

NAVIGATING DATA CHALLENGES: AI-DRIVEN DECISION SUPPORT FOR PRODUCT-SERVICE SYSTEM DEVELOPMENT



Doctoral Candidate: Omsri Aeddula
Opponent: Prof. Shaun West, Lucerne University, Schweiz
Examiner: Prof. Tobias Larsson, Blekinge Institute of Technology



Omsri Aeddula
oka@bth.se
Doctoral Thesis Defence
Mechanical Engineering
14 June 2024



**Product Development
Research Lab**

Complex Systems



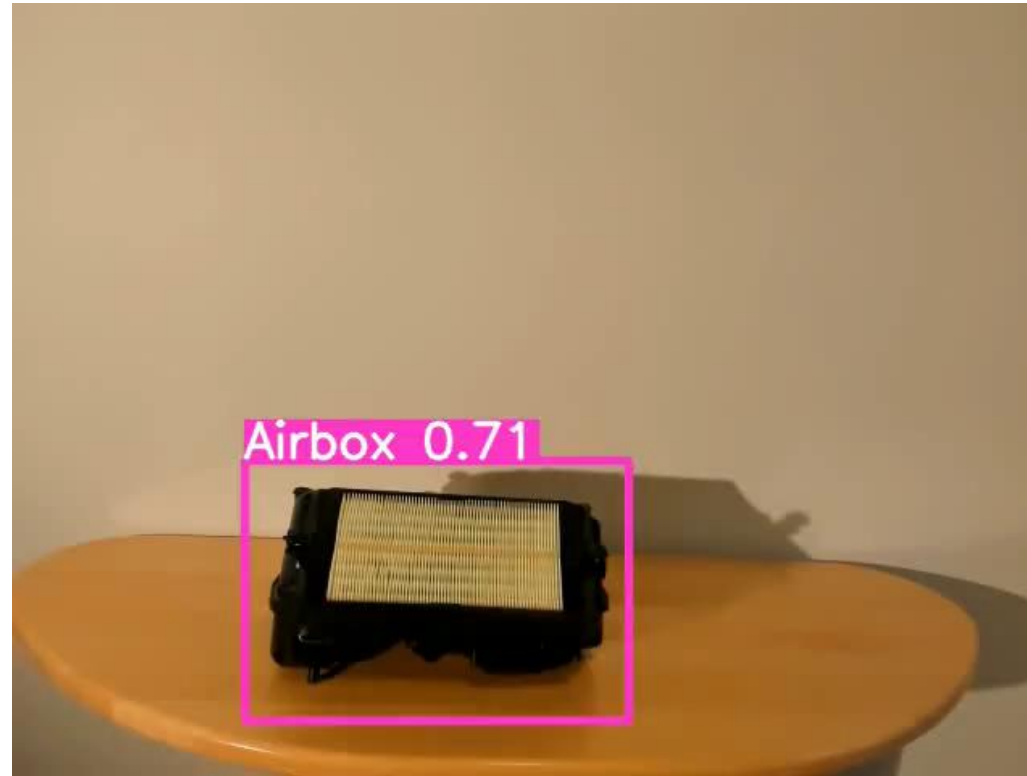
Complex Systems



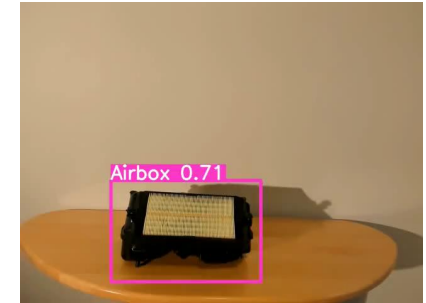
Complex Systems



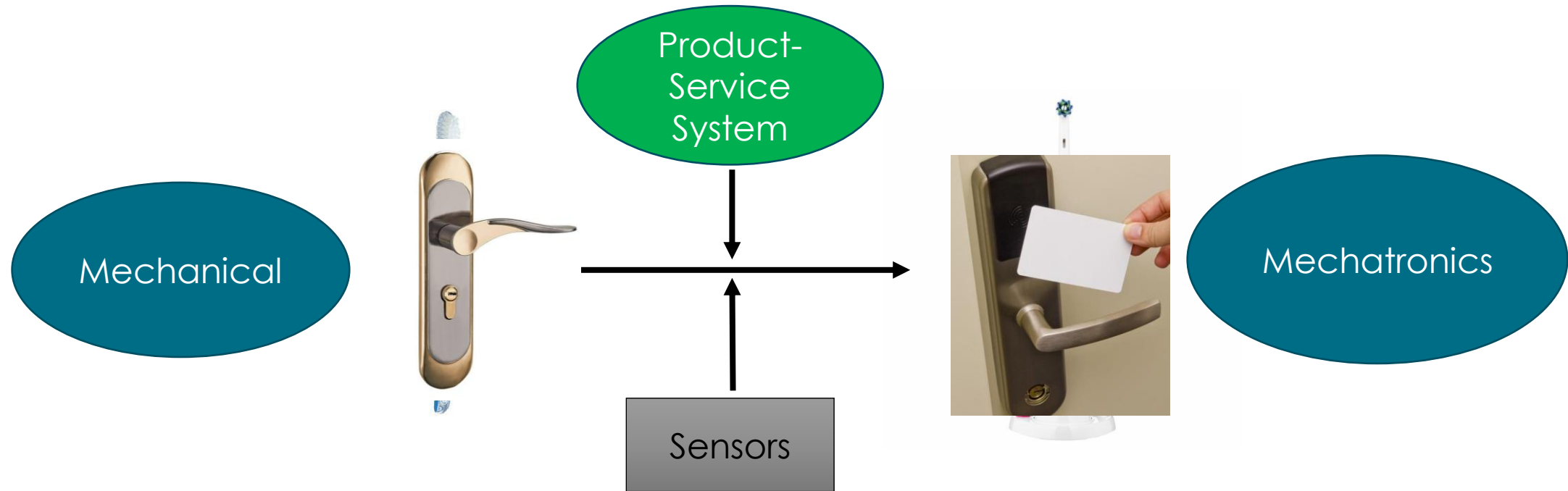
Complex Systems



Complex Systems

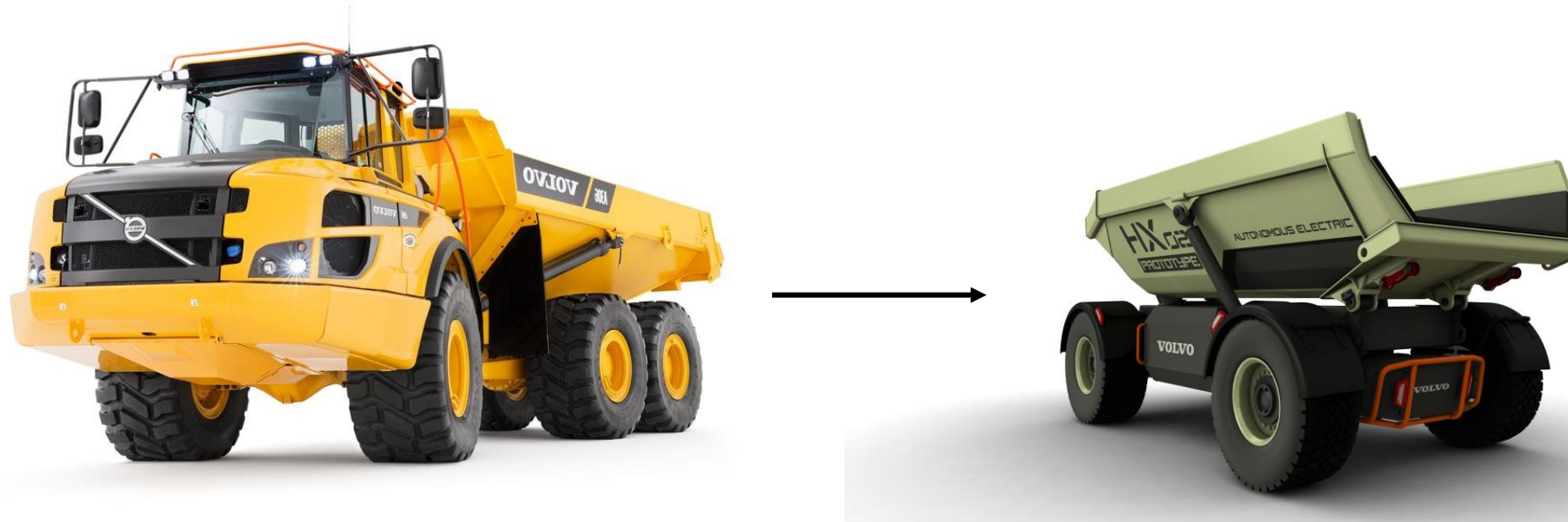


Complex Systems



Product Service Systems (PSS)

- Products and Service bundles – Cross functional teams.
- Lifecycle perspective
- Transforming data into information for commercial production.

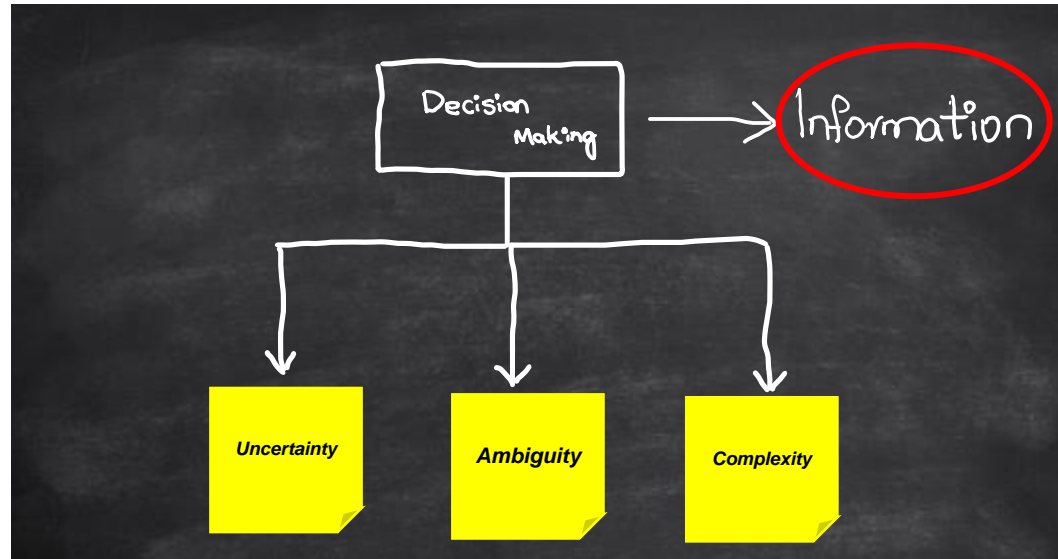


Product Service Systems (PSS)

- Products and Service bundles – Cross functional teams.
- Lifecycle perspective
- Transforming data into information for commercial production.



Decision Making



Decision Support Systems

- Computer based tools that assist decision-makers in solving complex problems.



