

# PhD Opportunity: A Digital Twin-Driven Approach to Predictive Safety and Control Optimisation in Human-Robot Collaborative for Diagnostics and Treatment (HRCDT)



## Main Supervisor: Dr Mark Ng, SMIEEE

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## Co-Supervisors:



Dr Morteza Tabatabaeipour



Dr Ming-wei Chang



Prof. James McLaughlin

## Main Essence of Research Activities

- Conduct research at the Multi-Agent and Advanced Robotics Centre (MAvRiC) using newly acquired Cobots and AMRs
- Develop DT-driven framework to enhance safety and optimise control in HRCDT
- Integrate real-time data from multi-modal sensors for monitoring and prediction
- Employ advanced hybrid techniques (model-based + data driven) to enhance robustness
- DT-capable HPC for computationally intensive tasks



File photos of human-robot collaboration in the medical sector

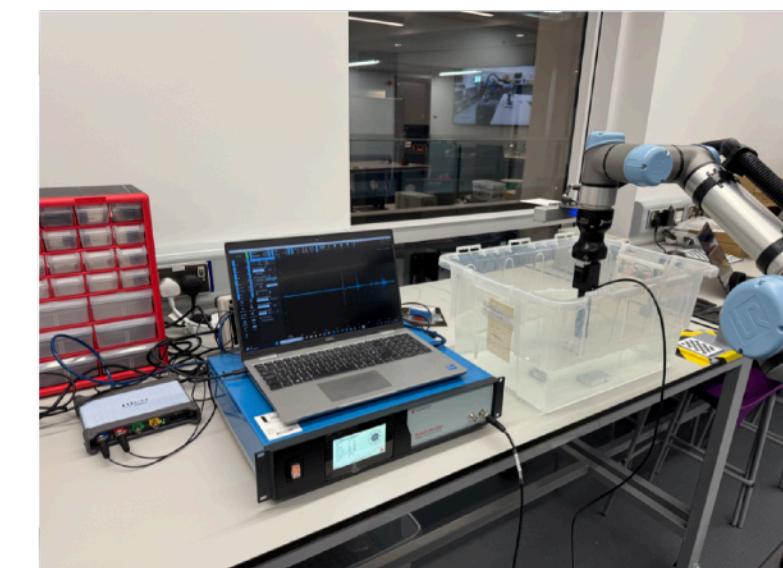
## Select Equipment at MAvRiC:



ER-FLEX Autonomous Systems



Turtlebots



US Pulsar and Transducer

### Other Collaborators and Partners



ELECTRONIC  
AUTOMATION  
ENGINEERS



Northumbria  
University  
NEWCASTLE







Belfast Health and  
Social Care Trust





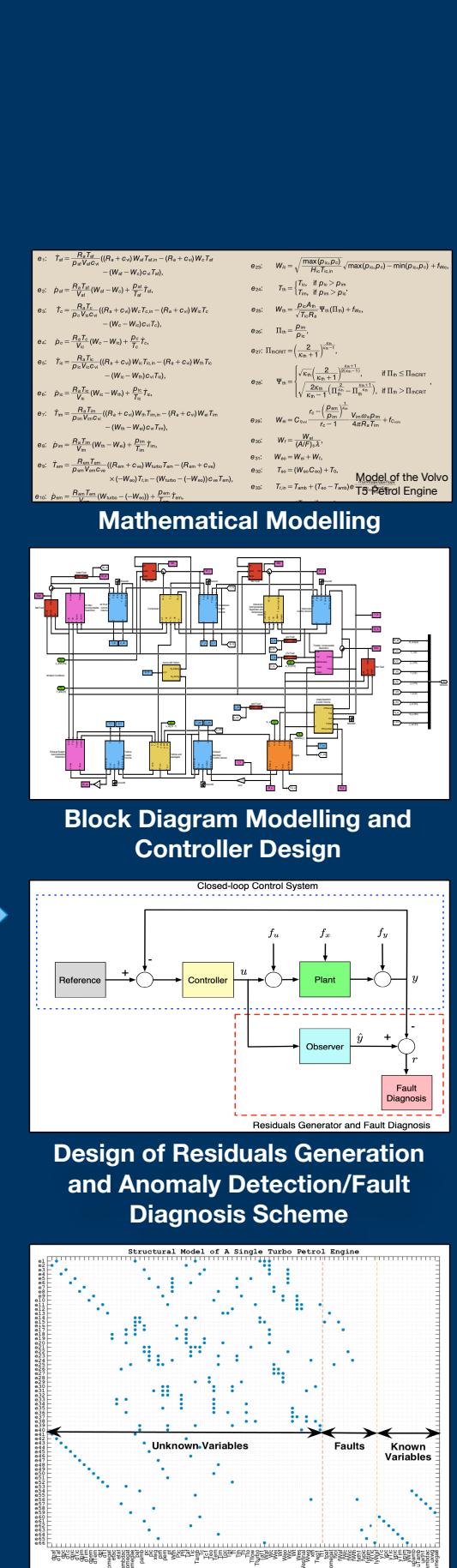


# Control Systems, Fault Diagnosis, Digital Twin, and Simulation Testbed

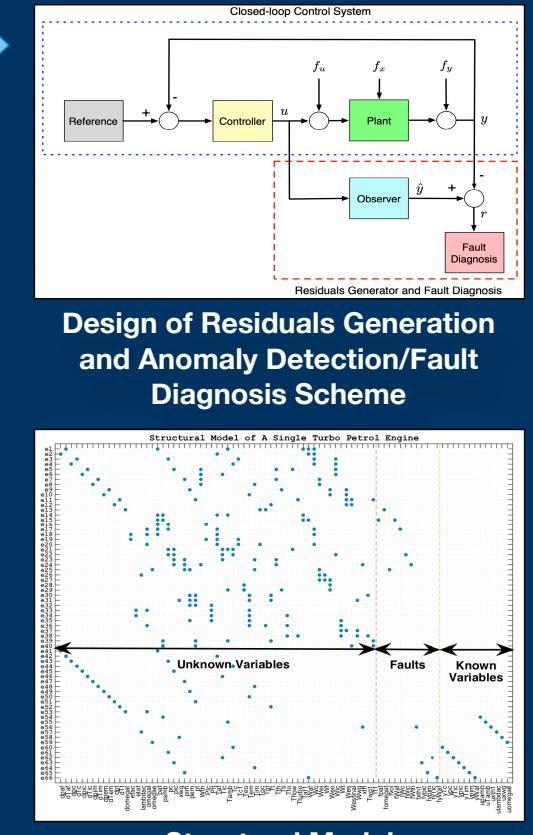
# Physical Systems



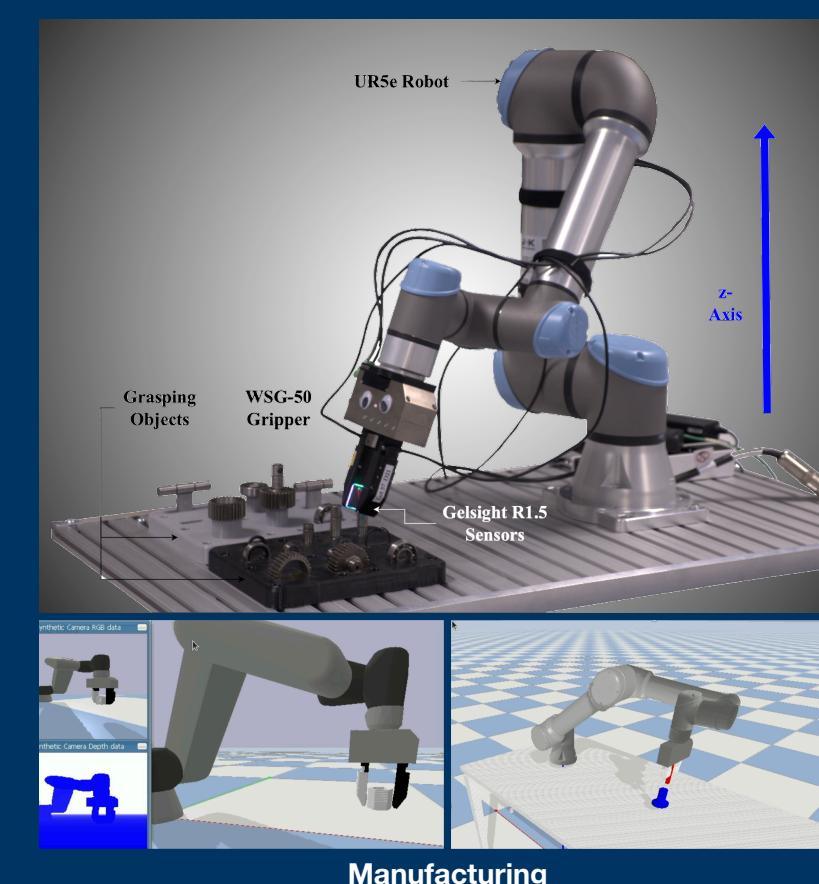
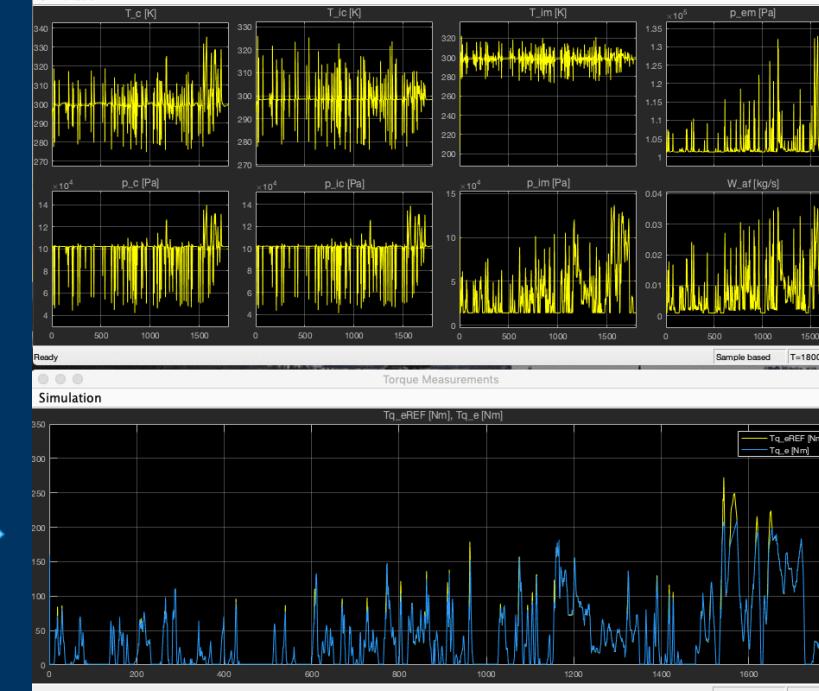
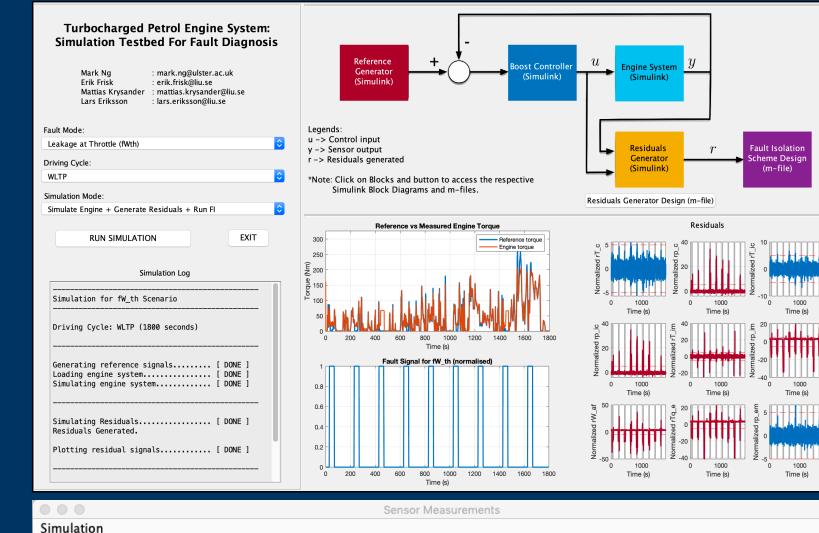
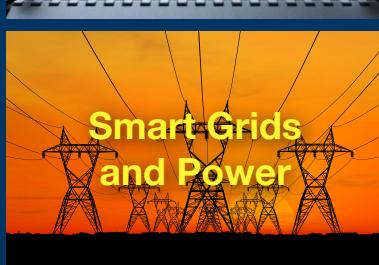
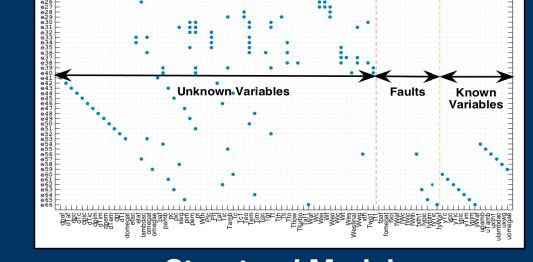
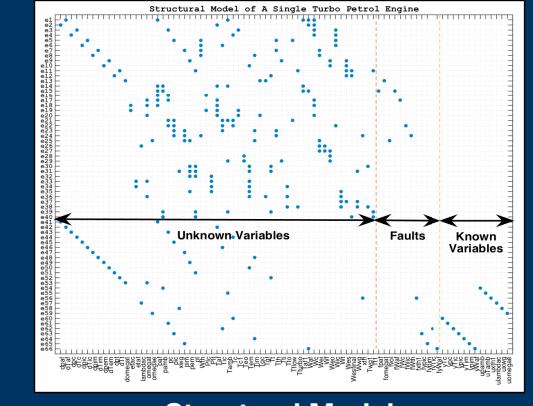
# Modelling and Parameterisation



