

# A Benchmark Framework for Advanced Control Methods of Maritime Cranes and Robotic Arms

F. Sanfilippo, L. I. Hatledal and H. Zhang  
Department of Maritime Technology and Operations  
Aalesund University College  
Postboks 1517, 6025 Aalesund, Norway  
{fisa, laht, hozh}@hials.no

K. Y. Pettersen  
Department of Engineering Cybernetics  
Norwegian University of Science and Technology  
7491 Trondheim, Norway  
kristin.y.pettersen@itk.ntnu.no

## INTRODUCTION

In this work, a benchmark framework for advanced control methods of maritime cranes and robotic arms is presented. The suite is based on the use of the Functional Mockup Interface (FMI), which is a tool independent standard for the exchange of dynamic models and for co-simulation. A set of routine tests, different cost functions and metrics are provided taking into account several factors including position and velocity accuracy, energy consumption, quality and safety for both the cranes and the surrounding environment. Each proposed routine test is task-oriented and try to reproduce, and systematically, consider realistic on-board operation scenarios. For instance, different standard transporting and lifting operations are taken into account. By considering task-oriented routines, this benchmark suite allows for comparing different control methods independently from the specific crane model to be controlled. Two alternative control methods for maritime cranes and robots, based on the use of Genetic Algorithms (GAs) [1] and on the use of Artificial Neural Networks (ANNs) [2] respectively, are considered as case-studies and related simulations are carried out to validate the benefits of the proposed benchmark suite. The underlying idea is shown in Fig. 1 and Fig. 2.



Fig. 1 The idea of using a benchmark suite for comparing different control methods.

