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Repairing is Caring - An Approach to an AI-Supported Product-Service-System for Bicycle Lifecycle Prolonging

International Conference on Adaptive and Self-Adaptive Systems and Applications

7th April 2025

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Outline

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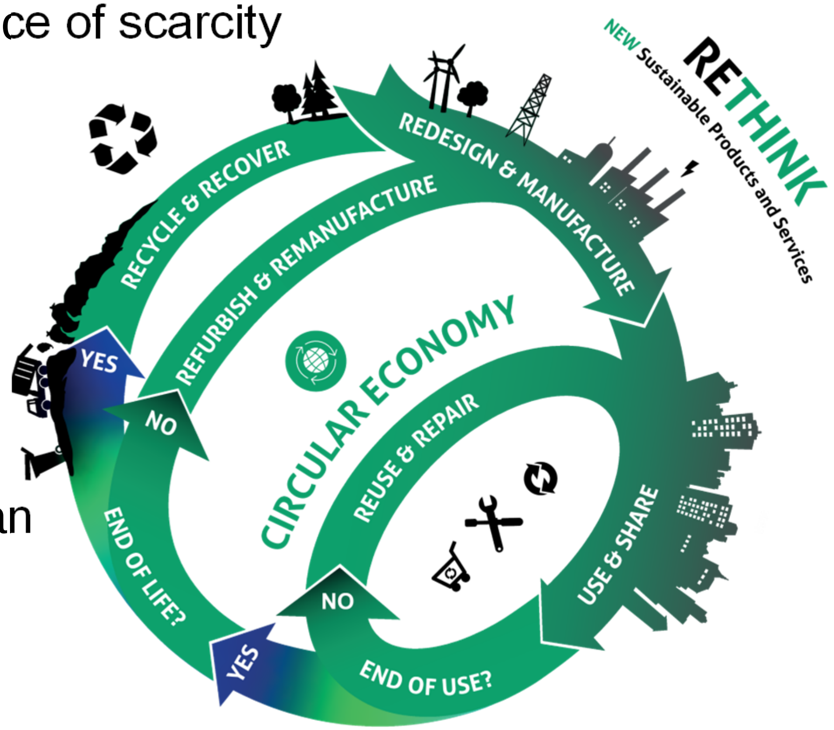
- Problem Scenario: Bicycle Owner and Repairer Perspective
- Bicycle Repair Ecosystem
- Data Collection Process for Lifecycle Decision
- Bicycle dataset: Acquisition, Overview, and Distribution
- AI-based Methodology: Architecture and Modeling Process
- Results: Defect Detection and Repairability Assessment use case
- Future Outlook

Motivation

- Earth has finite resources, resulting in an increasing prevalence of scarcity
- Therefore, transforming to a circular economy helps:
  - reduces waste
  - Increases the lifespan of products
  - Create a sustainable ecosystem on a large scale
- Repairing is a sustainable option to extend a product's lifespan
- Bicycles are good examples for reuse:
  - It plays an essential role in today's mobility ecosystems
  - Reduce the rate of emissions
  - Requires less space compared to other mobility solutions