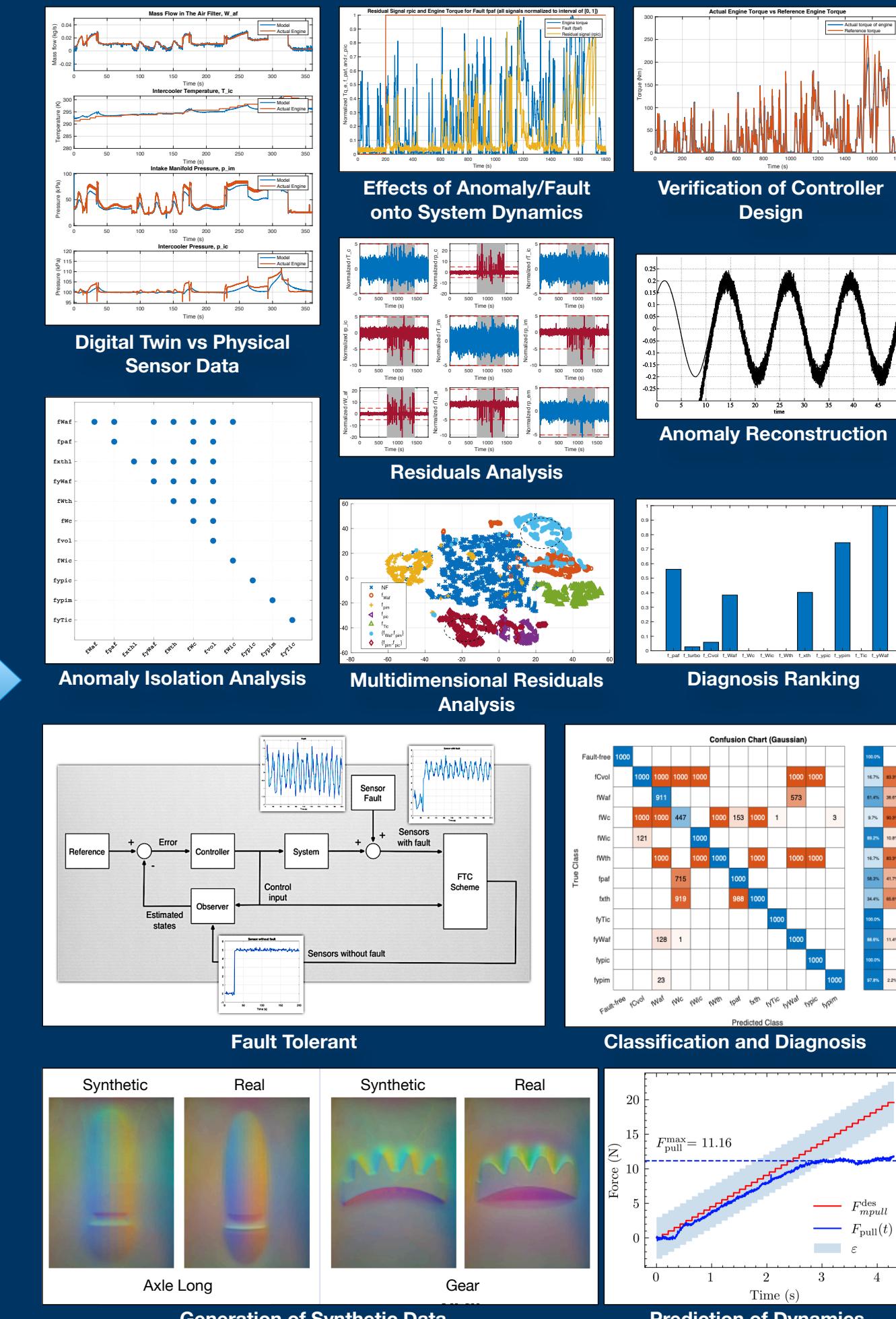
## Block Diagram Modelling and Controller Design



# Design of Residuals Generation and Anomaly Detection Diagnosis Scheme



# Prediction of Dynamics and Maintenance, Fault/Anomaly Diagnosis, Availability and Sustainability Analysis, Personalised Healthcare, Simulated Surgery, Improved Diagnosis, etc.