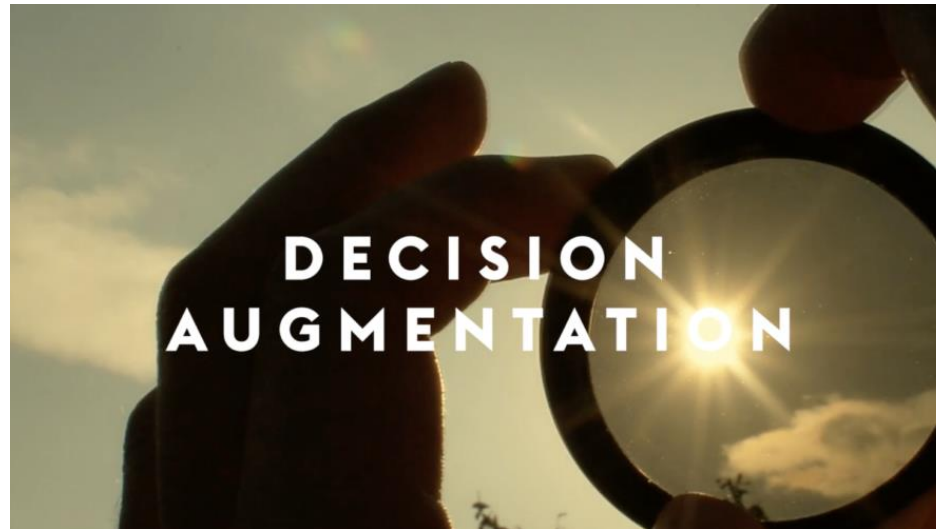
Need for New Approach

- Traditional methods may struggle with incomplete data and require strong intuition from decision-makers.



Research Question

- How can AI-powered data analysis approaches augment decision-support in early-stage PSS development by effectively addressing data complexity, ambiguity, and uncertainty?



