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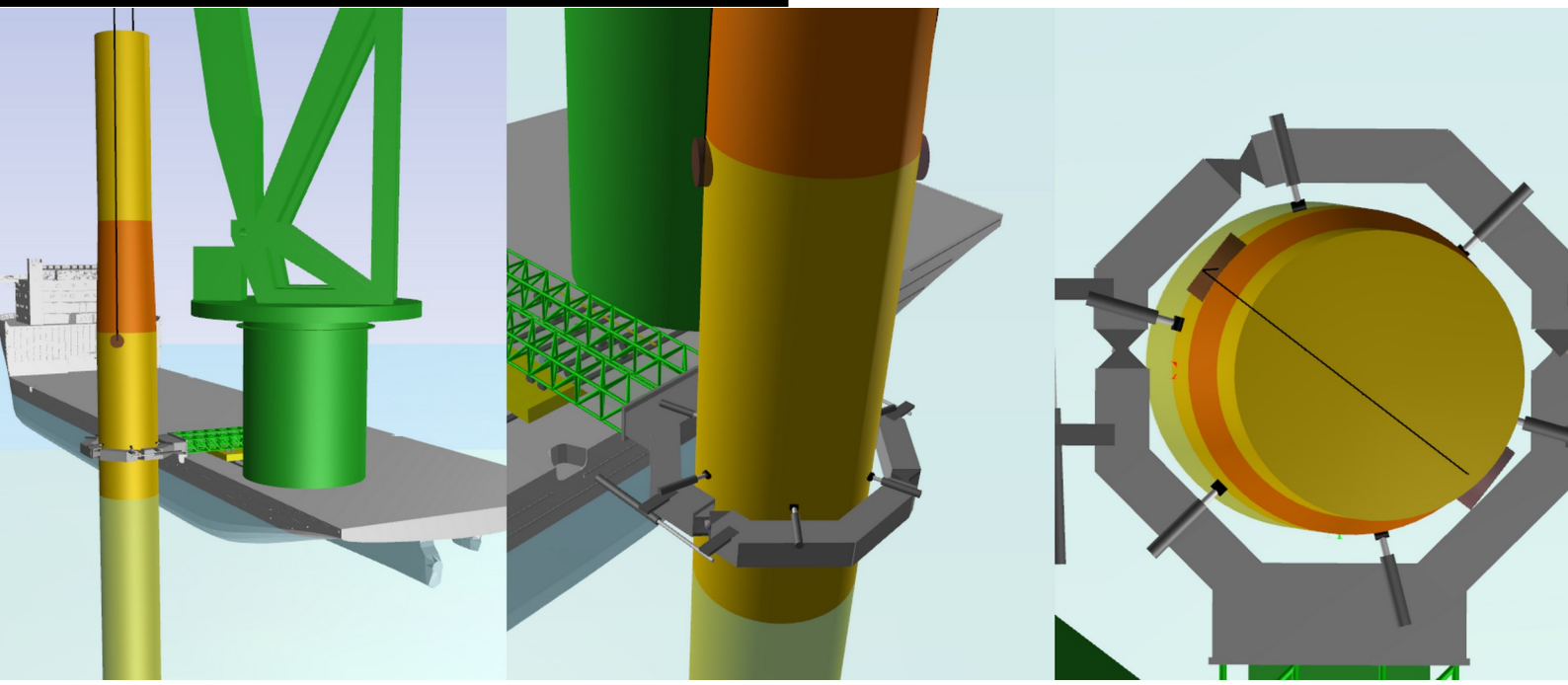
Motion Compensated Pile Grippers



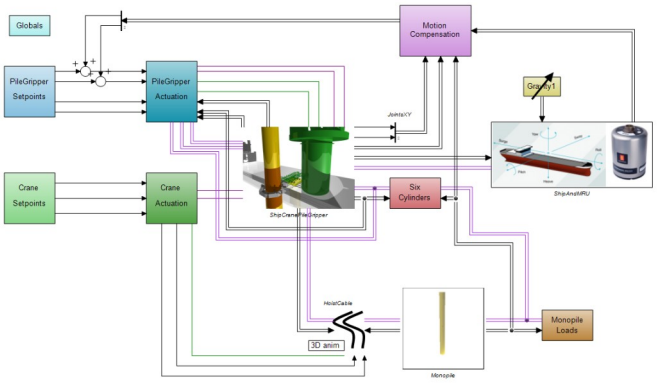
Design Study

Most offshore wind turbines are mounted on monopiles. These foundations are installed either by jack-up vessels or moored floating vessels. Jacking up a vessel or placing mooring lines takes considerable time. Therefore a new installation method is getting more and more attention: installing monopiles with a crane vessel under dynamic positioning (DP).

