplemented. The unimplemented functionality is an issue reporting and it relates to both the *OFR-3 Reporting road issues* and *OFR-4 Integrating FixMyStreet* unfulfilled requirements. The issue reporting functionality was supposed to allow Bumpy application users to photograph road issues, geo-tag those photographs with the issue coordinates and upload, or report, the issue to the system service for further processing. In addition, a FixMyStreet module was supposed to be integrated into the system so that issues reported by users would be forwarded to the FixMyStreet platform.

The reason issue reporting was dropped from the project is due to the fact that integrating FixMyStreet proved impractical and not feasible. Firstly, FixMyStreet is supposed to support the country in which it is supposed to work, since it also deals with location checking, local authorities, etc. neither Croatia nor Italy were supported by FixMyStreet. Secondly, FixMyStreet did not provide appropriate interfaces nor guides in order to integrate it with the system. While there potentially exists some way

to either integrate FixMyStreet or bypass these issues, it proved far too complex and outside of the scope of the project.

3.3.2 Possible improvements

Possible improvements to the system mostly relate to various optimizations to improve performance and accuracy. Examples include developing a better algorithm for trip statistics and road quality analysis, better visualisation of synthetic data such as speed, vibrations, road quality, performance improvements for displaying various elements on maps, etc. Additional features that could be added to the system are a login feature and filtering of data. Overall, system stability could also be improved.

3.4 Software installation and operation

Software installation, including backend, database, web and android applications can be found in “Installation instructions.pdf”.

4. Project work

Project work was done over the course of approximately 15 weeks by a team of 8 students from FER and POLIMI.

4.1 Organization and routines

As stated in the Project Plan document, the project was developed using the Scrum methodology over a series of Sprints. To be more precise, the first two Sprints lasted one week each, followed by five Sprints that lasted two weeks each. The final Sprint also lasted only one week. The reason for this change in Sprint duration is because initially, shorter Sprints allowed for quicker adjustments and fine-tuning to organization and Scrum process. Following that, two-week Sprints were more suited for longer tasks regarding system development and documentation writing. The final Sprint lasts only one week since it relates to the final week of project development before the project deadline, during which the project work was finalized.

Regarding Scrum roles, Sandra Kuzmić was elected Product Owner, while Carlo Casiglia was elected Scrum Master.

In accordance with the Scrum methodology, the project team participated in daily Scrum standups where each member would relay what they accomplished the previous day, what they were planning on working on during the day and what issues were blocking their work. Additionally, each week a meeting was held in which the team reflected on that week's progress. This meeting also served as a Sprint Meeting for Sprint planning and Sprint retrospectives on days when the previous Sprint ended. Alongside these daily and weekly internal team meetings, each week a meeting with the project supervisors was held if deemed necessary, where the supervisors gave their feedback on the current progress and project status. Occasional meetings with the product customer were also held, where current progress and various ideas were discussed.

Project tasks were defined in advance for each Sprint during Sprint Meetings with minor adjustments if needed. These adjustments were usually done in weekly meetings that occured in the middle of a Sprint. Task were mostly defined so that they would be relatively small and straightforward. Tasks were also mostly distributed during weekly meetings with occasional tasks being given to general roles such as Android or Backend so that members from those subgroups would at a later time decide on the person to complete the task.

Regarding development branching strategy, the master-develop-feature model was adopted as stated in the Project Plan document. Routines related to code review and testing as stated in the same document were abided by during the duration of the project.

4.1.1 Communication tools

For daily Scrum standups, Slack messaging platform was used. This platform was decided on due to its ease of use as well as the project team's familiarity with the platform. Additionally, since it would be difficult to decide on a certain time slot each

day in which all team members could be present, Slack allows each team member to, in their own time, contribute to the standup.

For weekly project team meetings Google Meet was used. For these meetings, audio and video communication was necessary to better discuss progress and plans. Additionally, this conferencing service performed well and allowed team members to enter the virtual conference room without any necessary credentials apart from one member who needed to provide valid credentials since Google Meet is a paid service.

For weekly meetings with supervisors Skype was used. Usually the team from Croatia and the team from Italy would get together at their respective faculties and use Skype to communicate faculty-to-faculty. Occasionally when a team member could not be present at their faculty at the time of the meeting they would also join the call remotely if possible.