RESEARCH CASE

Working Approach



Paper A



Challenge

Paper A



Challenge

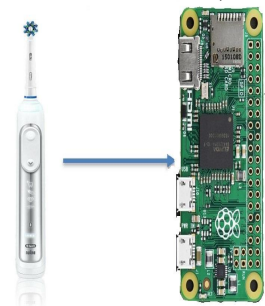


Solution

Paper A

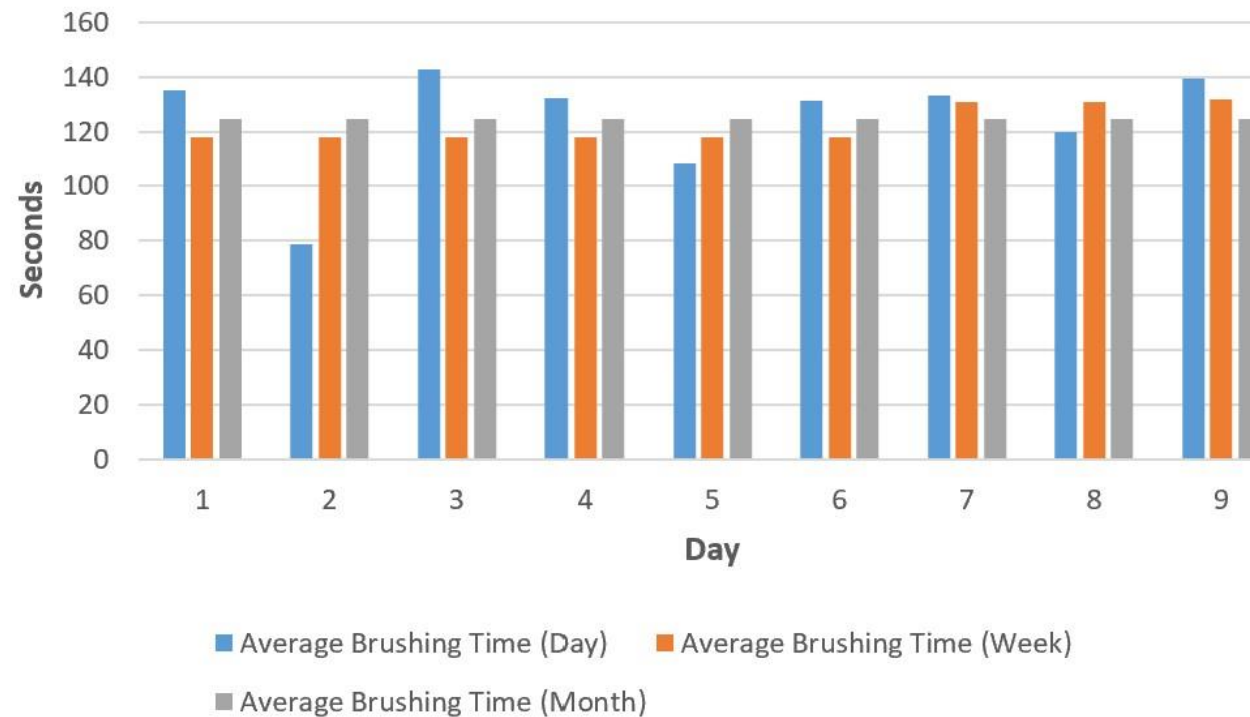


Challenge



Solution

Average Brushing Time

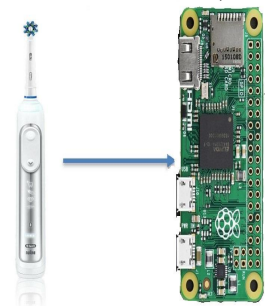


Outcomes

Paper A

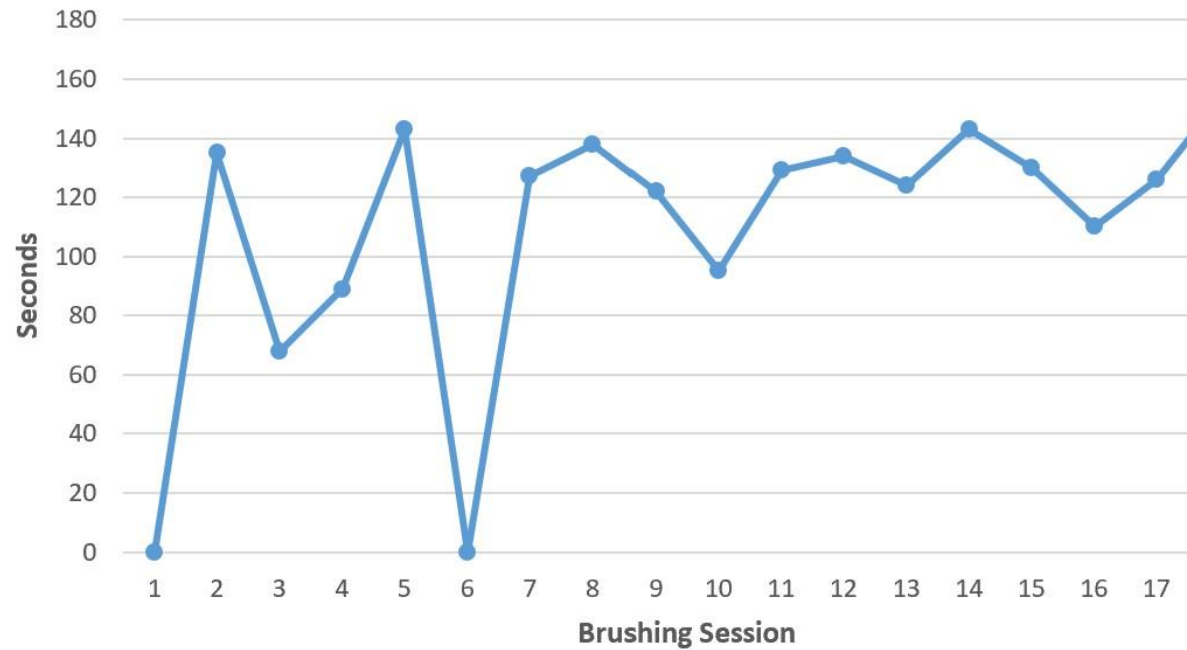


Challenge

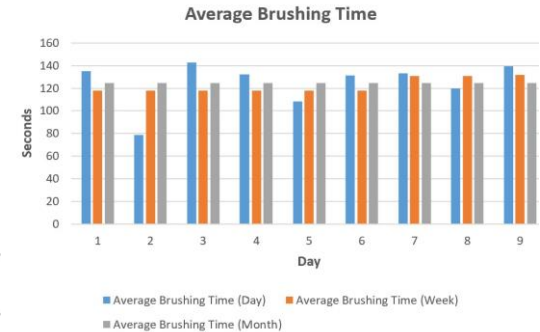


Solution

Total Brushing Time



Outcomes



Outcomes

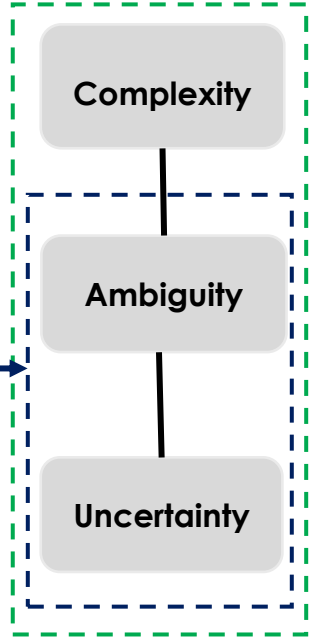
Paper A



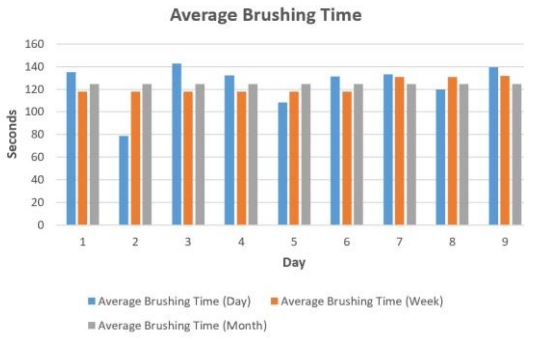
Challenge

Data Challenges

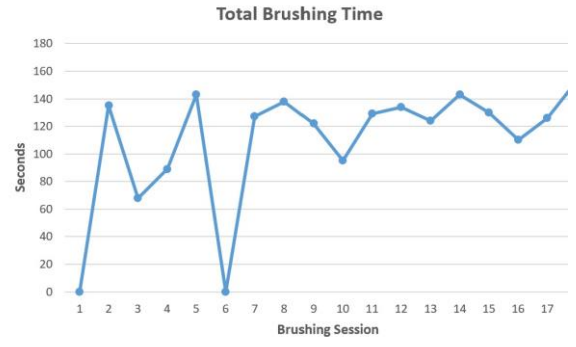
Paper A



Solution

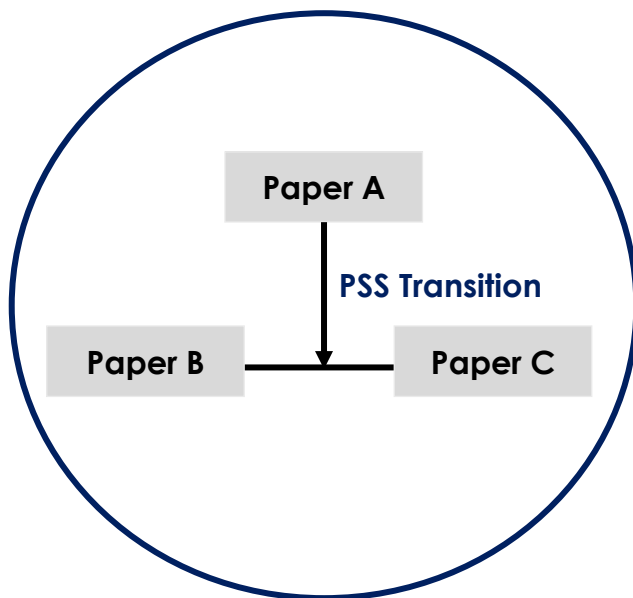


Outcomes



Outcomes



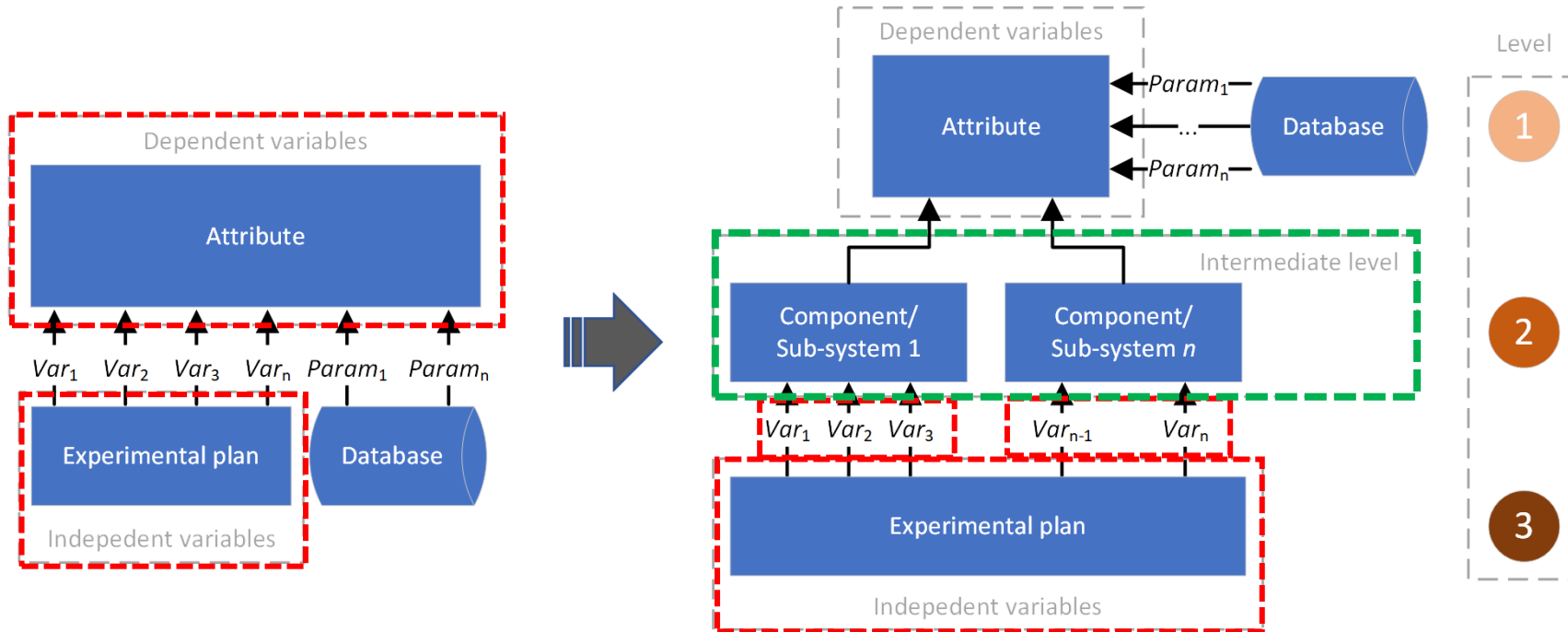


Paper B&C



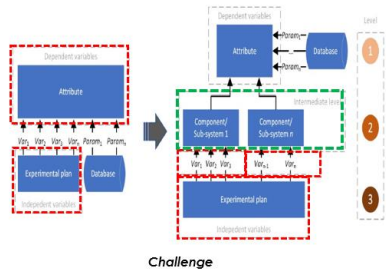
Heavy Construction Machine

Paper B&C

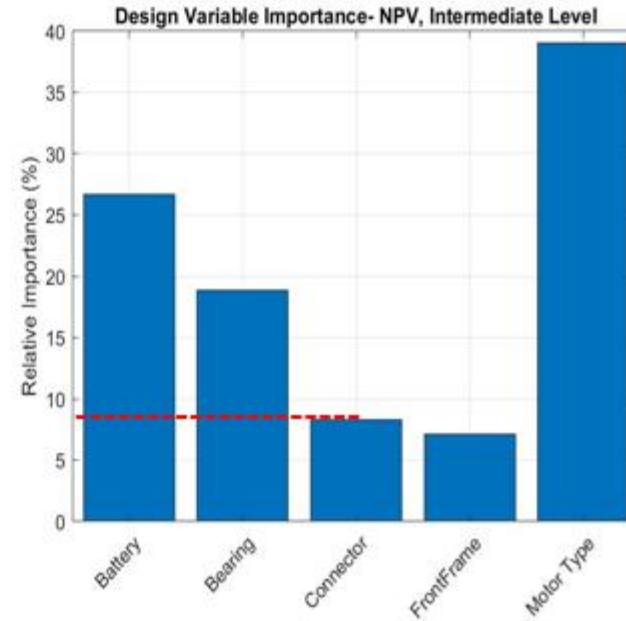
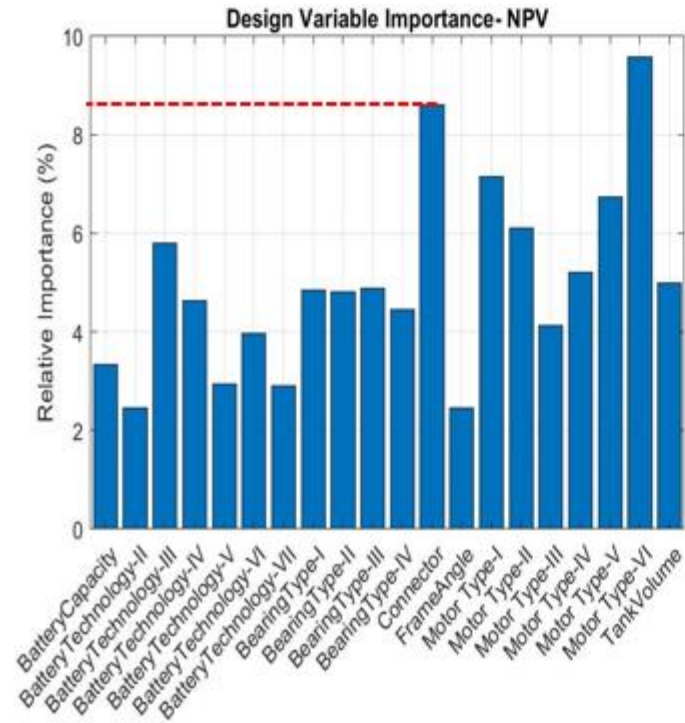


Challenge

Paper B&C



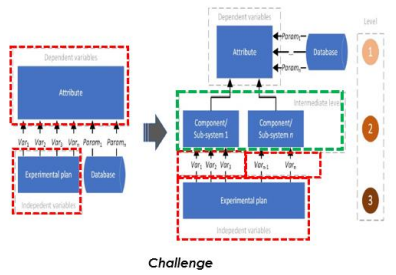
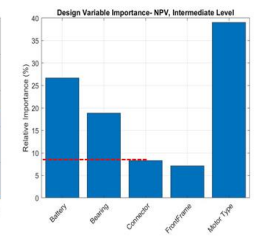
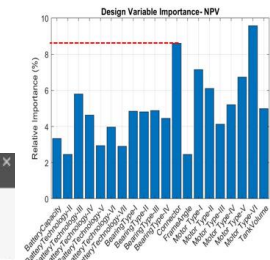
Challenge



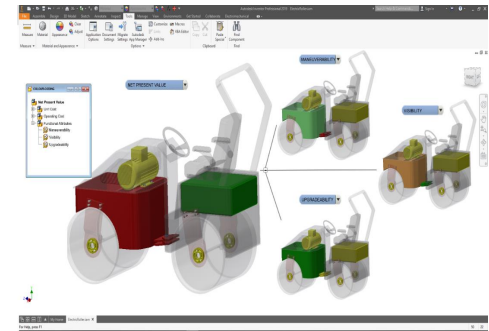
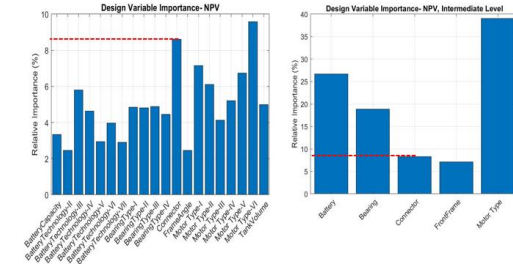
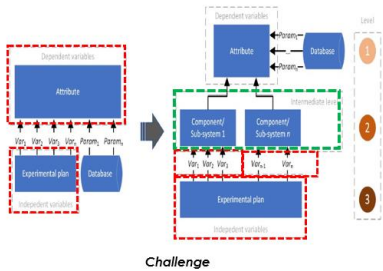
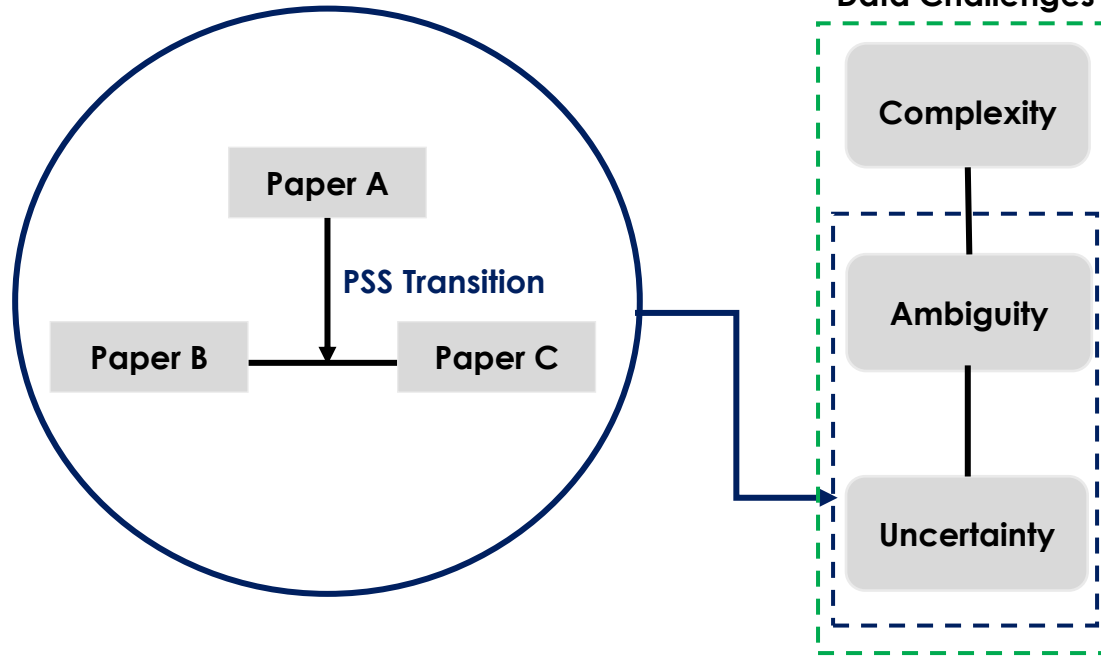
Paper B&C