\*Actual simulated and diagnosis results

Dr Mark Ng SMIEE

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**Website: [www.markusng.com](http://www.markusng.com)**

### Select Key Publications

- “A Realistic Simulation Testbed of A Turbocharged Spark Ignited Engine System: A Platform for the Evaluation of Fault Diagnosis Algorithms and Strategies”, *IEEE Control Systems Magazine*, 2020. DOI:10.1109/MCS.2019.2961793

“Design and Selection of Additional Residuals To Enhance Fault Isolation of A Turbocharged Spark Ignited Engine System”, *7th International Conference on Control, Decision and Information Technologies (CoDIT)*, Prague, Czech Republic, 2020. DOI:10.1109/CoDIT49905.2020.9263792

D. Jung, K. Y. Ng, E. Frisk, and M. Krysander (2018), “Combining model-based diagnosis and data-driven anomaly classifiers for fault isolation”, *Control Engineering Practice*, 2018. DOI:10.1016/j.conengprac.2018.08.013

“A Sliding Mode Observer for Infinitely Unobservable Descriptor Systems”, *IEEE Transactions on Automatic Control*, 2017. DOI:10.1109/TAC.2017.2665699

“A combined diagnosis system design using model-based and data-driven methods”, *IEEE 3rd Conference on Control and Fault-Tolerant Systems (SysTol)*, Barcelona, Spain, 2016. DOI:10.1109/SYSTOL.2016.7739747

“Predicting Maximum Permitted Process Forces for Object Grasping and Manipulation Using a Deep Learning Regression Model”, *8th IEEE Conference on Control Technology and Applications (CCTA)*, Northumbria University, UK, 2024. DOI: 10.1109/CCTA60707.2024.10666569

