Deep learning-based road segmentation using aerial imagery for automated change detection: Project Overview & Characteristics

1 Document version

Table 1: Document version

Nr.	Date	Version	Altered chapters	Type of altering	Author
1	31.03.2023	1.1	all	Creation	Adian Dawuda
2	15.04.2023	1.2	6.5	Update	Adian Dawuda
3	30.04.2023	1.3	6.5	Update	Adian Dawuda
4					
5					

2 Project information

Table 2: Overall project information

Project				
Title	Deep learning-based road segmentation using aerial imagery for automated change detection			
Acronym	RChan			
Period	Start:	07.03.2023	End:	30.06.2023

3 Project Content and Project Goals

Table 3: Project Content and Project Goals

Content & Goals
Project description *(~100-150 words)*
Through research and growingly accessible computing power, deep learning has emerged as a promising approach to extract information from images. This project aims to perform a change detection analysis on specific sections of the road network in Cologne, Germany using a U-Net architecture-based convolutional neural network (CNN) to generate binary semantic segmentation masks of roads from aerial images. The change detection will be between 1998 and 2019. The U-Net model is trained on an openly available dataset of roads in the state of Massachusetts. The test set for Cologne must be created, as no such dataset currently exists. The accuracy and ease of semantic segmentation for the change detection analysis are evaluated. The model is built using the TensorFlow framework and interacts with the imagery data in a Python environment. The processes and findings of this project are outlined in this paper. The code and pre-trained model are available on GitHub and GitLab.
Project purpose, benefits and target group description *(~100 words)*
The project will display the use of deep learning for automatically processing and retrieving information from the large and growing amount of Earth Observation (EO) data that is being created. Automating laborious and manually time-consuming mapping tasks such as road mapping has great potential to improve work efficiency and resource allocation. As the model is trained on a dataset of a different area than the final test set, the model's generalization capabilities are tested. Given the interdisciplinary application domains of image understanding and change detection, this project may provide valuable findings for a broad range of actors and contributes to the growing field of earth observation and deep learning.
Project objectives (please also include a listing of the sub-goals) *(~100 words)*
- To apply a change detection of selected areas of the road network in Cologne - To conduct automated semantic segmentation using deep learning (Extraction of roads from aerial images) ↪ To build a U-Net CNN and successfully pre- and postprocess images for the model - To write an IMRAD style paper outlining the project - To publish and present the findings
Non-Goals
Creating a broad multi-purpose model. Creating multiple final models. Conducting in depth change detection for the whole of Cologne. General analysis of deep learning methods and approaches.

4 Frame of the project

Table 4: Frame of the project – Part 1

Context
Up-to-date status *(~50-100 words)*
The overall project is currently in its early stages. The literature review phase is ongoing and the methodology is largely finalized. The training data, consisting of aerial images has been acquired. The test dataset of Cologne is currently being created.
Project setting *(~50 Wörter)*
The project is being conducted during the summer semester of 2023 in the *I3 Project* course in the M.Sc. Applied geoinformatics curriculum. Over the course of the semester, a total of 300 hours is to be spent working on the project. Of these 300 hours, the course seminar takes up 4 hours per week.

Table 5: Frame of the project – Part 2

Time frame of the project			
Start:	07.03.2023	**End:**	30.06.2023
Important Dates			
1	07.03.2023	Kick-off	
2	09.04.2023	Milestones: Understanding of RChan's position among the state-of-the-art development. Methodology approach finalized. Computing environment selected.	
3	09.05.2023	Pecha Kucha presentation	
4	04.06.2023	WP 5 complete and final results ready	
5	20.06.2023	Final poster presentation	
6	30.06.2023	Project completion (Paper submission)	

5 Resources & Budget

Table 6: Resources and Budget – Part 1

Project Team
Project Lead
Adian Dawuda
Project Team
Adian Dawuda

Table 7: Resources and Budget – Part 2

Resources
Personal costs

Project costs

Other Costs
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6 Project structure, description and risk matrix

6.1 Work packages overview

Table 8: Work packages overview

WP	Name of the Work Package	Time Frame [from – to]
1	Project Management	07.03.2023 – 30.06.2023
2	Literature Review & Methodology	07.03.2023 – 09.04.2023
3	Data Aquisition	13.03.2023 – 16.04.2023
4	Data Analysis	27.03.2023 – 07.05.2023
5	Testing, Evaluation, Validation	08.05.2023 – 04.06.2023
6	Dissemination	24.04.2023 – 25.06.2023