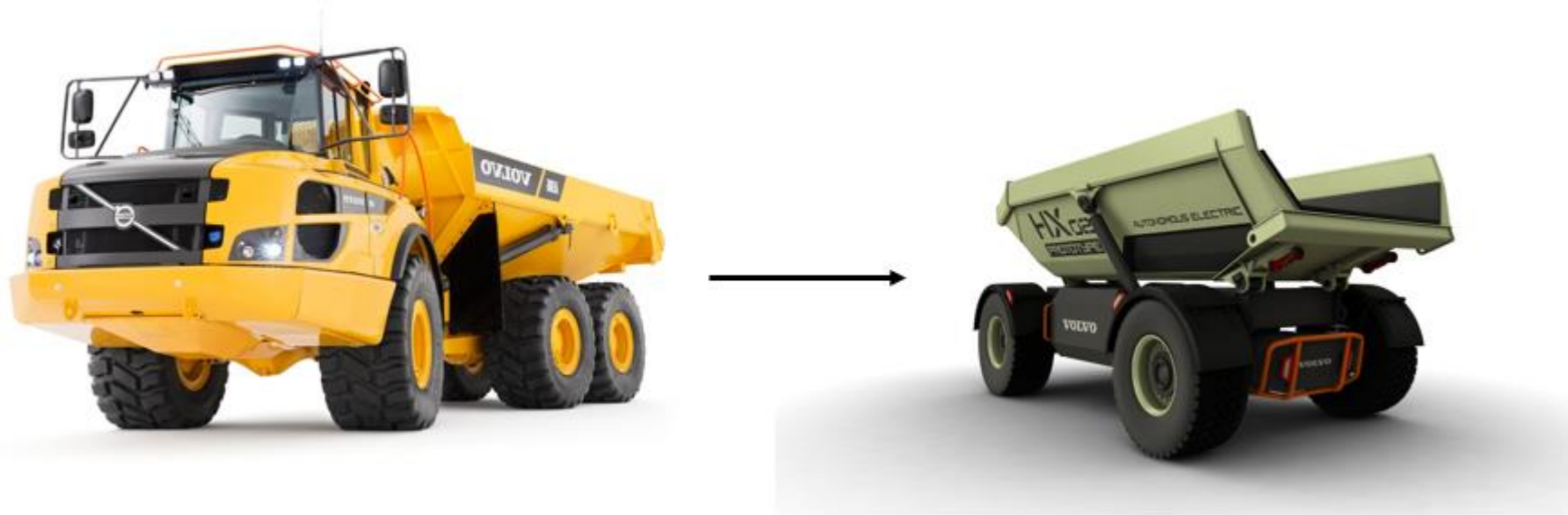
The screenshot shows the Autodesk Inventor Professional 2019 interface. The main window displays a 3D model of the utility vehicle with several design parameters highlighted in blue boxes: NET PRESENT VALUE, MANEUVERABILITY, VISIBILITY, and UPGRADEABILITY. A 'COLOUR-CODING' dialog box is open on the left, showing a tree view of design parameters including Net Present Value, Unit Cost, Operating Cost, Functional Attributes, Maneuverability, Visibility, and Upgradeability. The software interface includes a top menu bar, a ribbon with various tool tabs, and a bottom status bar.



Paper B&C

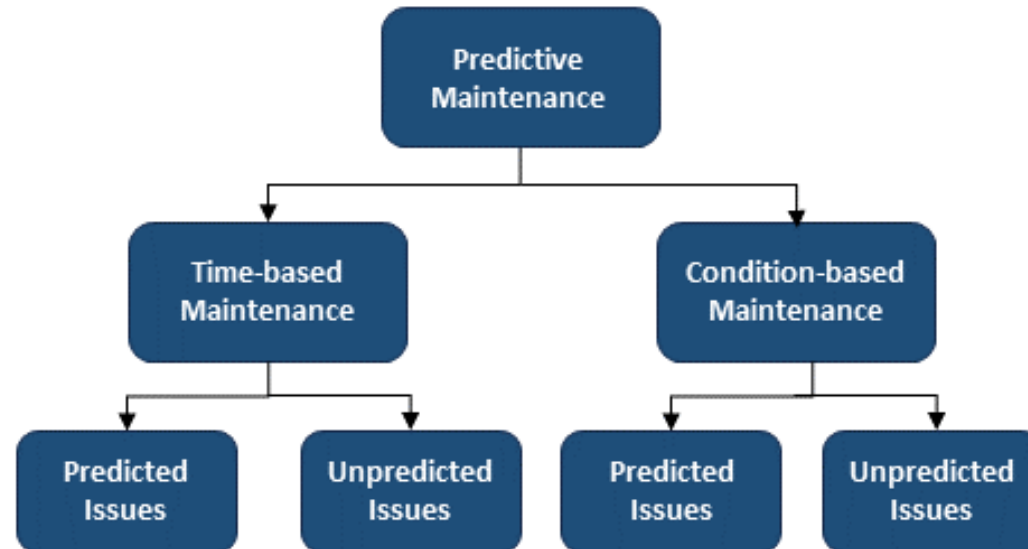
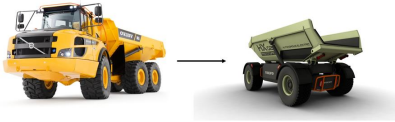


Paper D



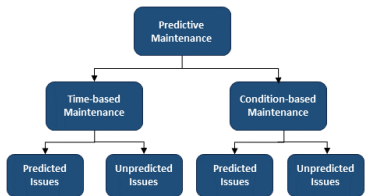
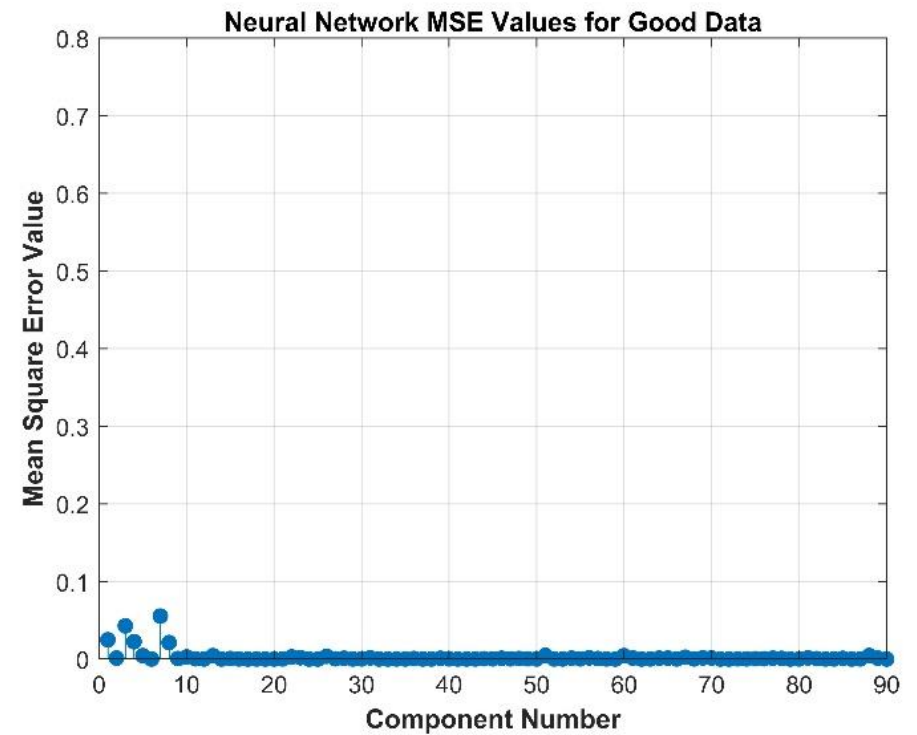
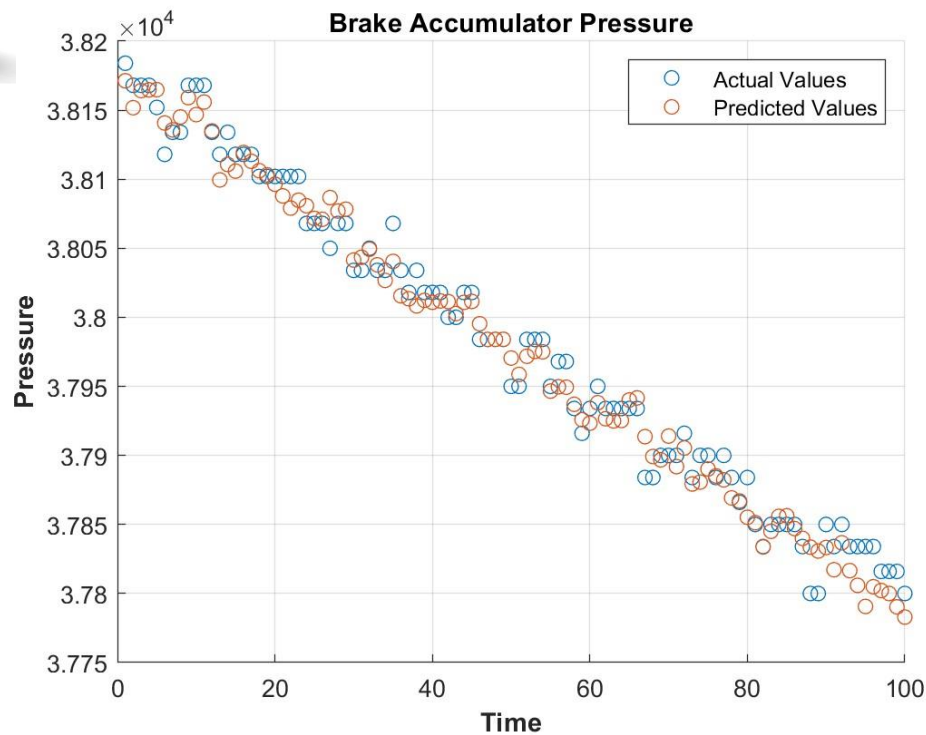
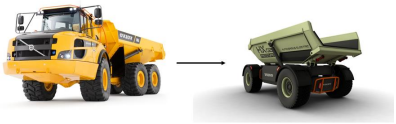
Challenge

Paper D



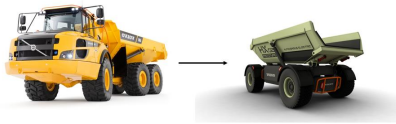
Solution

Paper D

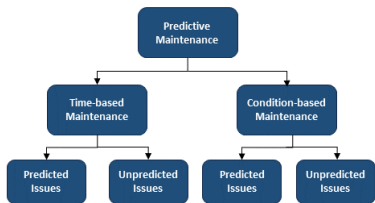
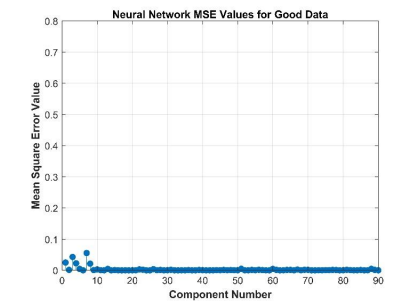
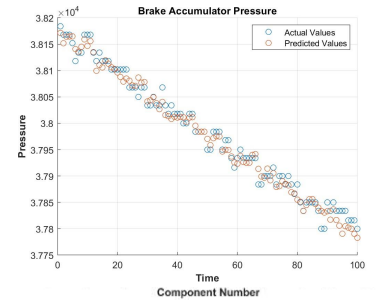


