A Flexible Control Architecture for the Crane Simulator of the Offshore Simulation Centre AS (OSC)

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INTRODUCTION

A flexible and general control system architecture that allows for modelling, simulation and control of different models of maritime cranes and, more generally, robotic arms was previously presented by our research group [1]. Each manipulator can be controlled by using the same universal input device regardless of differences in size, kinematic structure, degrees of freedom (DOFs), body morphology, constraints and affordances. The architecture presented establishes the base for the research of a flexible mapping procedure between a universal input device and the manipulators to be controlled.

In this work, the integration of the presented architecture with the Crane Simulator developed by the Offshore Simulator Centre AS (OSC) is addressed. The underlying idea is shown in Fig. 1. The OSC is the worlds most advanced provider of simulators for demanding offshore operations. This excellence is made possible by a very high level of operational know-how from the maritime cluster in Norway mixed with advanced computer technology, sophisticated mathematical models and state of the art 3D graphics display systems. This includes complete offshore vessel bridges with all relevant controls and systems. Using intelligent software and interfaces it is possible to change the vessel's environment including altering the weather, winds, waves and time of day at the touch of a button.

The integration of our flexible control architecture with the OSC represents a perfect match for investigating and testing alternative control methods. The communication protocol is discussed in detail in this paper. Related simulations are carried out to validate the efficiency of the proposed integration.

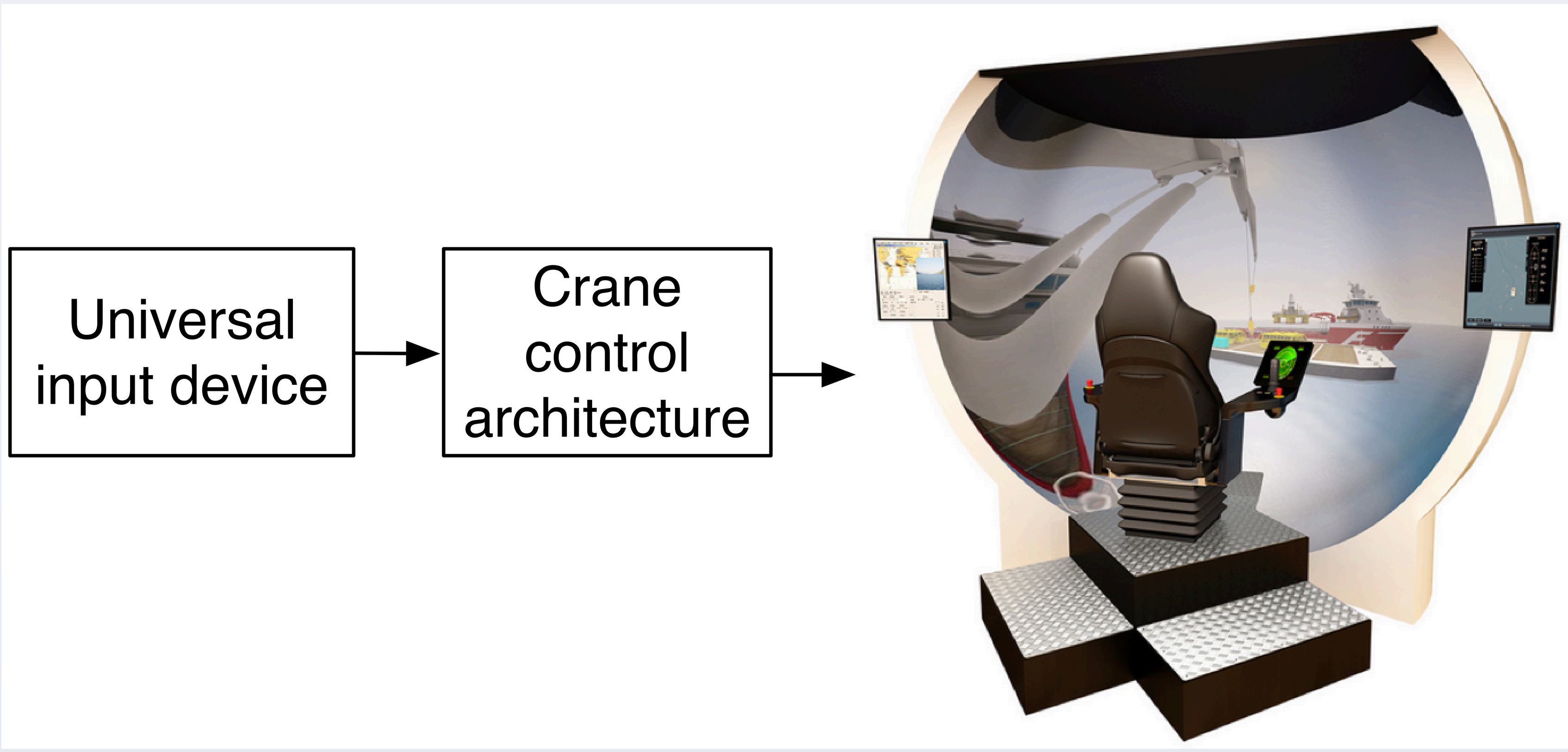

Fig. 1 The idea of integrating our flexible control architecture with the Crane Simulator of the Offshore Simulation Centre AS (OSC).