6.2 Work Breakdown Structure (WBS)

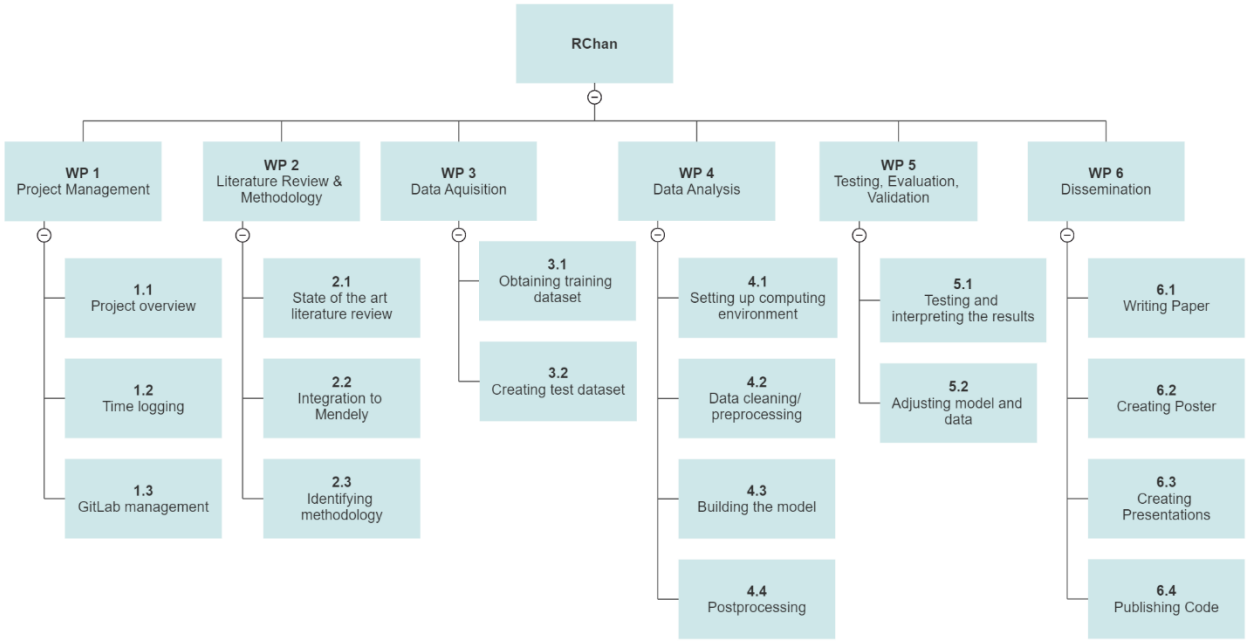

Figure 1 Work breakdown Structure

6.3 Detailed work plan

Table 9: Detailled Work Plan – WP1

WP 1	Project management	Duration	07.03.2023 – 30.06.2023
Project Lead	**Project team**		
Adian Dawuda	Adian Dawuda		
Objectives			
To Manage all aspects of the project (including Gitlab) and keep track of progress and time.			
Content & Tasks			
1.1: To regularly update project overview and time sheet 1.2: To update GitLab (at least bi-weekly)			
Expected results			
Up to date information of the project's status.			
Milestones & Deliverables			
D1: Project overview documents D2: GitLab Wiki and repository entries			

Table 10: Detailled Work Plan – WP1

WP 2	Literature Review & Methodology	Duration	07.03.2023 – 09.04.2023
Project Lead		**Project team**	
Adian Dawuda		Adian Dawuda	
Objectives			
To find and catalogue relevant literature and gain a good understanding of the state of the art for image segmentation/change detection. To identify the methodology to be used.			
Content & Tasks			
2.1: State of the art literature review 2.2: Integration to Mendely 2.3: To identify methodology (including choosing the model architecture)			
Expected results			
Catalogue of citable literature and overview of the state of the art leading to a clearly identified methodology.			
Milestones & Deliverables			
M1: Understanding of the project's position among the state-of-the-art development. M2: Selected methodology approach D1: Catalogue of citable literature			