Outcomes

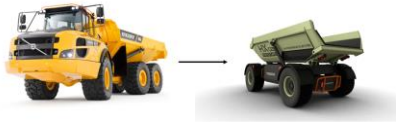
Paper D



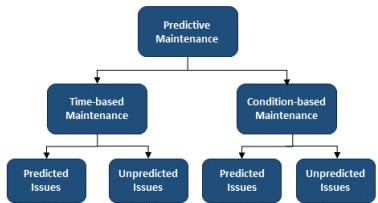
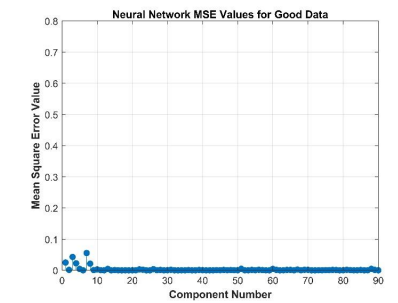
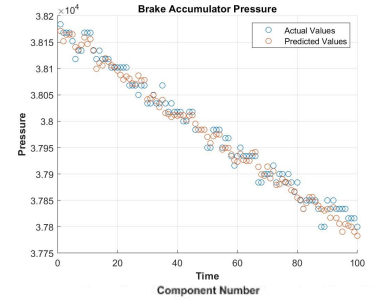
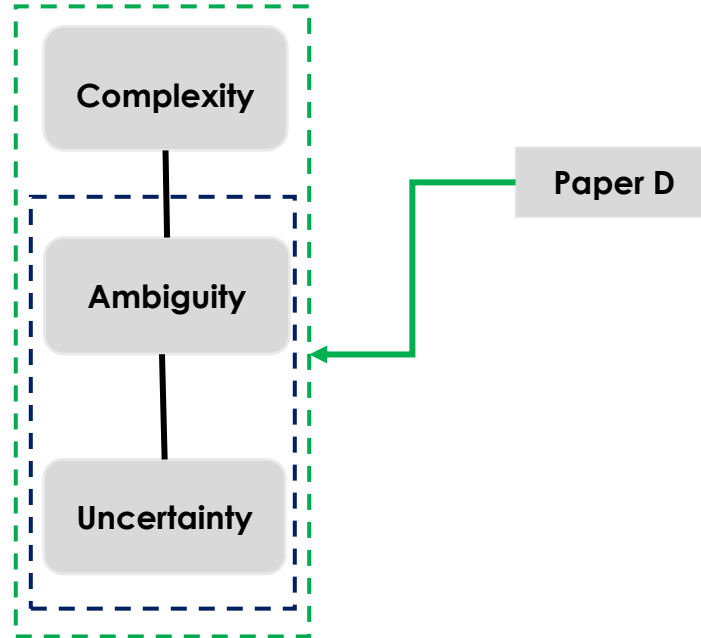
Type of Testing Data	Average Relative Error	Mean Absolute Error
Normal operational data	0.1027	0.0667
Normal operational data with interaction terms	0.1198	0.0391
Noisy operational data	0.1153	0.0469
Noisy operational data with interaction terms	0.0935	0.0208



Paper D



Data Challenges



Type of Testing Data	Average Relative Error	Mean Absolute Error
Normal operational data	0.1027	0.0667
Normal operational data with interaction terms	0.1198	0.0391
Noisy operational data	0.1153	0.0469
Noisy operational data with interaction terms	0.0935	0.0208



Paper E



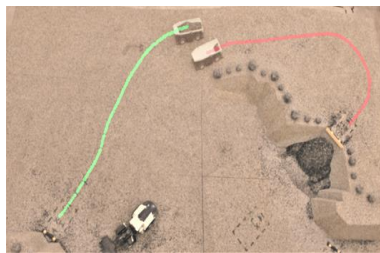
Challenge

Paper E



Solution

Paper E



0/3 | dx:0.0 | dy:0.0 | xv:0.0 | yv:0.0 | Pos:3.0 | Cam:3.0

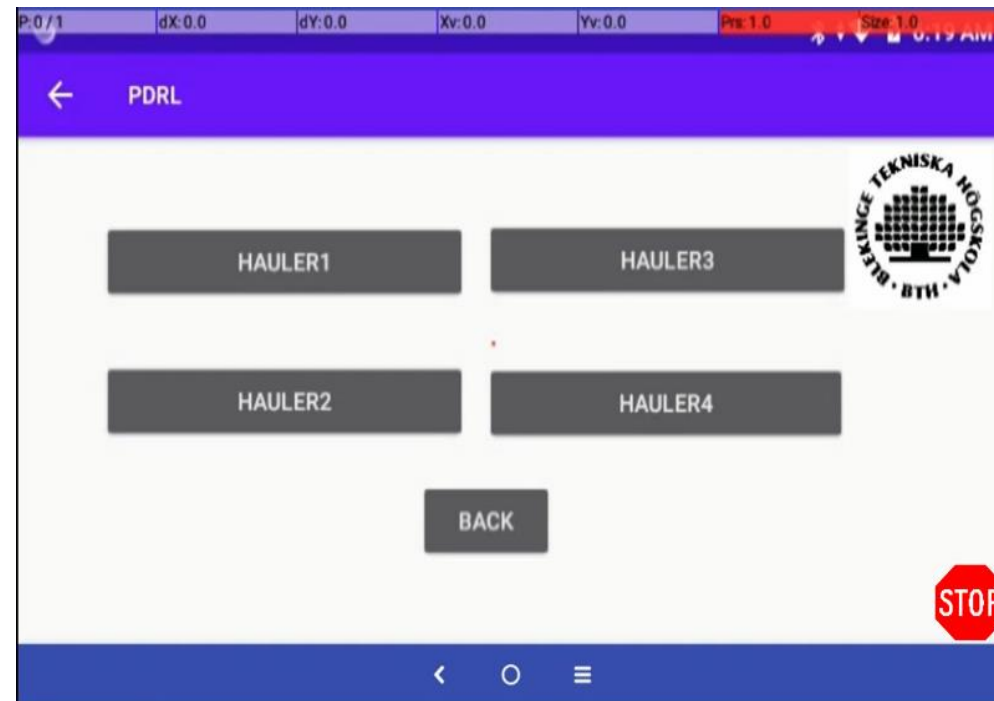
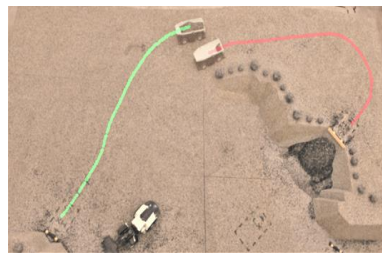
Hauler 1

Battery	93.69%
Speed	10 kmph
Activity	Way to Unloading
Cycles	3

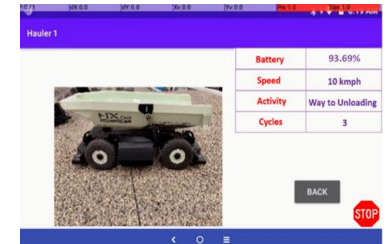
BACK

Outcomes

Paper E



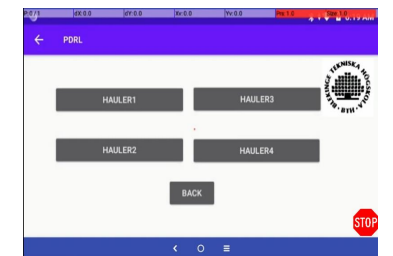
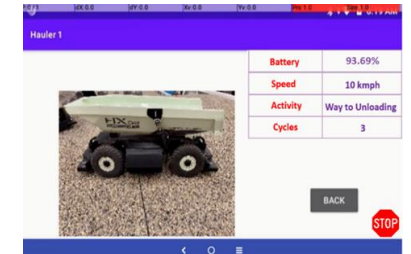
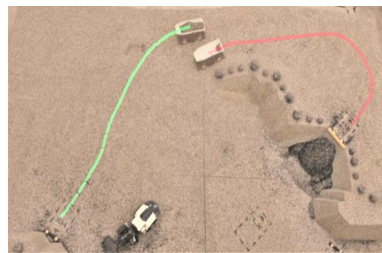
Outcomes



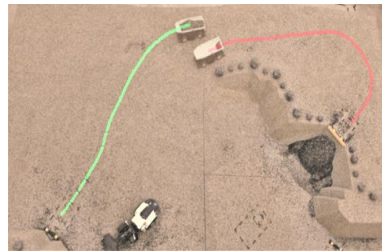
Paper E



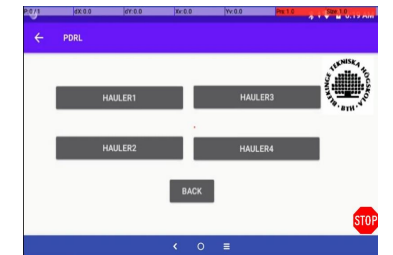
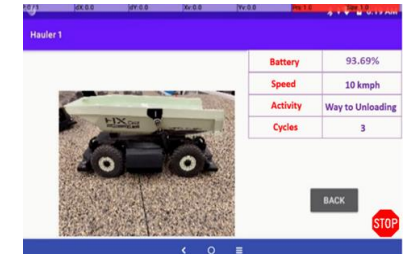
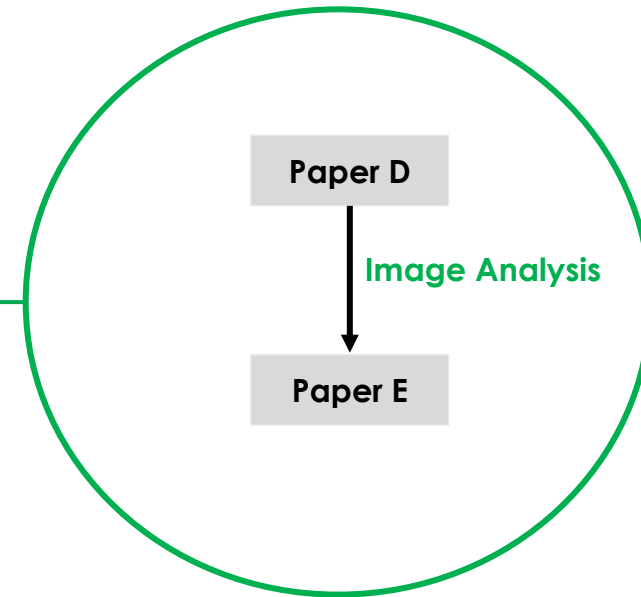
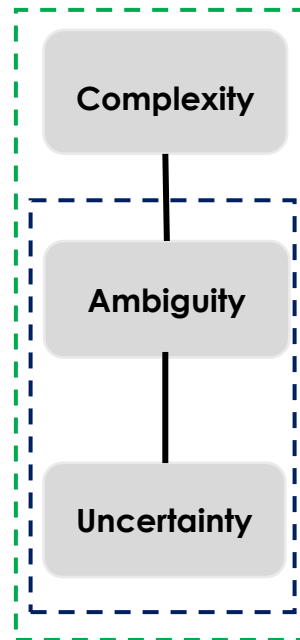
- Improve PSS Development
- How machines are being used
- Predictive Maintenance
- Better Planning and Reallocation