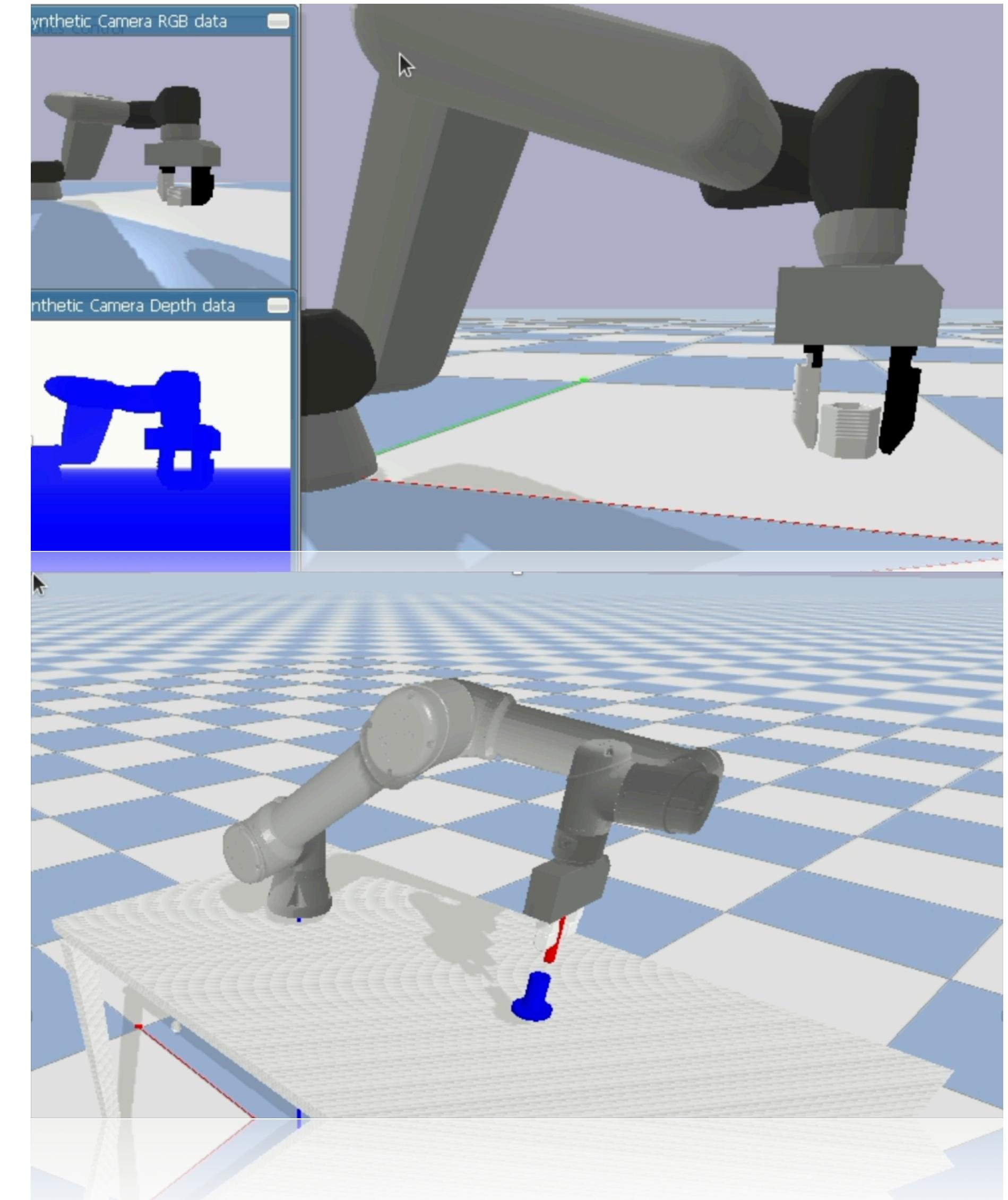
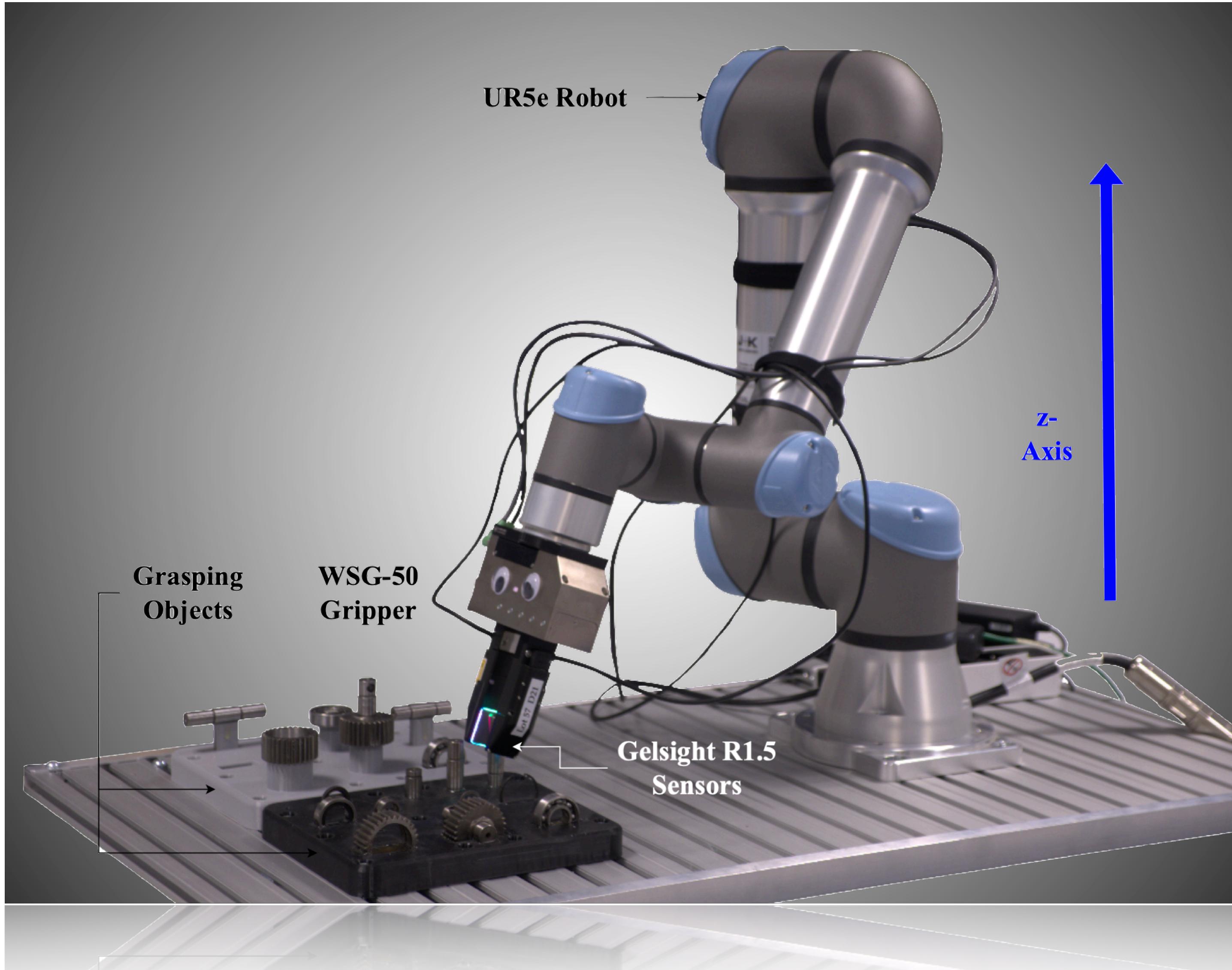
“Artificial intelligence in smart manufacturing: Emerging opportunities and prospects”, *Artificial Intelligence for Smart Manufacturing and Industry X.0*, Springer Nature, 2025. DOI: 10.1007/978-3-031-80154-9\_2

“Learning to Predict Grip Quality from Simulation: Establishing a Digital Twin to Generate Simulated Data for a Grip Stability Metric”, *arXiv preprint*, 2023. DOI: 10.48550/arXiv.2302.03504