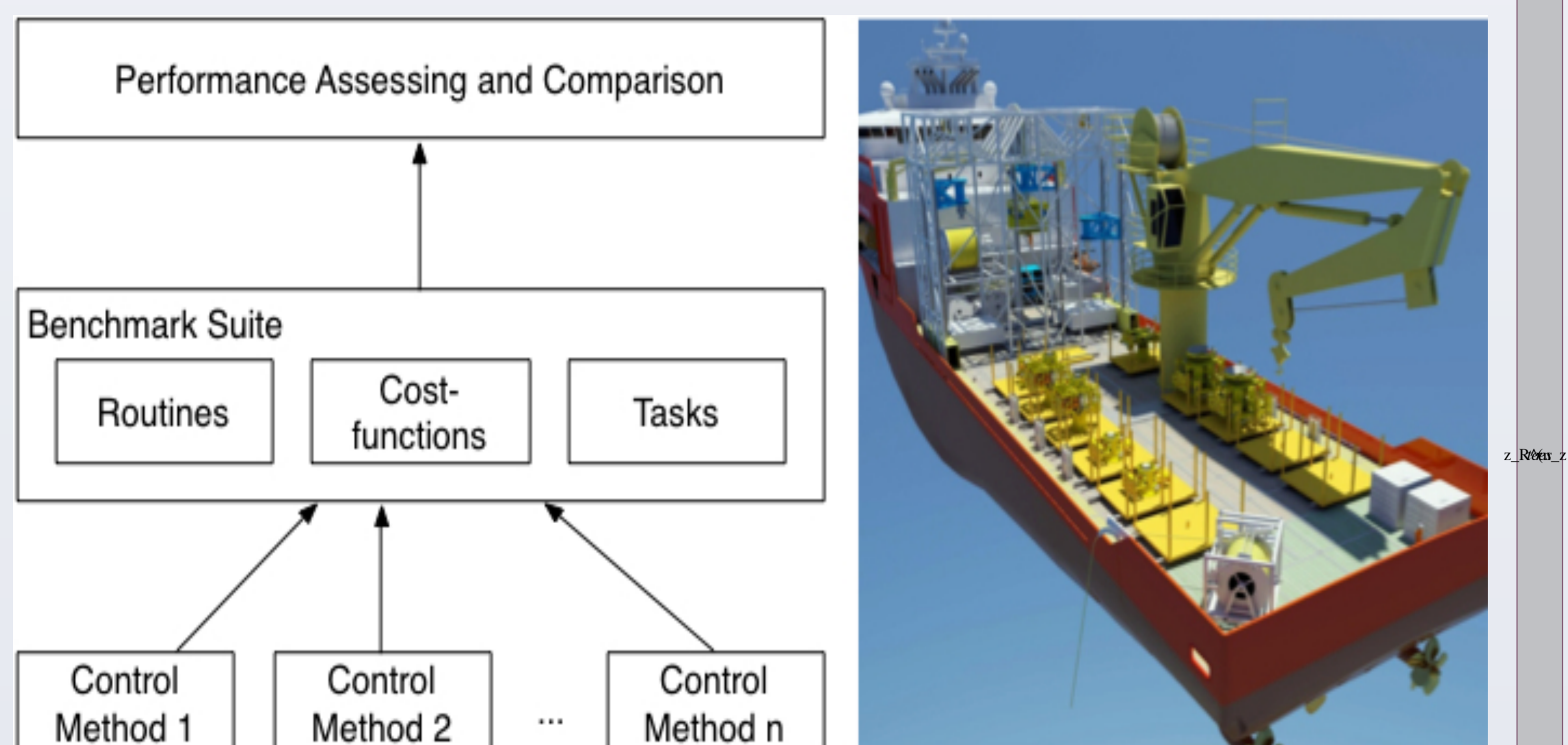


Fig. 2 The concept of realising a benchmark suite for advanced control methods of maritime cranes and robotic arms.

## BACKGROUND

Maritime cranes, compared with robotic arms, rely on a much more complex model of the environment with which they interact. These kinds of cranes are in fact widely used to handle and transfer objects from large container ships to smaller lighters or to the quays of the harbours. Therefore, their control is always a challenging task, which involves many problems such as load sway, positioning accuracy, wave motion compensation and collision avoidance. Even though the operating environment can be very challenging, it is still quite common to use relatively simple control interfaces to perform offshore crane operations. In most cases, the operator has to handle an array of levers and buttons to operate the crane joint by joint. When considering working efficiency and safety, this kind of control is extremely difficult to manage and relies on extensive experience with high operating skill level of the operators. Therefore, more flexible and reliable control approaches for maritime cranes are needed, and several research groups all over the world are starting to propose different innovative methods.

Contrary to the field of robotic arms, where at least a few benchmark suites and methods for estimating the efficiency of the considered control approach already exist, in the field of maritime cranes there is a lack of a universally recognised benchmarking methods for assessing the system performance. This is mainly the reason why, the current practice of publishing research results makes it extremely difficult not only to compare results of different control approaches, but also to asses the quality of the research presented by the authors.

## METHODS

In this work, a methodology for performing experimental activities in the area of maritime cranes and robotic arm control is outlined. Based on the use of the Functional Mockup Interface (FMI), which is a tool independent standard for the exchange of dynamic models and for co-simulation, a benchmark suite for advanced control methods of maritime cranes and robots is also presented. The suite includes a set of routine tests, different cost functions and metrics that take into account several factors including position and velocity accuracy, energy consumption, quality and safety for both the cranes and the surrounding environment. Each proposed routine test is task-oriented and try to reproduce, and systematically, consider realistic on-board operation scenarios. For instance, different standard transporting and lifting operations are taken into account.