Paper E

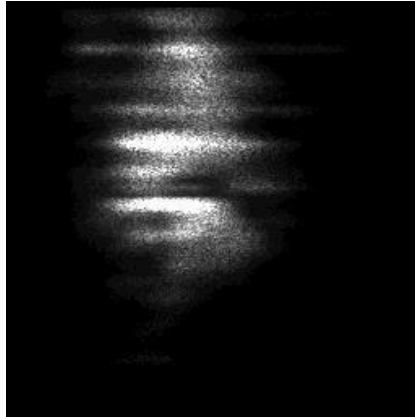


Data Challenges



Paper F

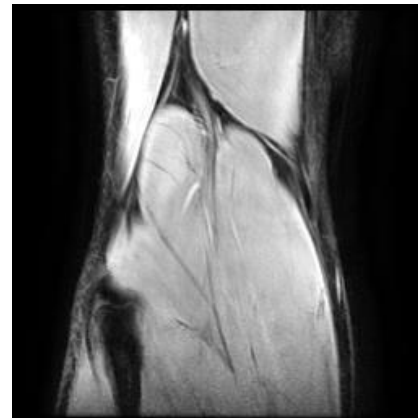
Non-Informative



Informative



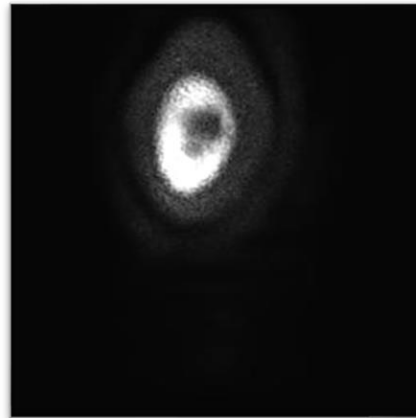
Non-Informative



Informative

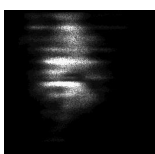
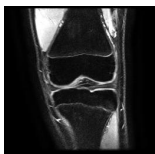
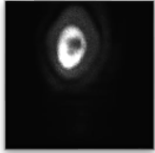


Non-Informative

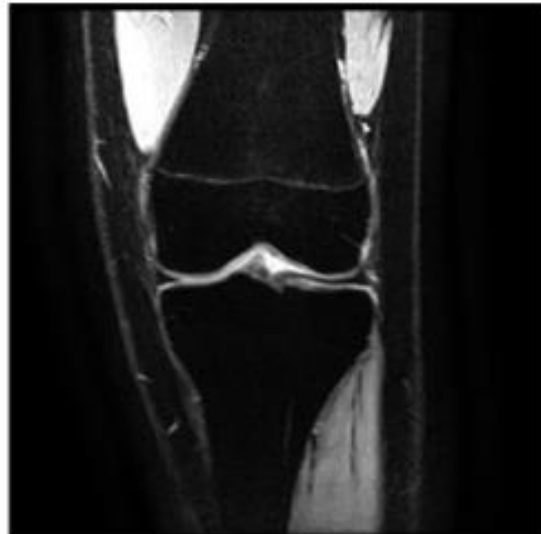


Challenge

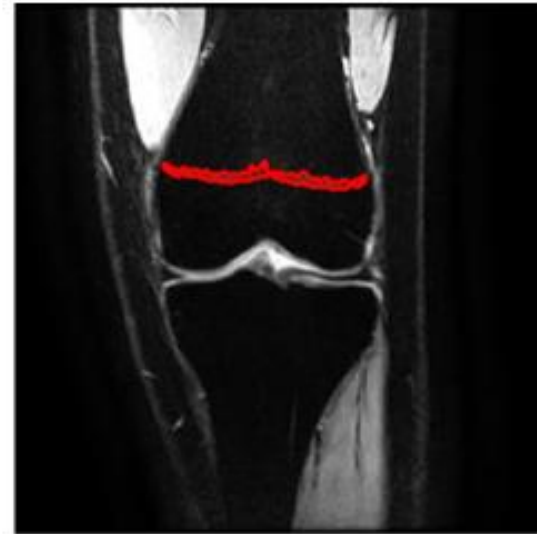
Paper F



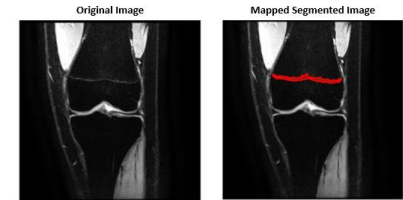
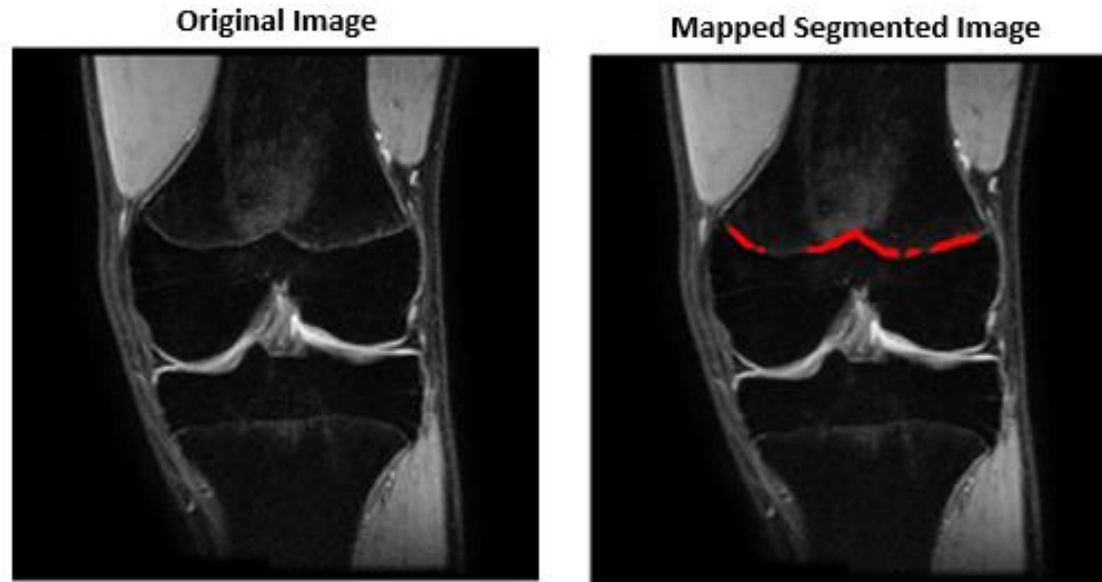
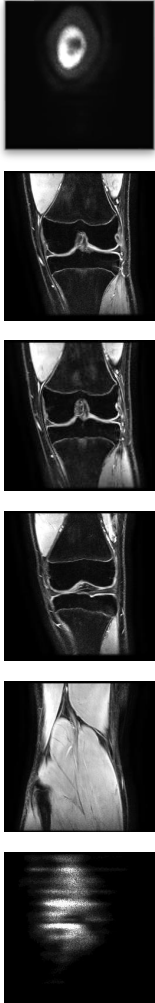
Original Image



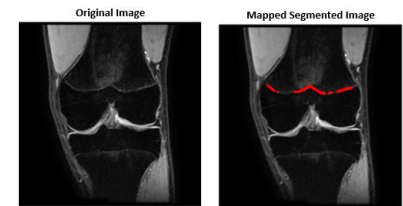
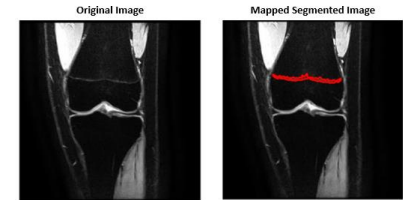
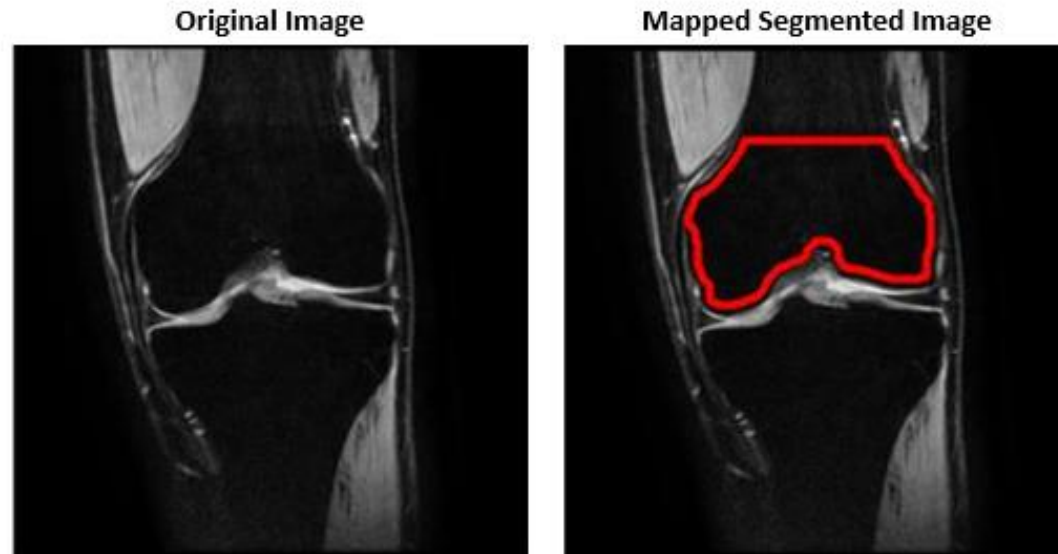
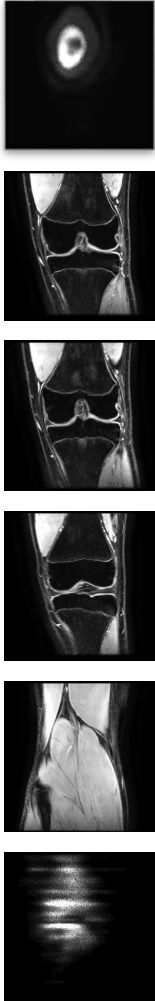
Mapped Segmented Image