BACKGROUND

Our preliminary studies on developing a flexible control architecture started by presenting a modular prototyping system architecture that allows for modelling, simulation and control of different robotic arms by using the Bond Graph Method [2]. The main drawback of this approach is that the complexity of the system tends to rise when considering a large number of DOFs. In addition, the system was implemented in 20-sim, which is a modeling and simulation program that can be used as a general developing environment but does not provide any specific native support for maritime applications such as winds or waves generation. To overcome these problems, a more flexible and reliable architecture was developed by using the Java programming language in [1]. Being Java a general-purpose programming language, it opens up to a variety of different possibilities including the implementation of different control methods, as well as the use of third-party libraries and visualisation environments. Regarding the visualisation environment, in this previous work, the game engine Unity3D was used to visualise the different models. However, even though Unity3D provides a set of quite advanced tools for 3D graphics, it is mainly a game engine and it does not natively provide any specific support for maritime applications. This justifies the need of switching to a simulation environment specifically designed for offshore applications. The OSC represents the worlds most advanced provider of simulators for demanding naval operations. Complete offshore vessel bridges can be simulated with all relevant controls and systems. The vessel's environment can be changed including altering the weather, winds, waves and time of day at the touch of a button. Therefore, the integration of our flexible control architecture with the OSC represents a perfect match for investigating and testing alternative control methods on a realistic environmental setup.

METHODS

The control architecture proposed in our previous work is briefly summarize this section. For further details, please see [1]. The adopted control system architecture is shown in Fig. 2. It is a client-server architecture with the input device running as a client and communicating with a server where the logic of the control algorithm is implemented. The controlled arms are simulated in the OSC crane simulator, which also acts as a client and provides the user with an intuitive visual feedback. The proposed architecture provides the possibility of controlling the arms in position mode or velocity mode.