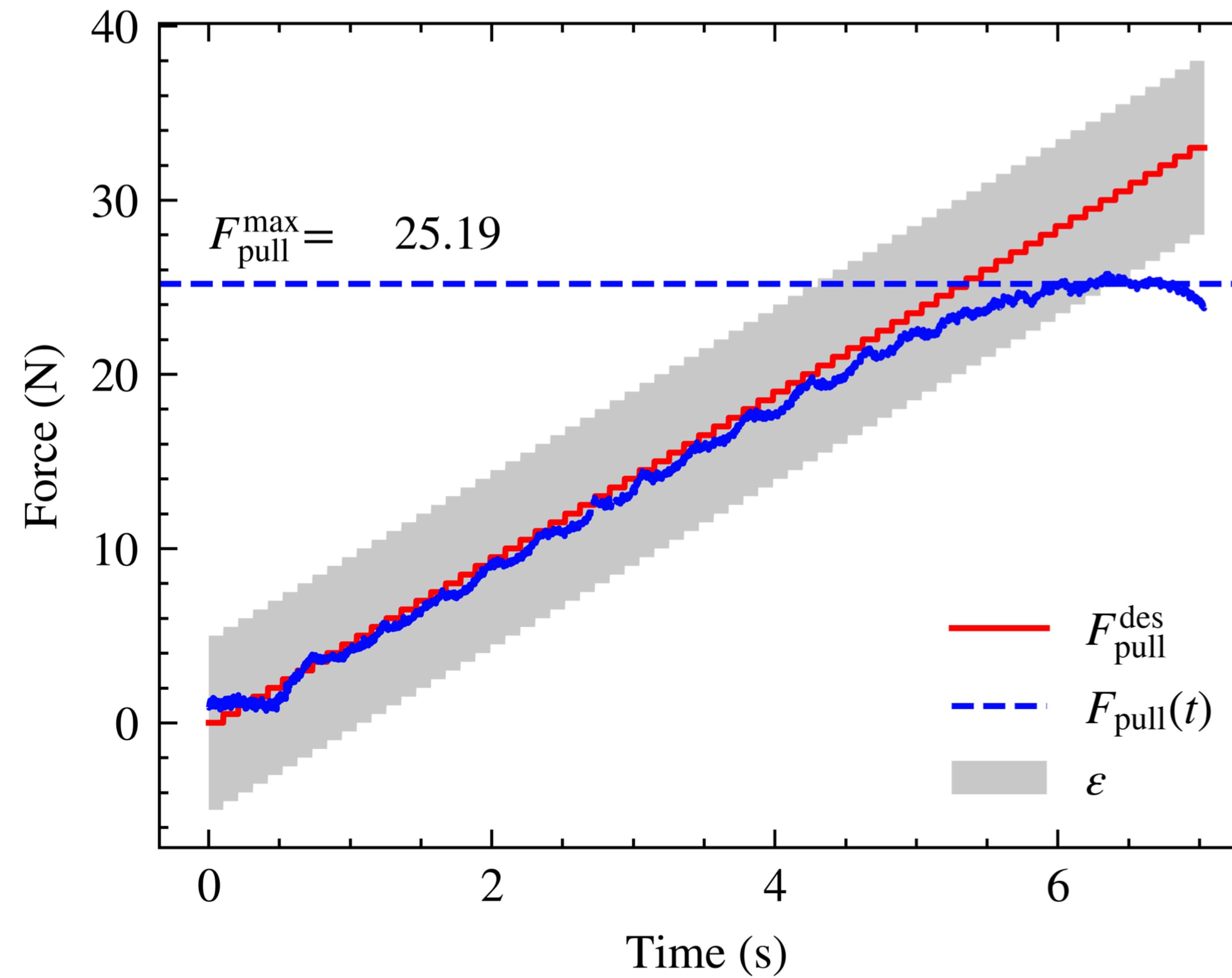
# Digital Twin to Generate Simulated Data for a Grip Stability Metric