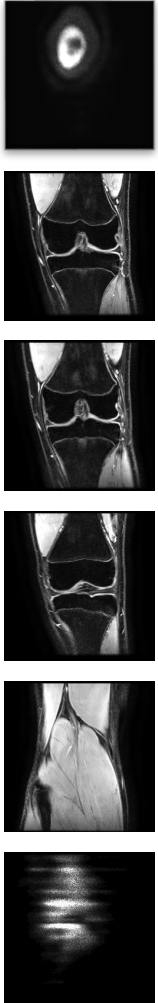
Paper F



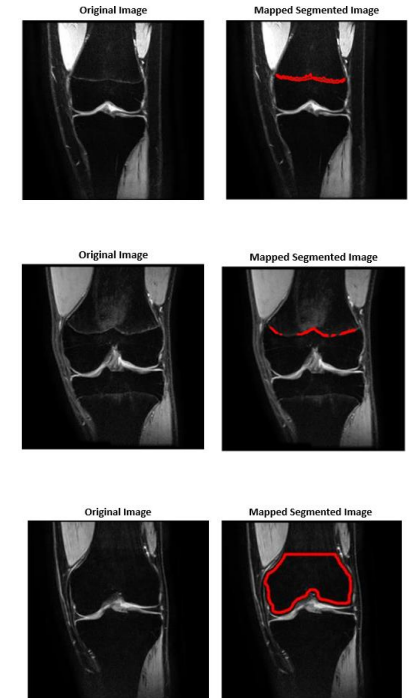
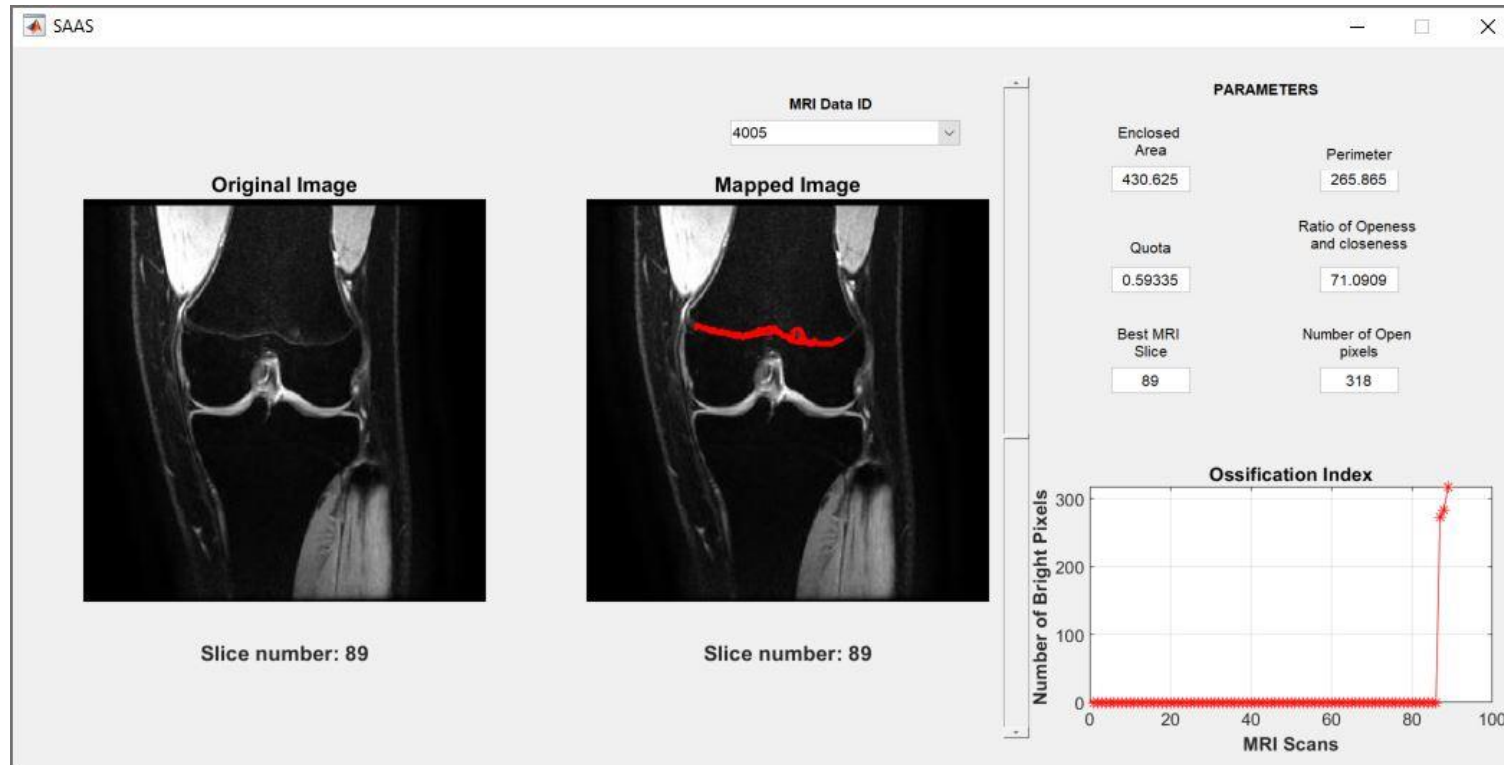
Paper F



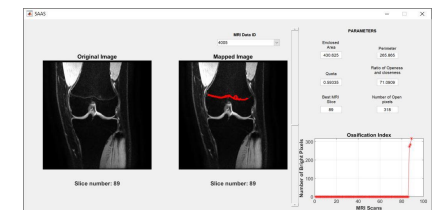
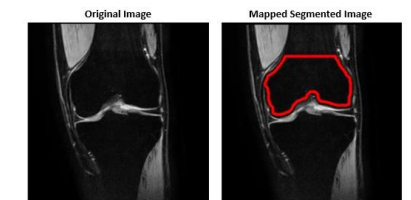
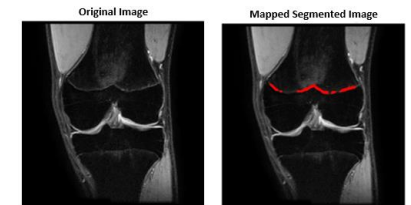
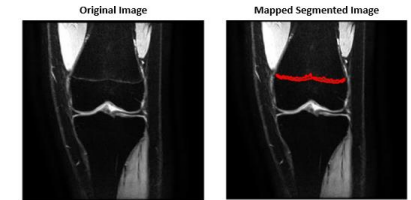
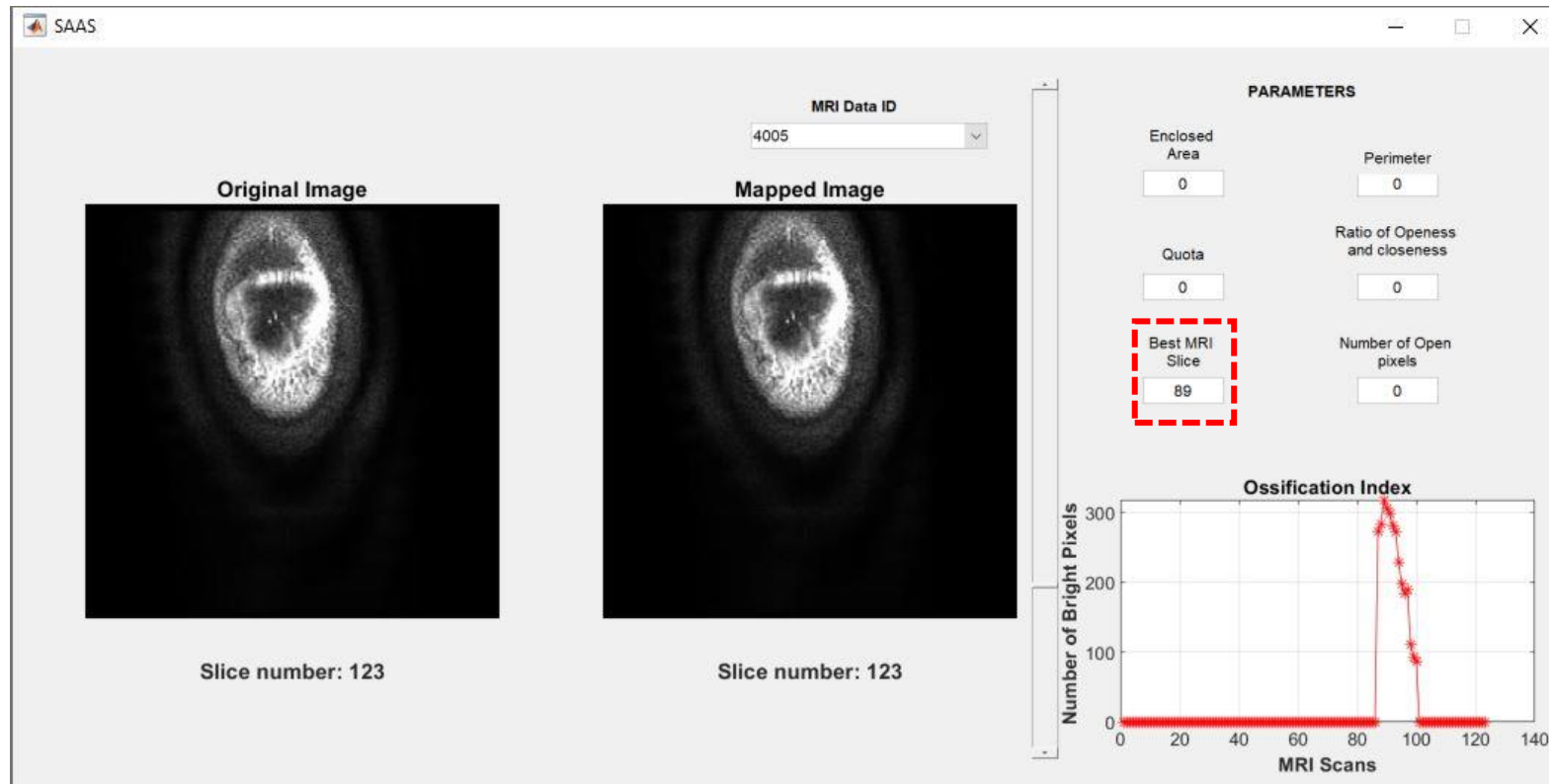
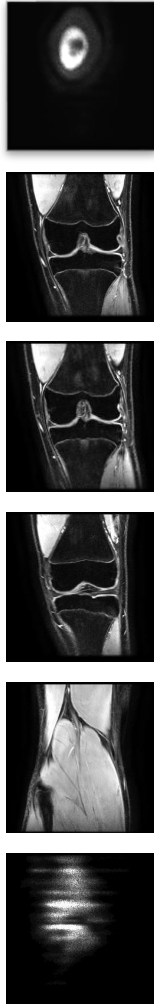
Paper F



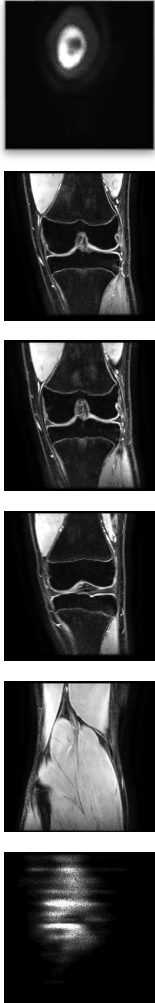
MRI Slices



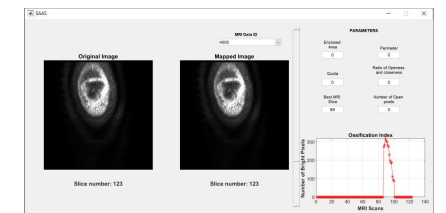
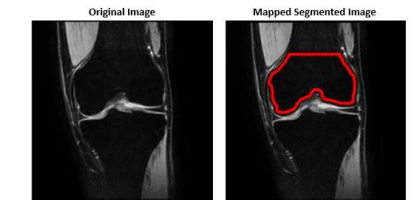
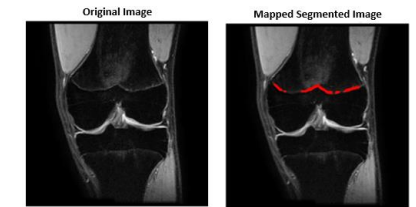
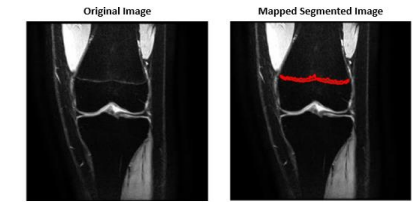
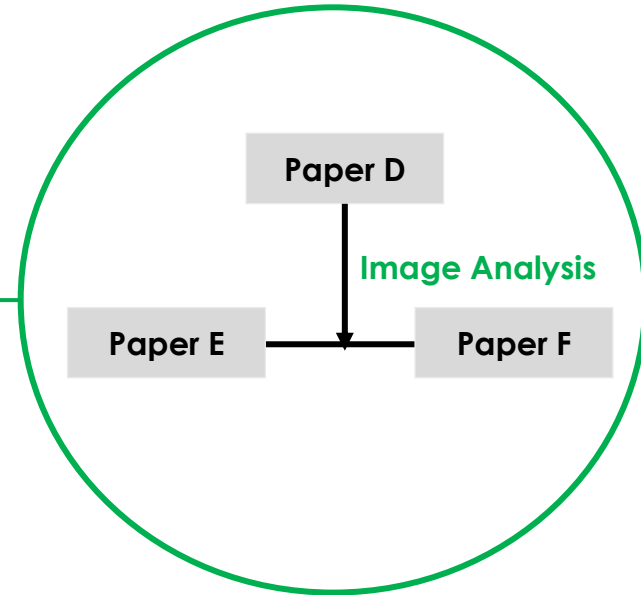
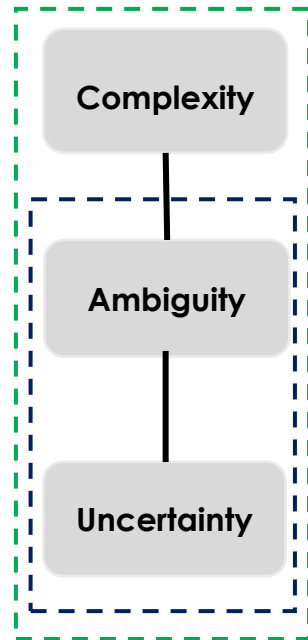
Paper F