For meetings with the project customer, Whereby was used. This service was recommended by the customer himself and served as an easy to use conferencing service. The only limitation of this service is that the free version which was used only allows up to 4 different users to use a conference room at the same time.

Additionally, e-mail was often used to organize meetings and share various documents.

4.4.1 Development tools

As a remote repository used for distributed development, GitHub was used. This service was decided on because it provided all necessary features for the development of the project software, as well as due to the fact that team members were familiar with it.

For the collaborative writing of documents, organization purposes and sharing, Google Drive, Google Docs and Excel sheets were used. These services and tools allowed for the organization of all project documents and files in a single location, as well as providing the ability to collaboratively write and contribute to those documents.

For the purposes of developing the Android application, the Android Studio integrated development environment was used. Similarly, PyCharm was used for the development of the backend service and IntelliJ IDEA was used for the development of the web frontend.

4.2 Project effort

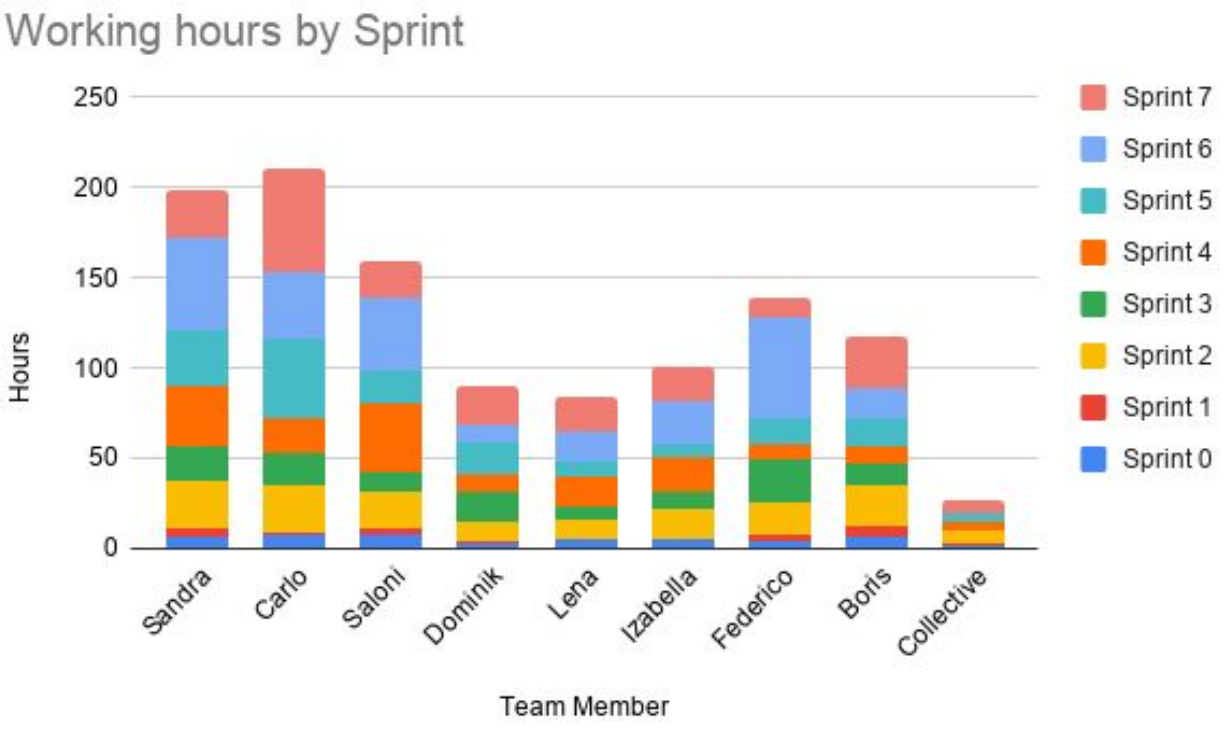
For the whole duration of the project, a project backlog was maintained. This project backlog noted all high-level items such as features and project activities to be completed during the project. For instance, a backlog item could be setting up a database, a creation of a certain Android screen, the development of an algorithm to calculate road quality etc. For each item, values for priority, estimated value and estimated effort were assigned. During the course of the project, as items from the backlog were completed, an additional value designating the number of the Sprint in which the item was completed would be added to the completed item.