Table 11: Detailled Work Plan – WP2

WP 3	Data Acquisition	Duration	13.03.2023 – 16.04.2023
Project Lead		**Project team**	
Adian Dawuda		Adian Dawuda	
Objectives			
To obtain and create all the necessary data for conducting the project (Train and Test images).			
Content & Tasks			
3.1: Obtaining training dataset 3.2: Creating test dataset (Cologne)			
Expected results			
Training and testing dataset of aerial images and their corresponding ground truth masks.			
Milestones & Deliverables			
D1: Training dataset D2: Test dataset			

Table 12: Detailled Work Plan – WP3

WP 4	Data Analysis	Duration	27.03.2023 – 07.05.2023
Project Lead		**Project team**	
Adian Dawuda		Adian Dawuda	
Objectives			
To build and apply a functioning U-Net deep learning model for road segmentation.			
Content & Tasks			
4.1: Setting up computing environment 4.2: Data cleaning/preprocessing 4.3: Building the model 4.4: Postprocessing			
Expected results			
A deep learning model that can read input images perform segmentation and output the segmented images. First results.			
Milestones & Deliverables			
M1: Adequate computing environment selected D1: Cleaned dataset/preprocessing code D2: U-Net CNN model D3: Image postprocessing code			

Table 13: Detailled Work Plan – WP4

WP 5	Testing, Evaluation, Validation	Duration	08.05.2023 – 04.06.2023
Project Lead		**Project team**	
Adian Dawuda		Adian Dawuda	
Objectives			
To test and evaluate the performance of the model. To apply changes to the model/input/hyperparameters to improve the performance. To repeat these steps and finetune the model.			
Content & Tasks			
5.1: Testing and interpreting 5.2: Adjusting model and data			
Expected results			
A finetuned model, delivering better results than before this step.			
Milestones & Deliverables			
M1: Numerous milestones for improving the model D1: Final model delivering the best results (many previous iterations also deliverables)			

Table 14: Detailled Work Plan – WP5

WP 6	Dissemination	Duration	24.04.2023 – 25.06.2023
Project Lead		**Project team**	
Adian Dawuda		Adian Dawuda	
Objectives			
To write the paper describing the project comprising Introduction, Methods, Results and Discussion parts. To create two presentations. To publish the code used for the analysis.			
Content & Tasks			
6.1: Writing paper 6.2: Creating poster 6.3: Creating presentations 6.4: Publishing code			
Expected results			
An IMRAD-style paper of the project. Final poster and Pecha Kucha presentations. Cleaned and commented code used for the analysis.			
Milestones & Deliverables			
D1: The paper of the project D2: Poster of the project D3: Pecha Kucha and final Presentations D4: Code used for the project			

6.4 Milestone plan

Table 15: Milestone plan

MS	Name	Date Completion
M1	Understanding of RChan's position among the state-of-the-art development.	09.04.2023
M2	Selected methodology approach	09.04.2023
M3	Adequate computing environment selected	09.04.2023
M4	Numerous improvement milestones during the Testing, Evaluation, Validation WP	04.06.2023