Stefanie Wucherer, Robert McMurray, Kok Yew Ng, and Florian Kerber

# Physical Setup vs Digital Twin

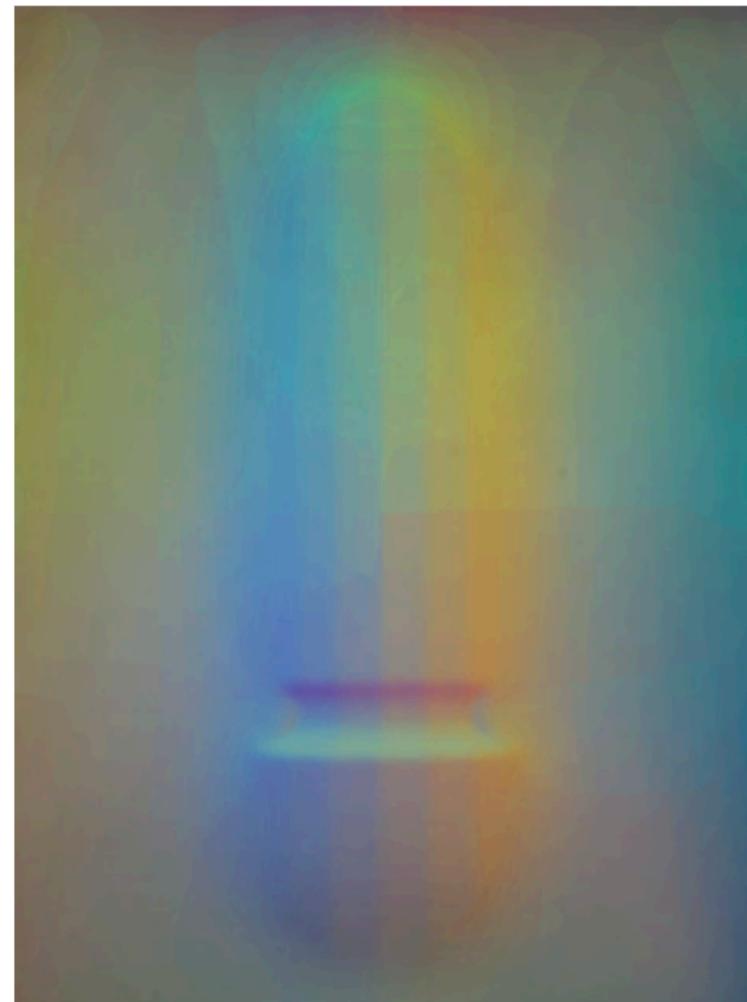


# Prediction of Grip Force Using Deep Learning

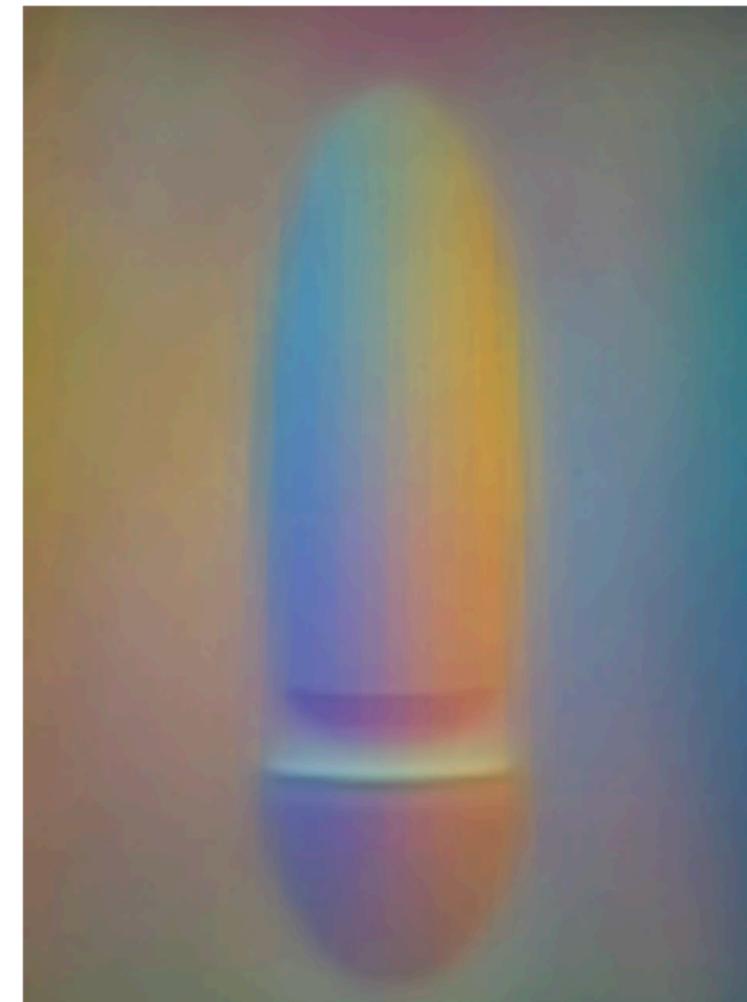


# Generation of Synthetic Data for Existing and Potential Future Assembly Parts

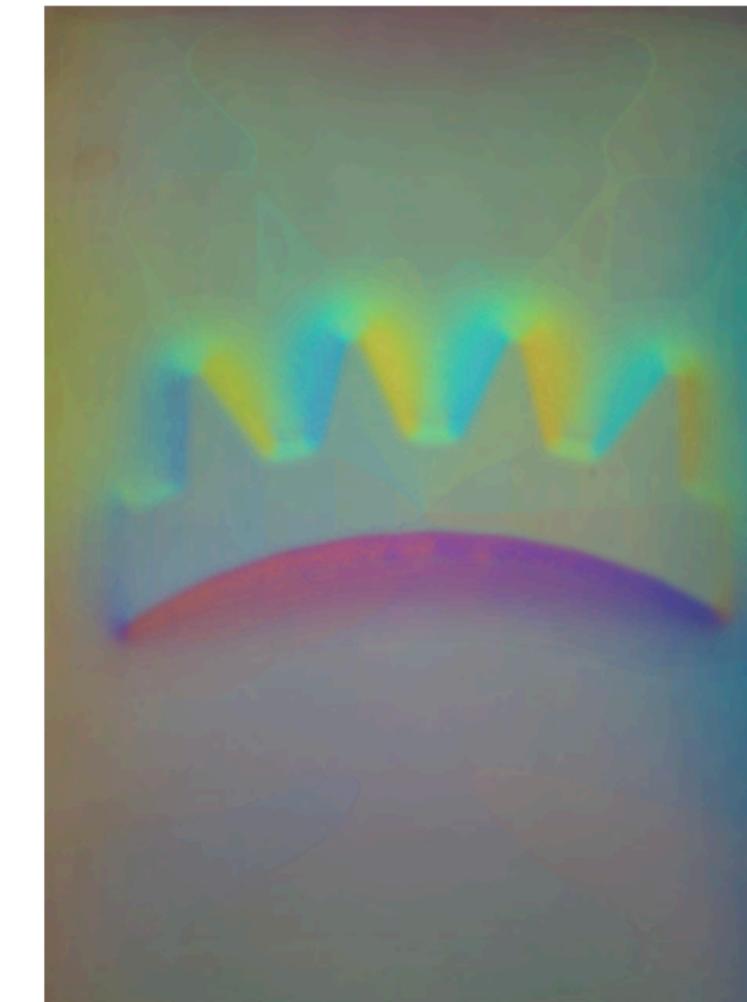