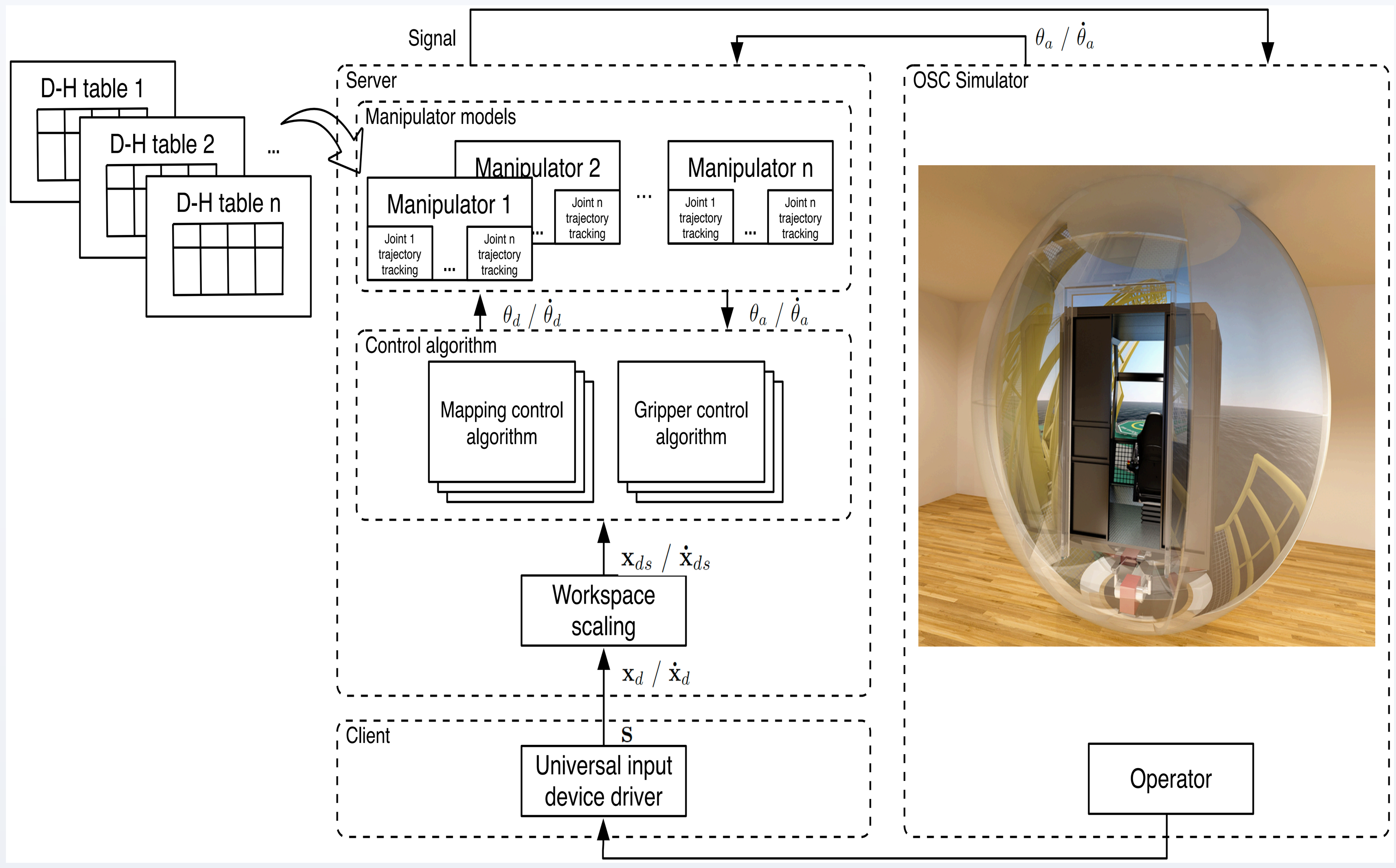

Fig. 2 The proposed system architecture.

For the integration between our framework architecture and the OSC Crane Simulator, the Google Protocol Buffers protocol is adopted, as shown in Fig. 3. The use of this protocol, is an imposed requirement from OSC in the first place. In fact, OSC widely uses Protocol Buffers for several applications. In addition, there are several advantages in preferring this specific data interchange format instead of other similar alternatives in terms of flexibility, reliability and performance. Protocol Buffers are a robust, efficient and automated mechanism for serializing structured data. This mechanism allows for defining how data should be structured once, then special generated source code can be used to easily write and read the structured data to and from a variety of data streams and using a variety of languages. It is even possible to update the data structure without breaking deployed programs that are compiled against the ``old" format.

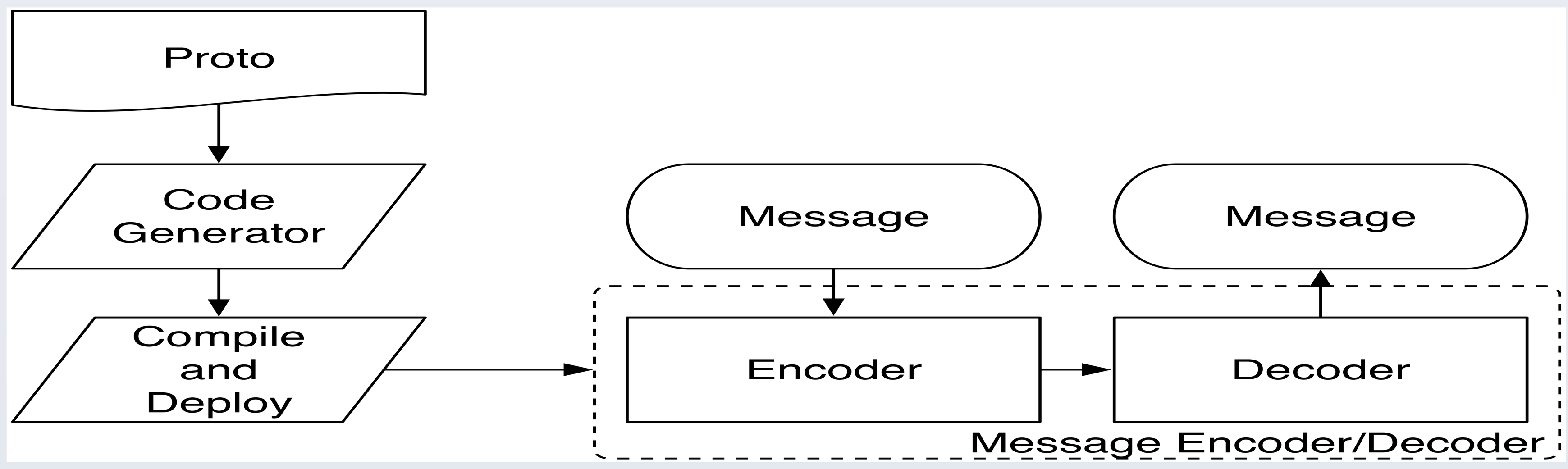

Fig. 3 To use Protocol Buffers, it is necessary to generate code for each message that need to be encoded, and use the generated code to encode/decode the message.

CONCLUSIONS

This work highlights the potential of integrating our flexible and general control system architecture with the Crane Simulator developed by the Offshore Simulator Centre AS (OSC). In the future, different control algorithms such as the ones implemented in [3] may be tested.

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