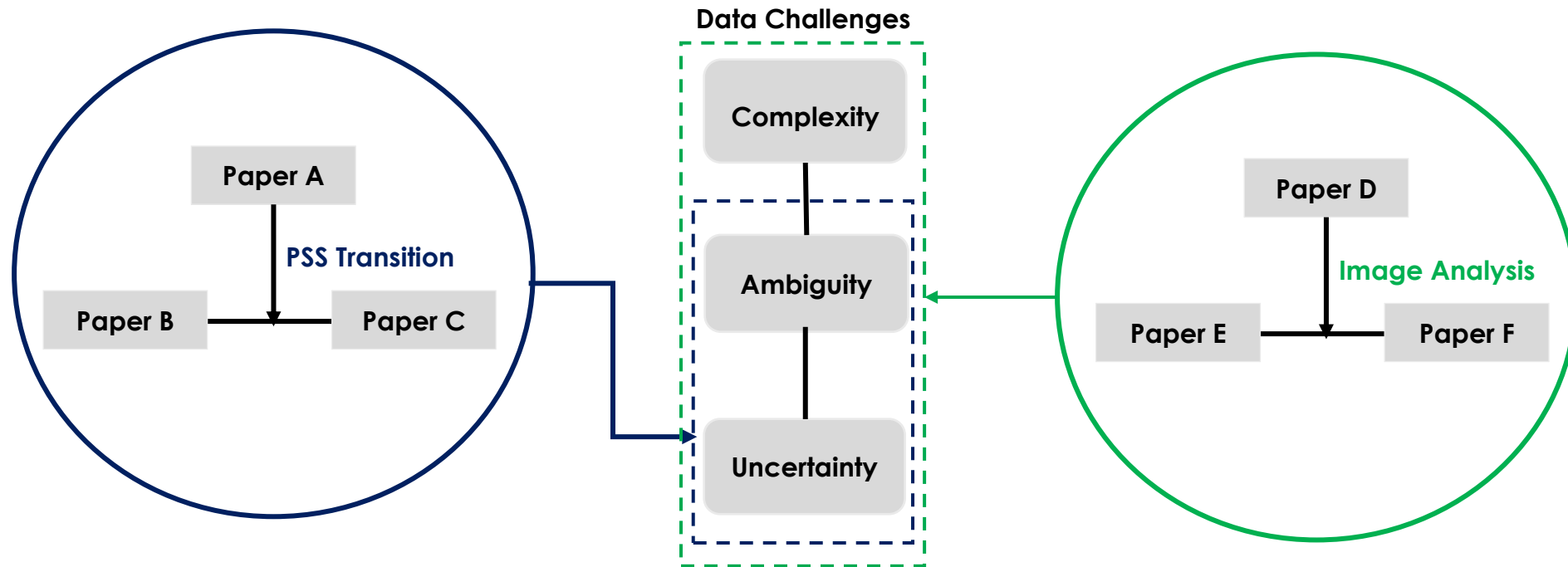
Paper F



Data Challenges



SUMMARY



A Solution with Bluetooth Low Energy Technology to Support Oral HealthCare Decisions for Improving Oral Hygiene

Data Analysis Method Supporting Cause and Effect Studies in Product-Service System Development

Artificial Neural Networks Supporting Cause-and-Effect Studies in Product-Service System Development,

AI Driven Predictive Maintenance for Autonomous Vehicles for Product-Service System Development,

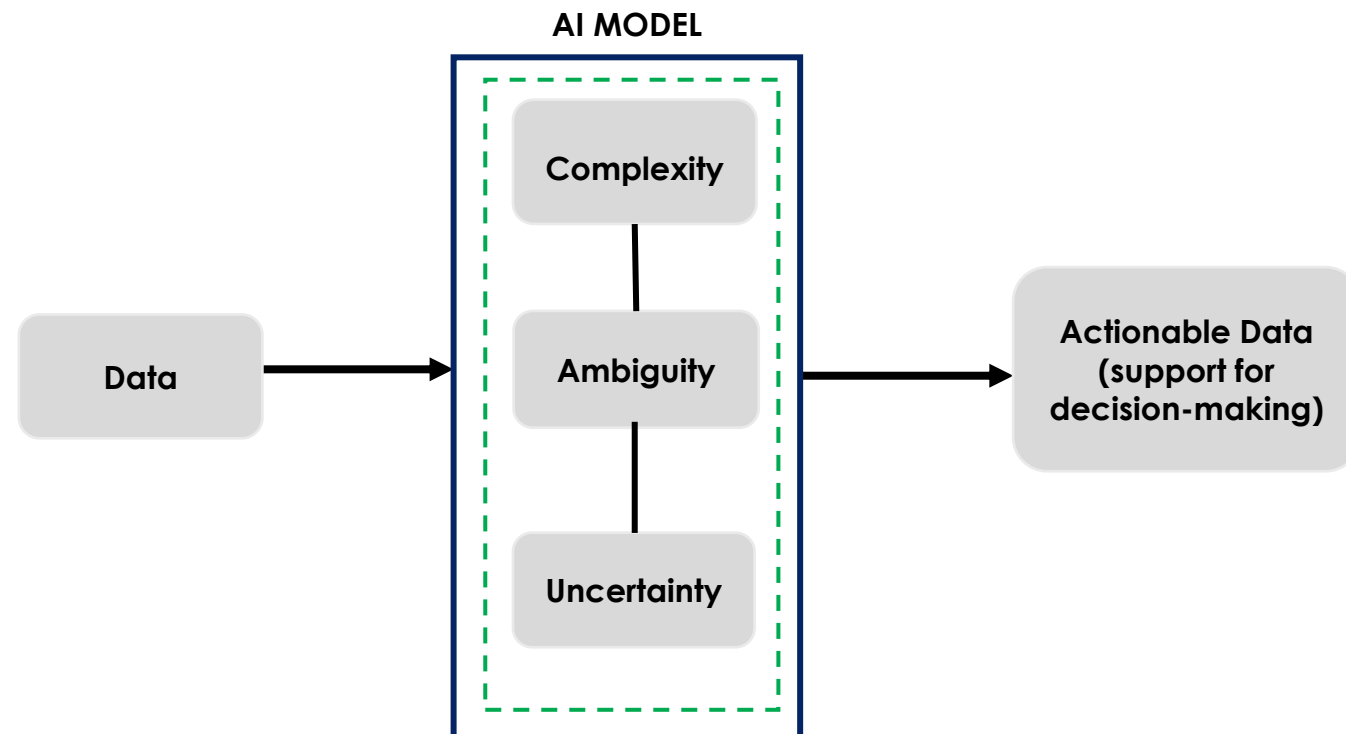
AI-Driven Comprehension of Autonomous Construction Equipment Behavior for Improved PSS Development.

AI-driven Ossification Assessment in Knee MRI: A Product-Service System Development for Informed Clinical Decision-Making



Results

- Combining data analysis with visualization system i.e., DSS
- Associating data and information, aiding understanding and building of knowledge
- Increases the efficiency and effectiveness of the decision-making process
- Cross-functional teams - augmenting the decision support



CONCLUSIONS

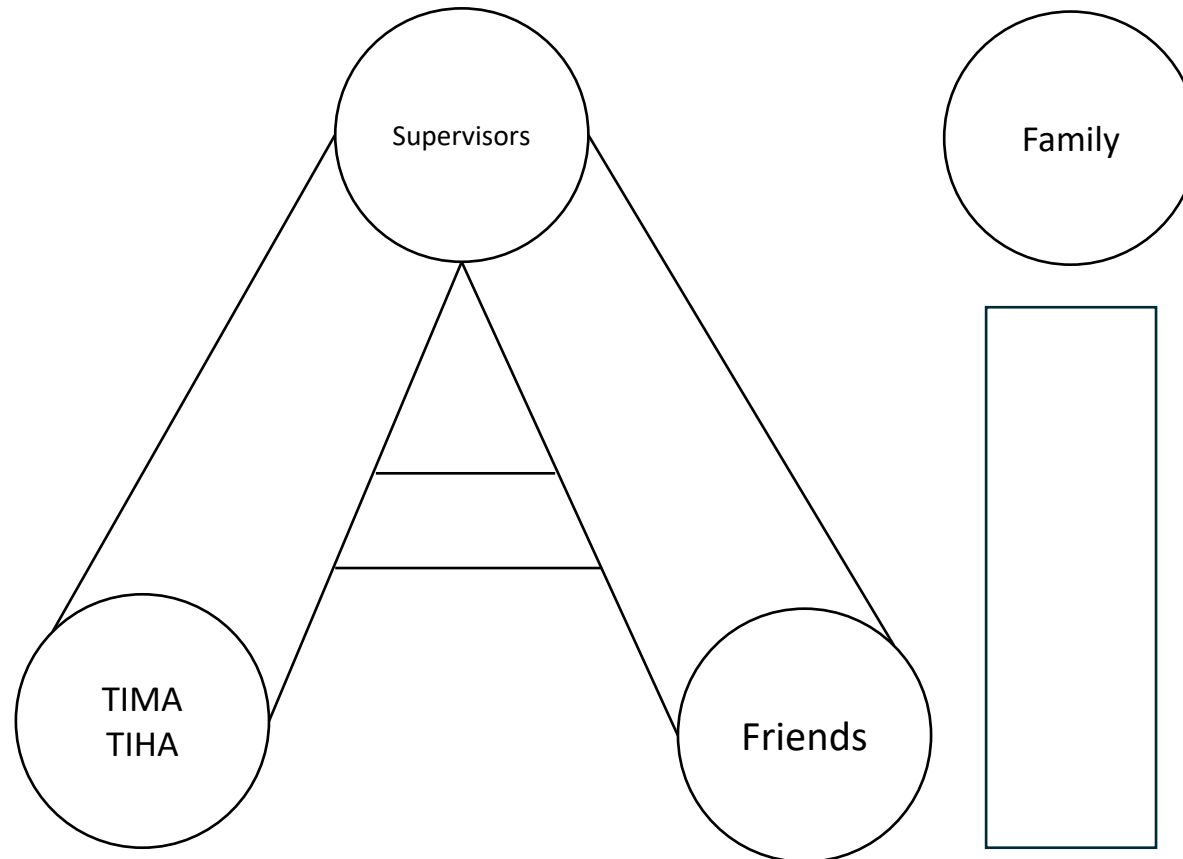
Research Key Takeaways



Conclusions

- Addresses data challenges
- AI-Driven Insights
- Augments decision support
- AI as powerful tool for PSS development
- **Future Works:**
 - Reinforcement Learning
 - Expanding vision models
 - Human-AI collaboration through vision models
 - Digital Twins
 - Evaluating the Impact of AI-powered support tools

Acknowledgements





THANK YOU



Product Development
Research Lab