From these backlog items, concrete tasks would be produced either directly or a single item in the backlog would result in several concrete tasks to be completed.

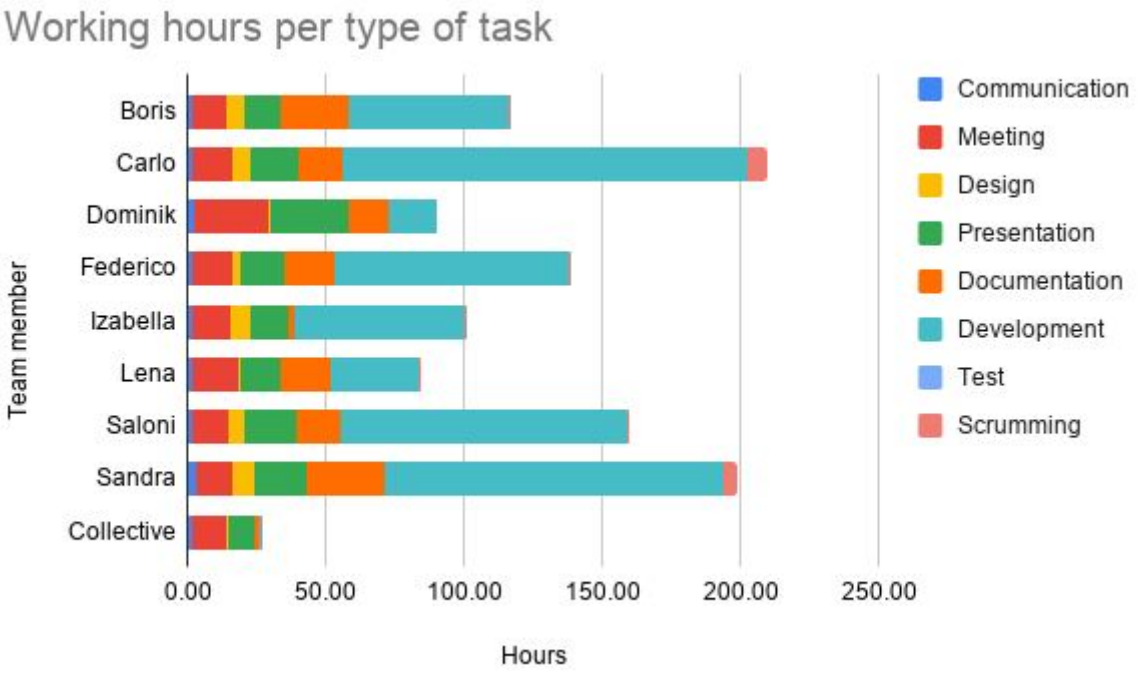
These tasks would be assigned to each new Sprint with the idea that they would be completed in that Sprint. With that in mind, for each Sprint a set of tasks would be decided on during the Sprint planning and assigned to team members. The importance of a task as well as whether it can be completed during the following Sprint would be considered. Generally speaking, each Sprint would contain tasks related to the Android application, web frontend, backend, database, deployment, documentation, presentations or collective tasks to which all team members contributed.