Controllab has carried out a simulation study for placing monopiles with a DP crane vessel. Simulations have been carried out to investigate the forces and torques acting on various points in the system. Also, the required power and stability of the pile gripper have been evaluated. In the study, a generic vessel, crane and pile gripper are used. These components can easily be replaced to investigate specific designs for third parties.

Simulation Model

During the placement and hammering, the monopile has to be kept upright. A pile gripper is used for this task. The pile gripper has to be motion compensated because of the motion of the vessel in wind, current and waves. The combination of the crane vessel, motion compensated pile gripper and monopile is a highly dynamic system with complex interactions of forces and motions.



The best way to analyze dynamic systems is by using 3D simulation models. Such a simulation model will describe the motions and forces of all the components in 3 dimensions (3 translations and 3 rotations).

Controllab has created such a 3D simulation model. The model contains 3D models of the ship, crane, pile gripper and monopile including all control systems. The model can be used to analyze and improve new pile gripper designs.

Controller Design

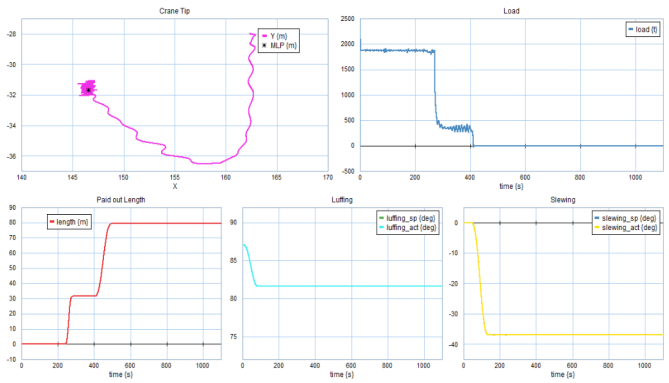
To run the pile gripper, a control system is required that uses sensor data (MRU, GPS, monopile inclination) and calculates the set-points for its actuators. Controllab has developed a control software module that performs all the necessary calculations:

- Measure vessel and monopile position and orientation
- Use backward kinematics to calculate the actuator set-points.
- Feedback loop controllers to turn the actuator set-points into actuator positions.
- Feed-forward control to increase the performance.
- Safety system to prevent damage to the pile gripper in abnormal conditions.

Simulation

In the study we have run many simulations and found interesting results on various topics:

- The best procedure for lifting the monopile and drilling it into the seabed.
- Optimal of operation and stability of the pile gripper.
- Optimal operation of the gripper ring cylinders.
- Stability of the DP system.
- The required power.
- Emergency procedures.

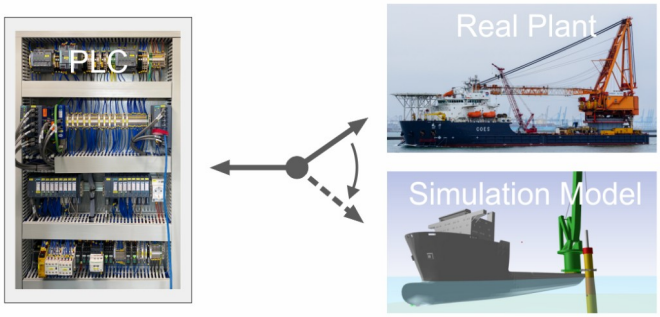


To keep the monopile in the center of the gripper ring, cylinders are used. Large variations of load and power were found between different cylinder control implementations.

The pile griper operates under significant loads while keeping a high accuracy and speed. This is very demanding for the control system. To ensure a proper operation of the pile gripper, the control software has to be thoroughly tested. This can be done with HIL simulation.

Future Applications

The simulation model of the design study can be coupled to our toolbox for HIL simulation. With this toolbox, you can connect a PLC with the simulation model and test the PLC code before the real pile gripper is available. This is known as Hardware-in-the-Loop (HIL) simulation.



With HIL simulation you can also test the control software for a pile gripper under conditions that are impossible or dangerous with a real gripper. This allows you to verify the correct operation of your code to a degree impossible otherwise.

More Information

Controllab has a track record of successful motion compensation control systems for access bridges, cranes and other equipment. If you want to know more, please contact us

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