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Problem Scenario

Owner

- Wants to get rid of an old bike
- with the lowest effort and time feasible

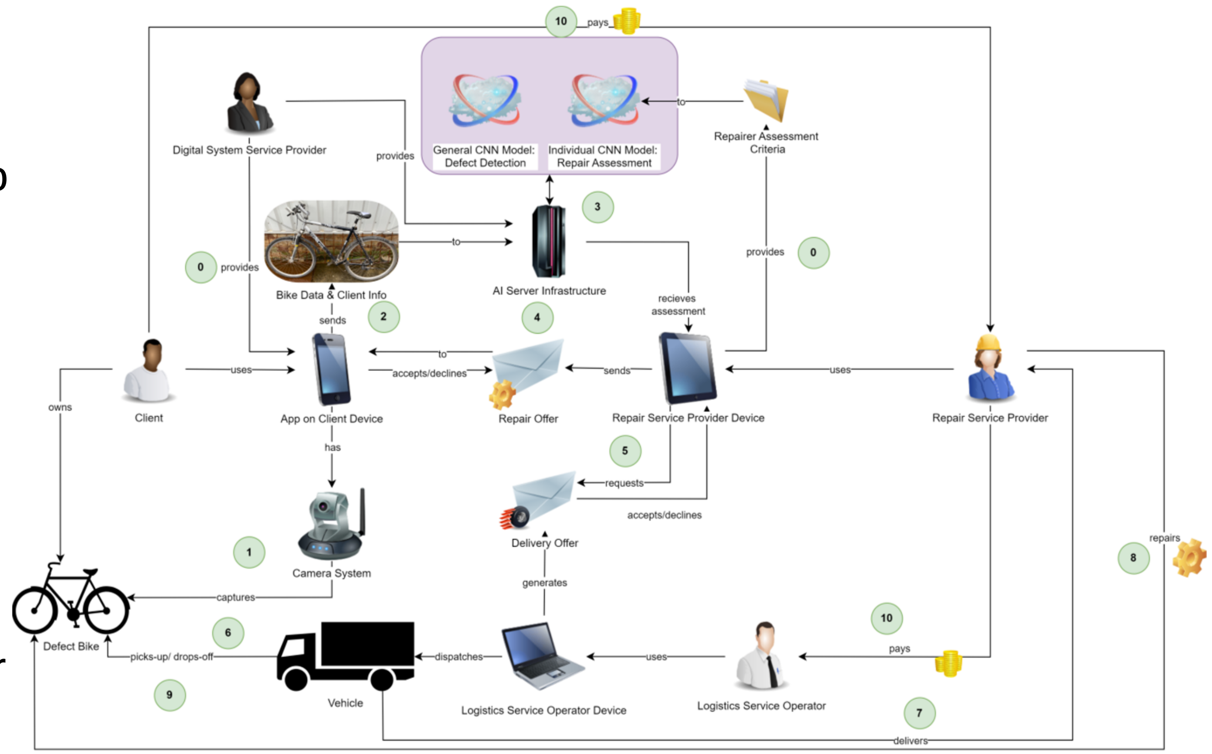
Repairer

- Wants to repair bikes quickly and in an economically feasible way
- Need to know the defect or missing component
- Resell the repaired bikes

Repairer perspective

Product-Service-System for bicycle repairing

- Step 1: The client initiates the process
- Step 2: Processing of images and sending them to the AI Server Infrastructure
- Step 3: Repairability assessment by the model, trained on the assessment criteria of the repairer
- Step 4: The repairer submits an offer to the Client
- Step 5: The repairer contacts the logistics provider
- Steps 6 & 7: The logistics provider picks up the bicycle
- Steps 8 & 9: Repairing and returning the bicycle to the client



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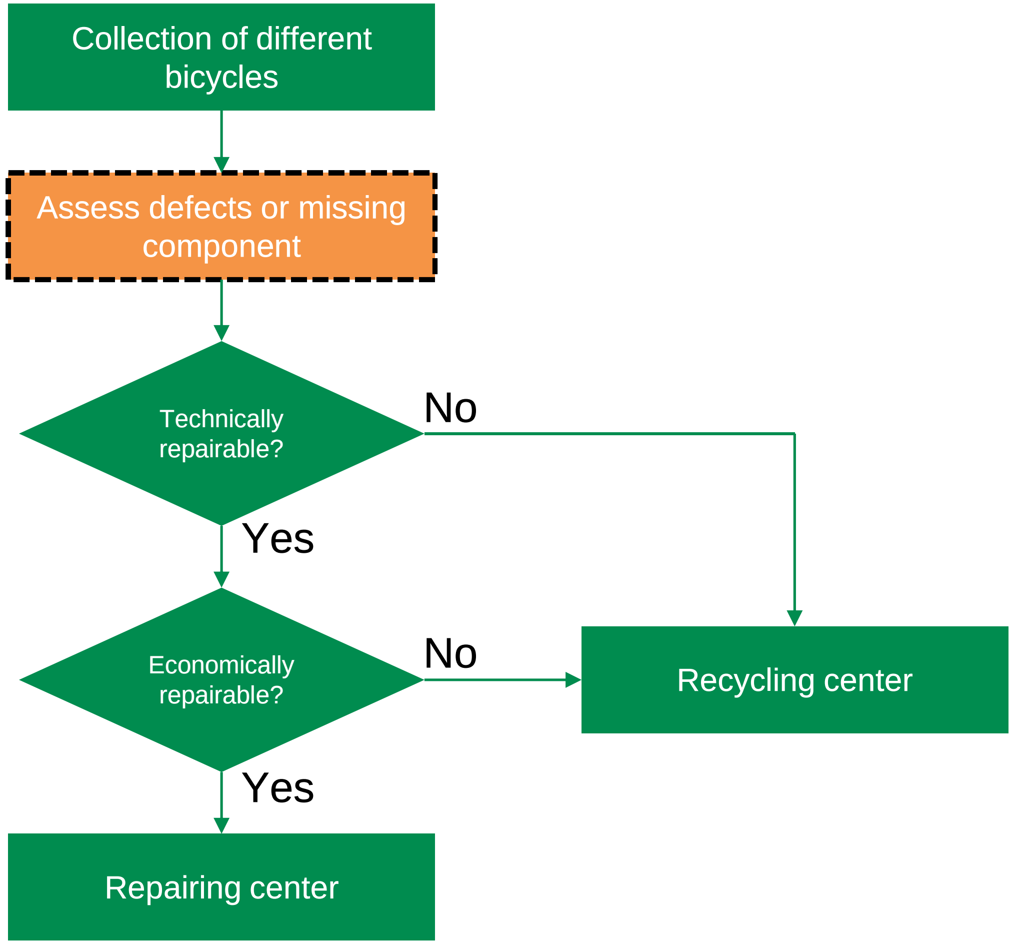
Data Collection Process for Lifecycle Decision