4.3 Worked hours

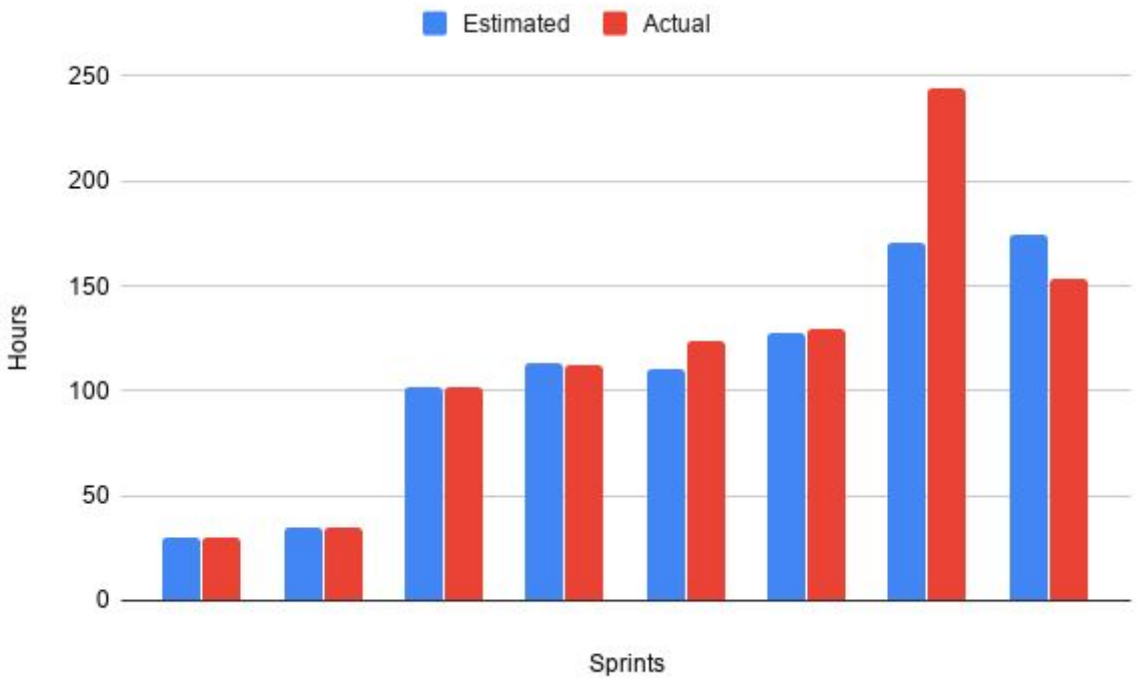
For each Sprint, project team members all recorded their working hours in a shared Excel sheet detailing all the tasks that need completing in that Sprint. Along real working hours, for each task, required working hours would be also estimated.



Working hours by Sprint for each team member



Working hours by type of task for each team member



Difference between estimated working hours and actual working hours by Sprint

4.4 Positive experiences

Regarding positive experiences, there were several. On a general level, the entire team devoted themselves to the project in a committed and serious manner. All

members put a lot of effort into the project and contributed as much as they could. Major decisions were always discussed and made as a team. On a more detailed level, the Scrum methodology was quickly adopted and abided to. The branching and code reviewing strategy was strictly followed. All team members would regularly participate in weekly meetings with the exception of situations where someone could not attend. Regular meetings with supervisors, as well as occasional meeting with the customer were organized so that as much feedback as possible could be obtained. Organizational tables and sheets detailing tasks, working hours, etc. were fairly well maintained.

4.5 Improvement possibilities

While there have been many positive experiences, that is, routines and processes executed well during the duration of the project, there are several things that leave room for improvement.

While communication generally was consistent and executed well, occasionally periods of low communication would arise. This lack of communication would most often manifests itself as a lack of contribution to daily Scrum standups. Team member would either ignore the standup or feel that if they are not doing anything on that particular day they have nothing to contribute to the standup. Poor communication can very subtly and quickly manifest itself if not careful.

Another misstep was not fully adhering to an iterative development process. Instead of implementing a minimum viable product, getting customer feedback and iteratively improving it and adding new features, much of the development as well as some features were fully implemented towards the end of the project. Also, in the early stages of planning and designing the system, the resulting definitions were often too vague due to uncertainty which resulted in lost time and a poor understanding of the system and requirements.

Customer feedback was always taken into consideration, but often this would lean more towards the software that was being developed as opposed to documentation revisions and improvements. The changes to the document recommended by the supervisors were noted, but the implementation of those changes was usually pushed back to make time for software development.

With regards to project risks defined in the Project Plan document, most risks were avoided. Miscommunication with the customer was mostly avoided, with the exception of a few instances where the team was left unsure what certain features should behave like. Poor communication with the team was also mostly avoided, excluding the previously mentioned lack of daily standup contributions. While failure to meet deadlines was avoided, a noticeable amount of work was done near the end of the project with a degree of rushing work. Inexperience with tools was not evident due to the team organizing itself with regards to each member's skills. Finally, a certain lack of quality assurance is present due to the rushing of some features as well as a significant amount of manually testing system components.

End of document