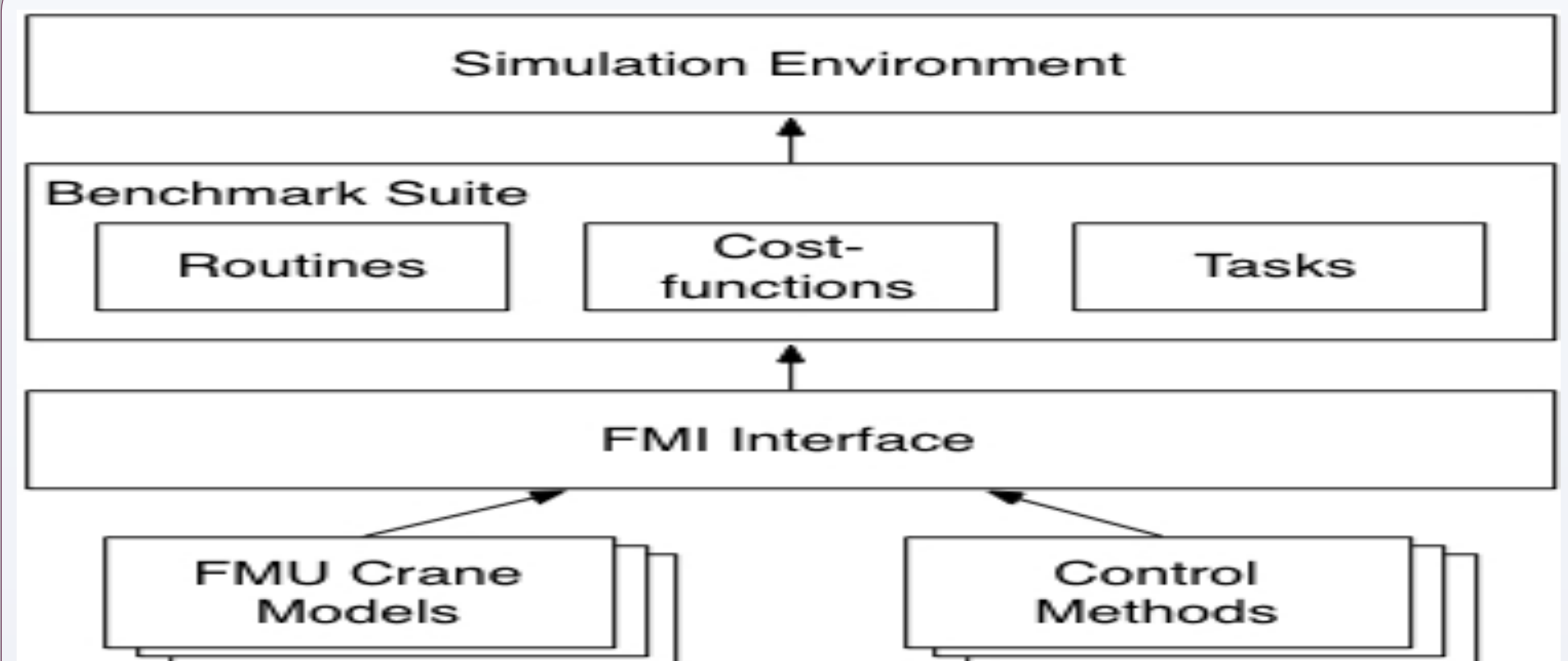


Fig. 3 The proposed system architecture.

The proposed system architecture is shown in Fig. 3. Since the maritime cranes usually operates in a very complex and challenging environment it is almost impossible to perform tests and benchmarks in a real experiment setup. A possible way to compare different control methods relies on the idea of using a virtual environment that closely simulates the desired systems and allows for replicating a set of reference tasks and related performance metrics. Different performance indices can be used to asses the effectiveness of the compared control approaches as shown in Fig. 4.