- Collection of 112 old bicycles during the phase of one month
- Identification of missing or defective components
- If the bicycle is repairable:
  - The defect is repaired
  - Missing components are replaced
- If the bicycle is not repairable, it directly goes to the recycling center



Bicycle Data Acquisition

- Gather the details on each parts
- Guide to assess the overall condition of the bicycle
- Talking with the repairer
- Options for each component:
  - functional
  - defect
  - missing
- Classify the bike as repairable or not (for our repairer)

Bicycle
- Manufacturer
- Bike Type
- Wheel size
- Gearshift Type
- Number of Gears

Breaks (Type)
- Front wheel break assessment
- Rear wheel break assessment

Drive Train
- Left pedal assessment
- Right pedal assessment
- Chainring assessment
- Gear shift assessment
- Pinion/Cassette assessment

Light (Type)
- Front light assessment
- Rear light assessment
- Dynamo assessment

Wheels
- Front wheel tire assessment
- Rear wheel tire assessment
- Front wheel impeller assessment
- Rear wheel impeller assessment

Frame (Condition)

Handlebar (Condition)

Dataset Overview

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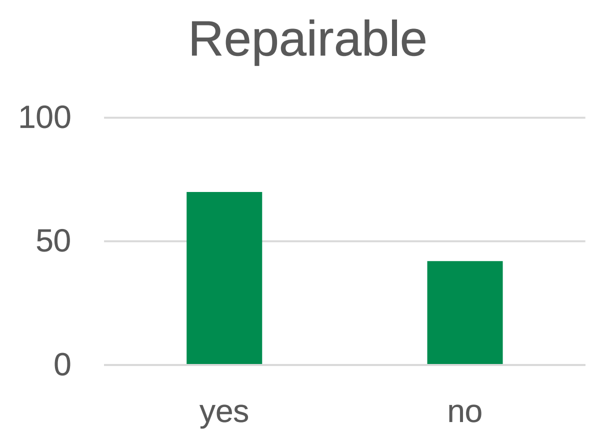
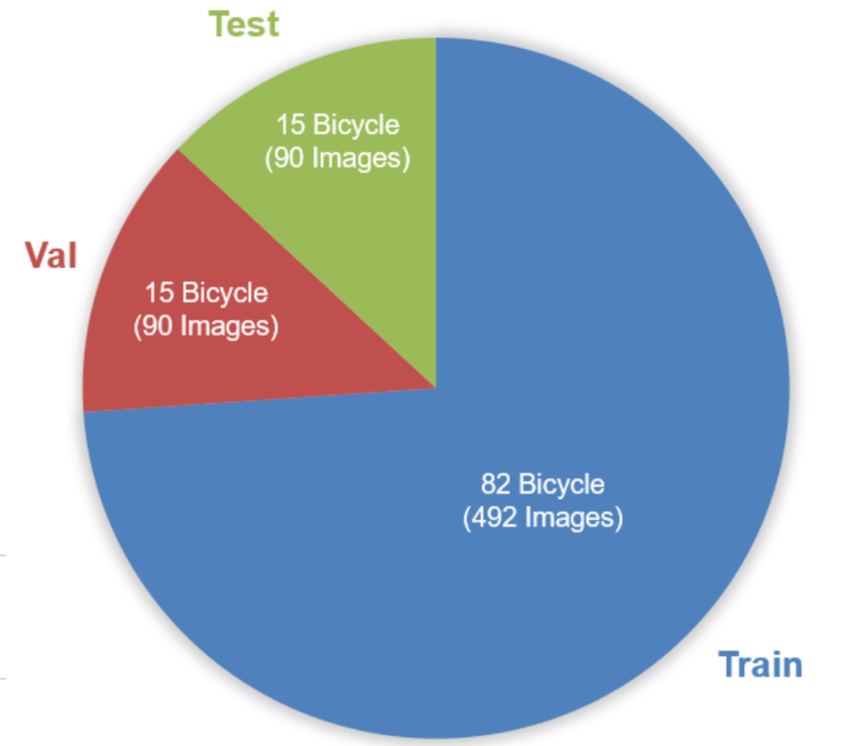
Dataset Distribution