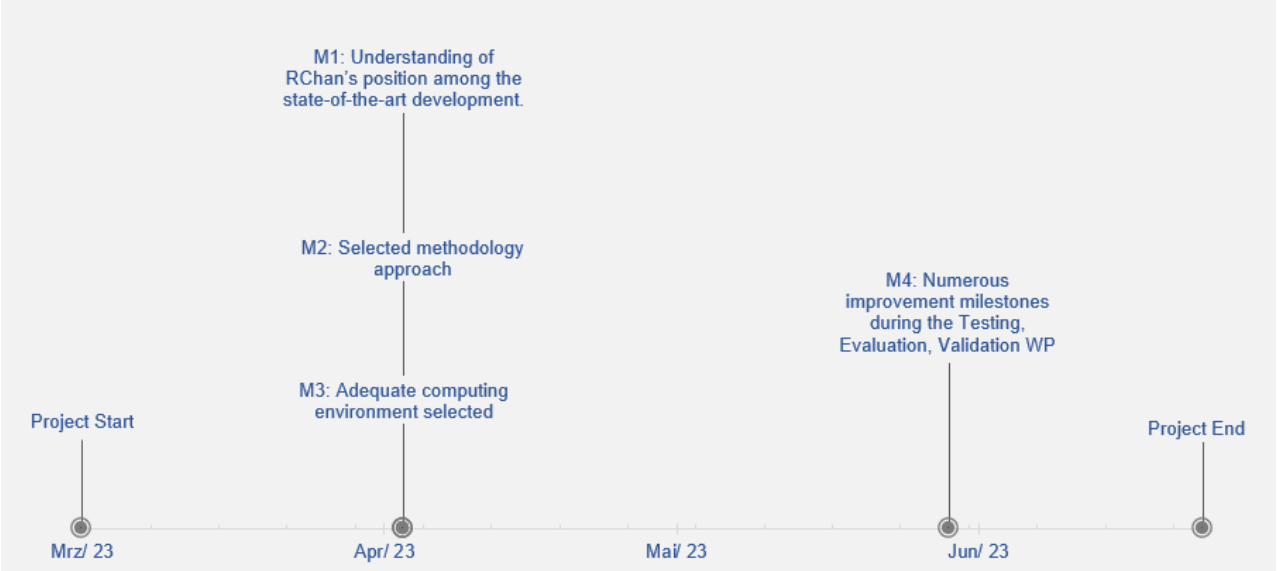

Figure 2 Milestones

6.5 Gantt Chart

Project Name	Deep learning-based road segmentation using aerial imagery for automated change detection
Project Acronym	RChan
Project Manager	Adian Dawuda
Project Deliverable	Model, Code and Paper/Documentation
Start Date	3/7/2023
End Date	6/30/2023
Overall Progress	45 %

WP	Time Estimate (hours)	Tasks	Responsible	Start	End	Status
1	**30 (10%)**	**Project Management**				
1.1	10	Project overview (Gantt chart, Pert chart, risk analysis)	Adian	KW10	KW26	In progress
1.2	3	Time logging	Adian	KW10	KW26	In progress
1.3	17	GitLab management	Adian	KW10	KW26	In progress
2	**30 (10%)**	**Literature Review & Methodology**				
2.1	18	State of the art literature review	Adian	KW10	KW14	Completed
2.2	2	Integration to Mendely	Adian	KW10	KW14	Completed
2.3	10	Identifying methodology (incl choosing model architecture)	Adian	KW10	KW14	Completed
3	**30 (10%)**	**Data Aquisition**				
3.1	10	Obtaining training dataset	Adian	KW11	KW13	Completed
3.2	20	Creating test dataset	Adian	KW11	KW15	In progress
4	**60 (20%)**	**Data Analysis**				
4.1	5	Setting up computing environment	Adian	KW13	KW14	Completed
4.2	15	Data cleaning/preprocessing	Adian	KW14	KW18	In progress
4.3	30	Building the model	Adian	KW14	KW18	In progress
4.4	10	Postprocessing	Adian	KW14	KW18	In progress
5	**60 (20%)**	**Testing, Evaluation, Validation**				
5.1	40	Testing and interpreting the results	Adian	KW19	KW22	Not started
5.2	20	Adjusting model and data	Adian	KW19	KW22	Not started
6	**90 (30%)**	**Dissemination**				
6.1	50	Writing Paper	Adian	KW19	KW25	Not started
6.2	10	Creating Poster	Adian	KW23	KW25	Not started
6.3	20	Creating Presentations	Adian	KW17	KW25	In progress
6.4	10	Publishing Code	Adian	KW23	KW25	Not started
		Completion			KW26	