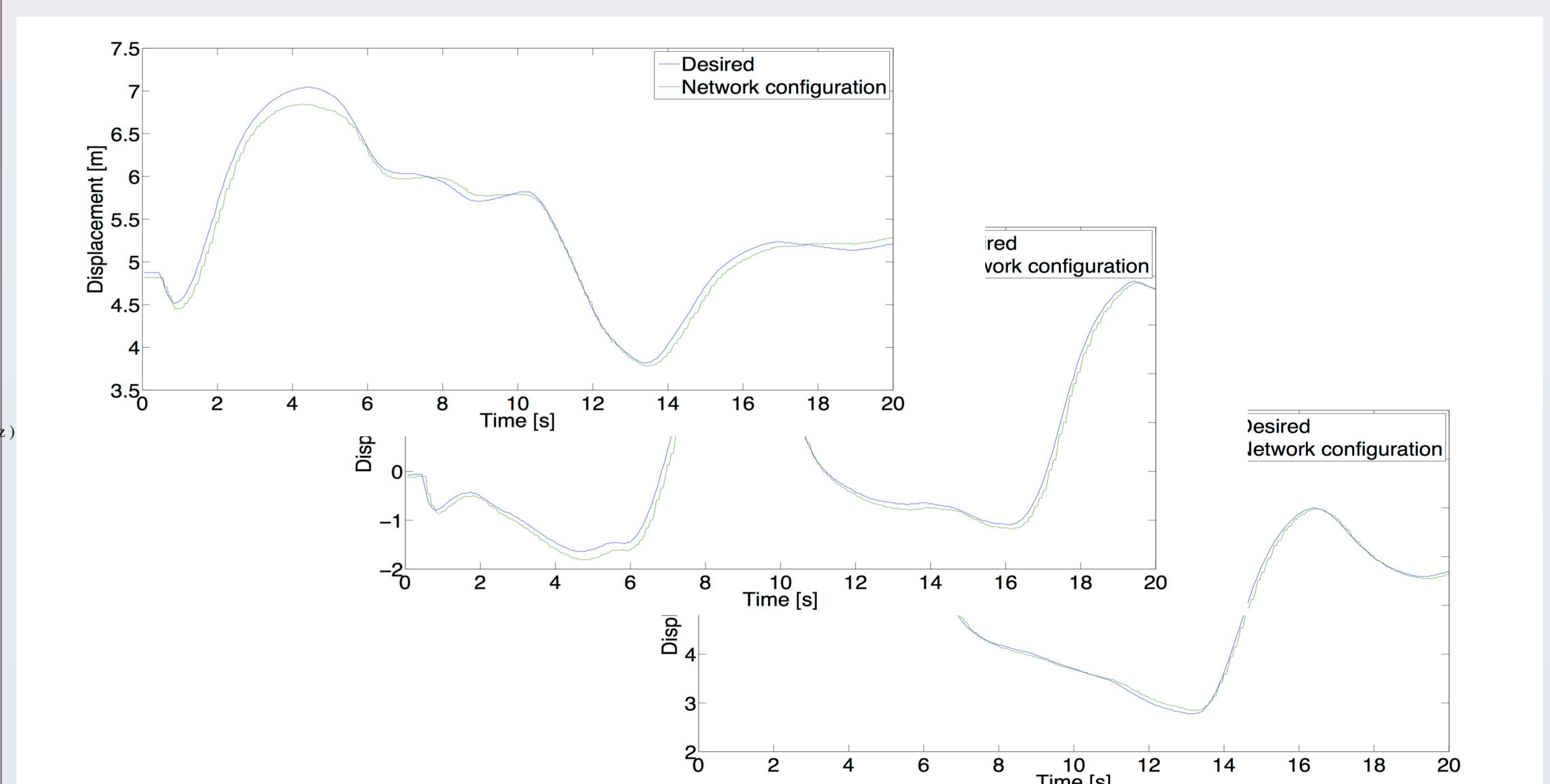


Fig. 4 Different performances indices can be used to compare different control methods.

## CONCLUSIONS

This work highlights the potential of developing a benchmark framework for advanced control methods of maritime cranes and robotic arms. The potential of this framework has been shown by comparing two different alternative control approaches. However, it is difficult to define a benchmark that is commonly accepted by the community mainly because of divergent viewpoints on a problem from different research groups. In the future, different control algorithms such as the ones implemented in [3] may be tested.

## REFERENCES

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## CONTACTS

Filippo Sanfilippo is a PhD candidate in Engineering Cybernetics at the Norwegian University of Science and Technology and research assistant at the faculty of Marine Technology and Operations, Aalesund University College. Supervisors: Professor Kristin Ytterstad Pettersen, Professor Houxiang Zhang and Professor Domenico Prattichizzo.

Email: fisa@hials.no