- Total 112 bicycles:
  - Correspond to 672 images
- 70 bicycles are repairable:
  - Correspond to 420 images
- 42 bicycles are not repairable:
  - Correspond to 252 images





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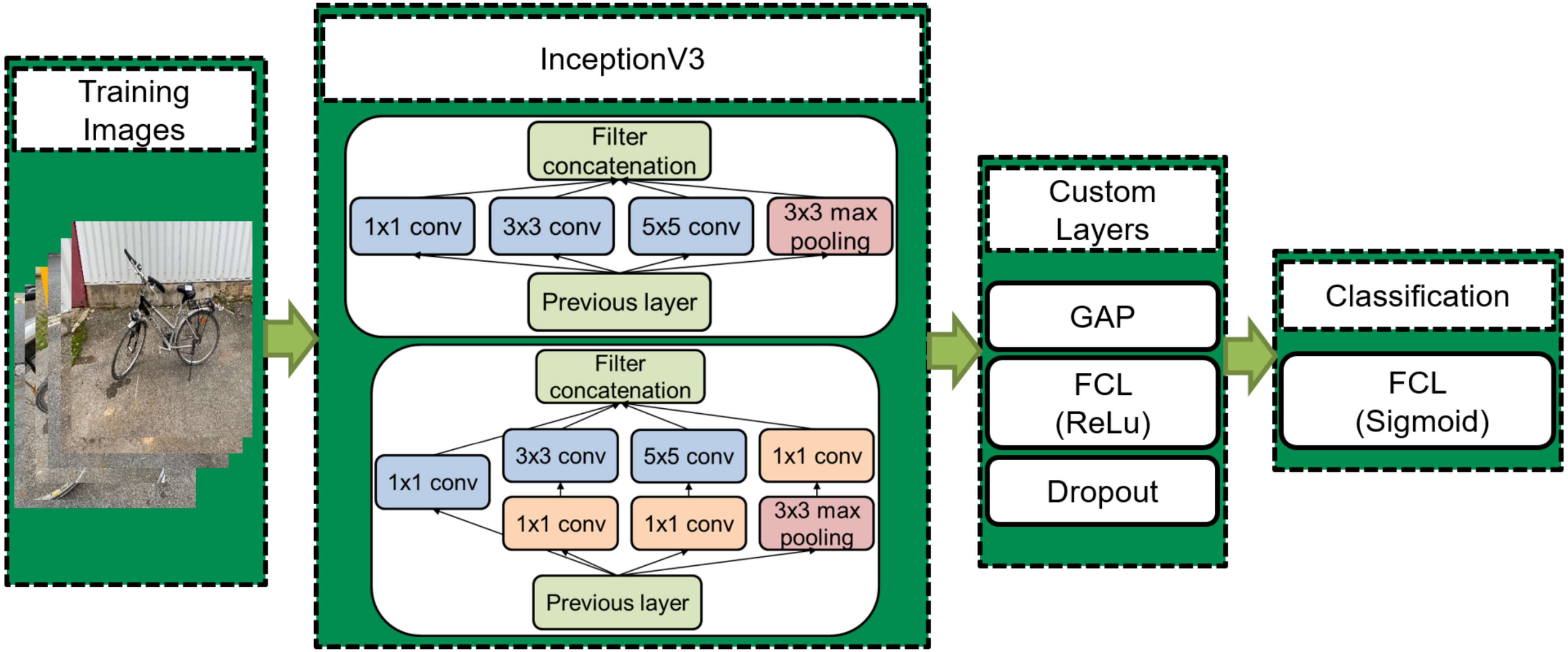
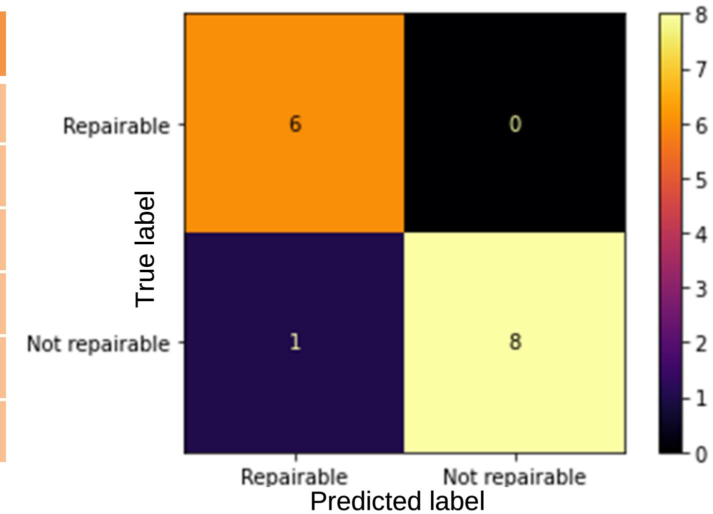
AI Architecture