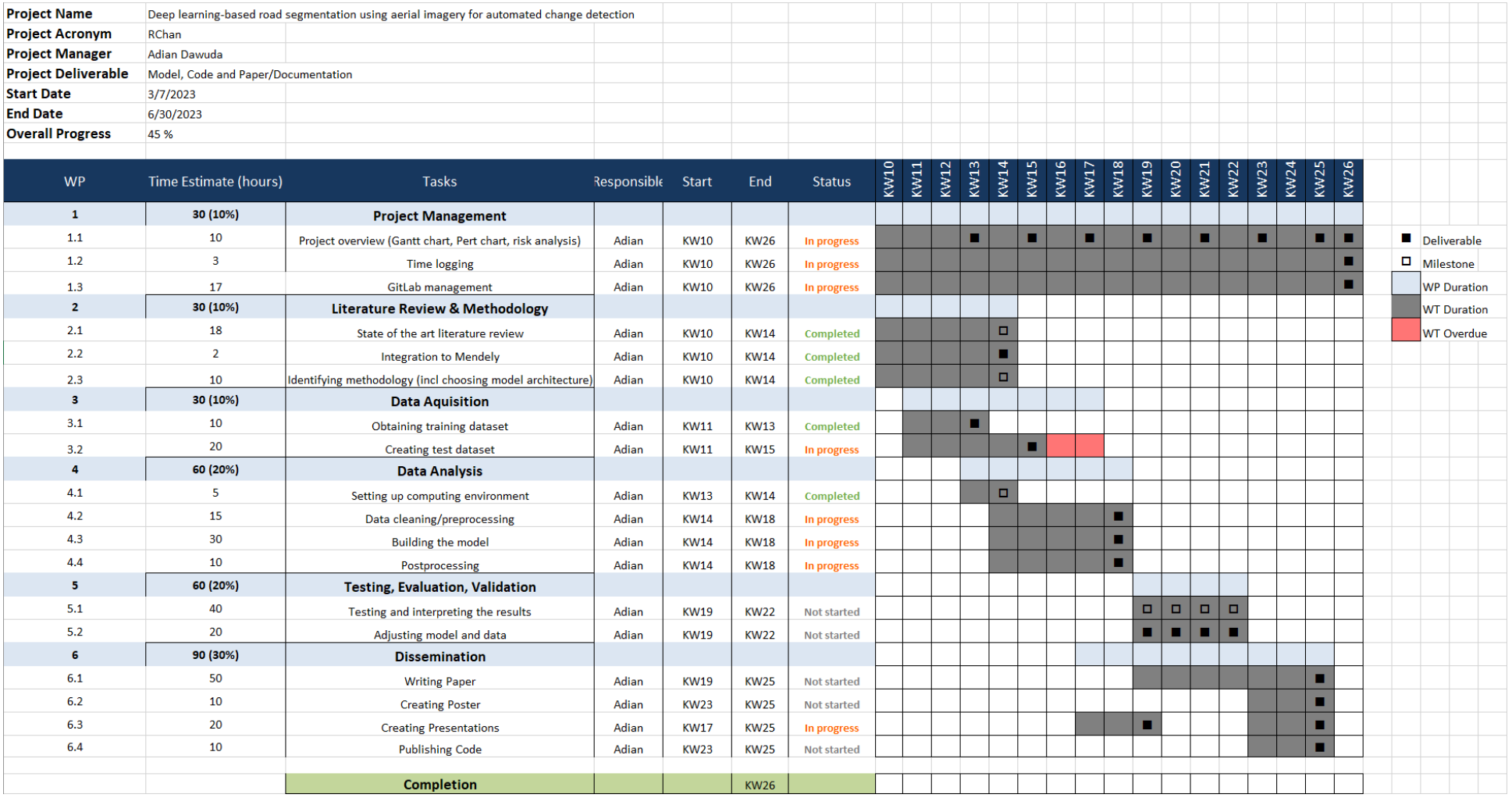

Figure 3 Gantt Chart

6.6 Risk Matrix

Table 16: Risk matrix

No	Risk	Potential adverse impact	Risk level*	Risk management strategy	Responsibility
1	Cannot obtain training dataset.	Bad performance of the model due to lacking/unsuitable training data or no model at all.	C	Research available datasets.	Adian Dawuda
2	Cannot find/create test dataset.	Cannot conduct change detection of Cologne road network.	C	Early research of available datasets and or availability of necessary data for dataset creation.	Adian Dawuda
3	Problems with Google Collab (denied access, servers down).	No access to computing environment -> cannot develop or test model.	L	Local computing environment or Google Collab alternatives (e.g., Azure Notebook).	Adian Dawuda
4	Coding problems or errors that hinder the development of a functioning workflow (e.g., cannot read images, model does not compile or predict masks).	Inability to perform the desired analysis.	M	Small errors often occur and are mostly easily fixable. Looking up common problems on the internet may provide solutions. Peers or members of the department could be asked for help in extreme cases.	Adian Dawuda
5	Underestimation of tasks (time).	Late project completion.	L	Continuous project management to keep track of the project's progress and status. Well thought out time plan with one week of additional buffer planned.	Adian Dawuda

*High (H), Medium (M), Low (L), Cleared (C)

7 Additional comments

Table 17: Additional comments

Comments
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8 Approval

Table 18: Approval

Freigabe			
Date:	---	Date:	---
—		—	
Signature principal investigator		Signature project lead/contractor	

9 Attachments

Attachment 1: Gantt chart (biweekly updated).