**Taxim**



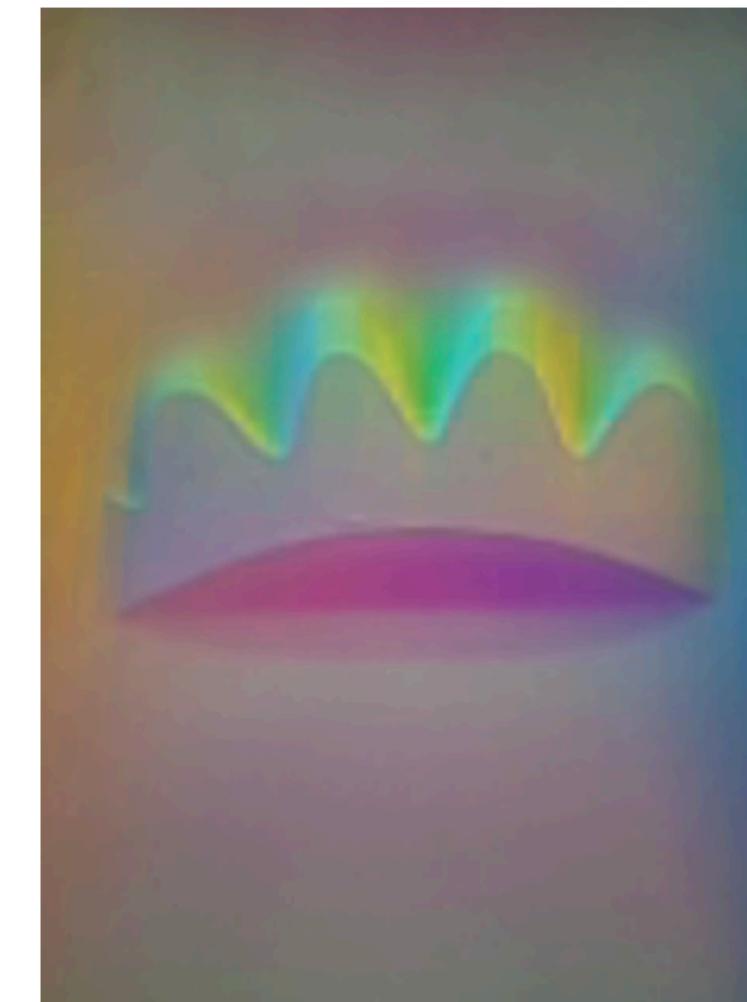
**Real**



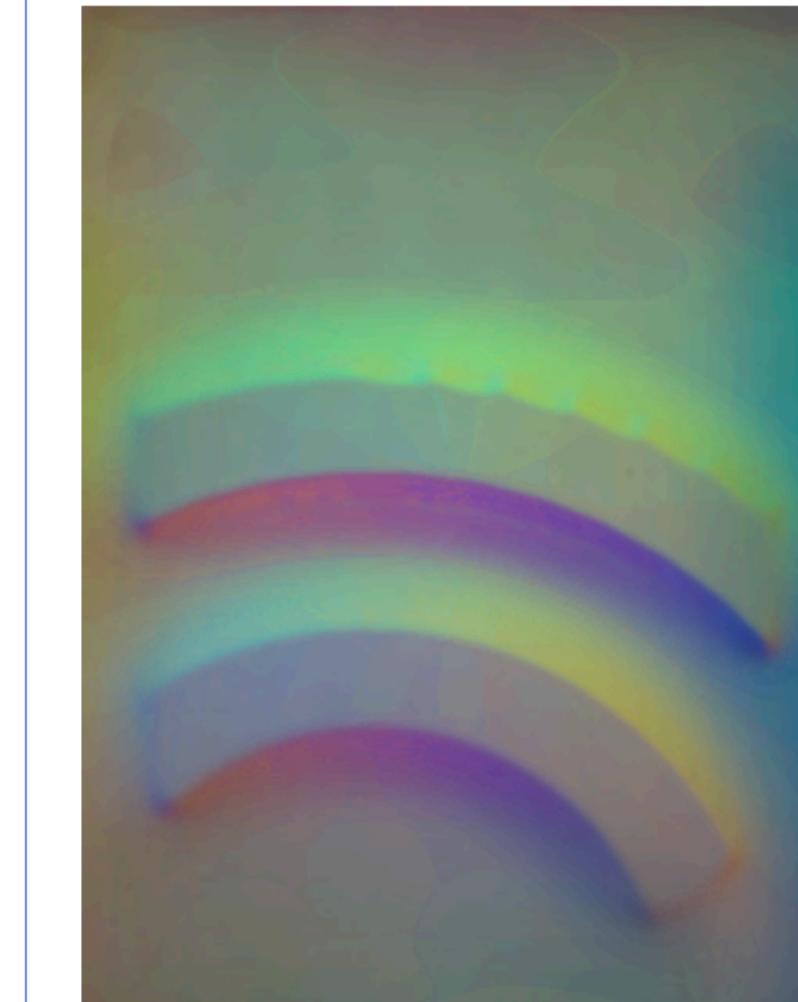
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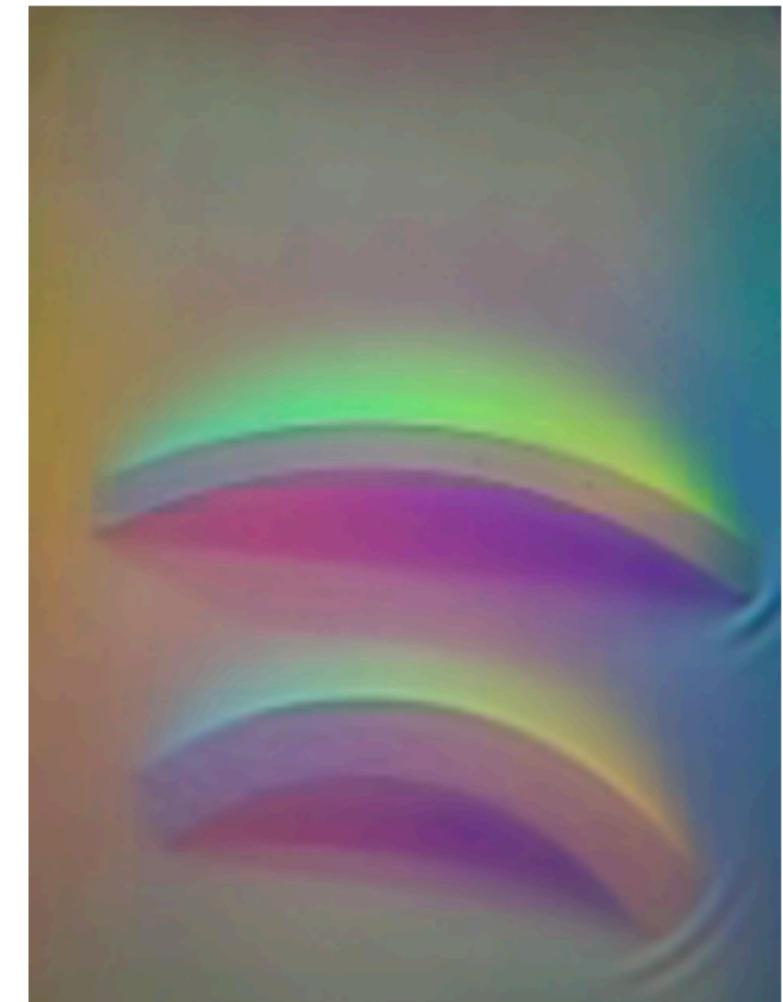
**Real**



**Taxim**



**Real**



**Axle long**

long axle

**Gear**

gear

**Ball bearing**

ball bearing