Achieved Results

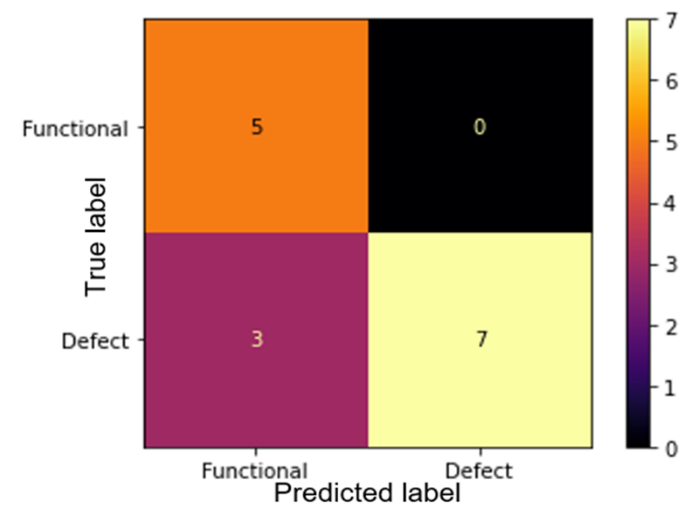
Repairability Assessment Use Case

	Precision	Recall	F1-score	Support
Repairable	0.86	1.00	0.92	6
Not repairable	1.00	0.89	0.94	9
accuracy			0.93	15
macro avg	0.93	0.94	0.93	15
weighted avg	0.94	0.93	0.94	15



Defect Detection Use Case

	Precision	Recall	F1-score	Support
Repairable	0.62	1.00	0.77	5
Not repairable	1.00	0.70	0.82	10
accuracy			0.80	15
macro avg	0.81	0.85	0.80	15
weighted avg	0.88	0.80	0.81	15



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Future Outlook

- Examine how the model would perform in the case of detecting defects for multiple components

- Building a multi-output model to evaluate damages and thus guide repairability decisions, however
  - Design the hyperparameter optimization workflow
  - Find the right balance between generalizability and specificity

- Developing reconfigurable pipeline framework:
  - To facilitate the customization of training processes according to the specific requirements of each repair service provider
  - Enable the stakeholders of the system to select tailored training criteria aligned with their unique operational contexts and respective needs

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Thank you very much for your attention!