# On the Controllability of a Floating Offshore Wind Turbine

Nikhar Abbas and Lucy Pao
University of Colorado Boulder

## Abstract


- An analytical method for assessing the controllability of floating offshore wind turbines (FOWTs) is presented.
- Linear control theory principles are applied to linearized FOWT models to establish quantifiable metrics to determine differences in turbine models from a controls perspective.
- A simplified point-mass model to demonstrate the idea of control energy is introduced
- The DTU 10MW wind turbine on floating semi-submersible platforms is used to demonstrate these analysis methods within the FOWT space


## Theory

The Controllability Gramian:

$$W_c(t) = \int_0^t e^{A(t-\tau)} B B^T e^{A^T(t-\tau)} d\tau$$

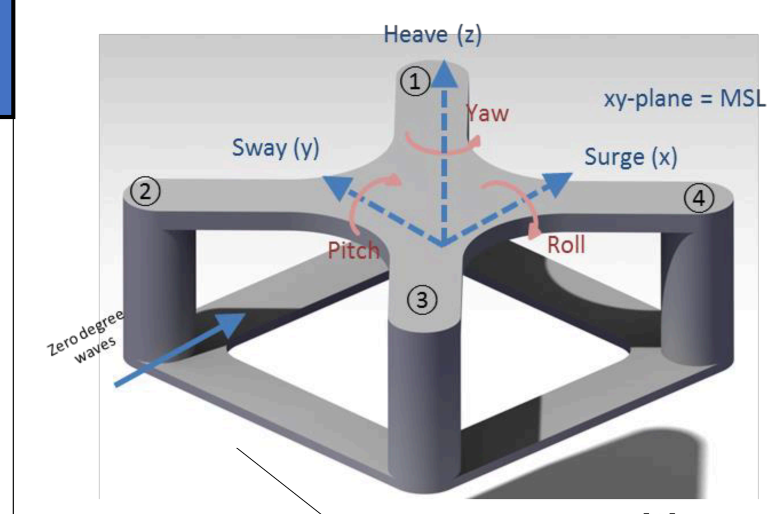
Energy to reach a desired state:

$$E_{x_{des,min}}(t) = [e^{At_1}x_0 - x_{des}]^T W_c^{-1} [e^{At_1}x_0 - x_{des}]$$

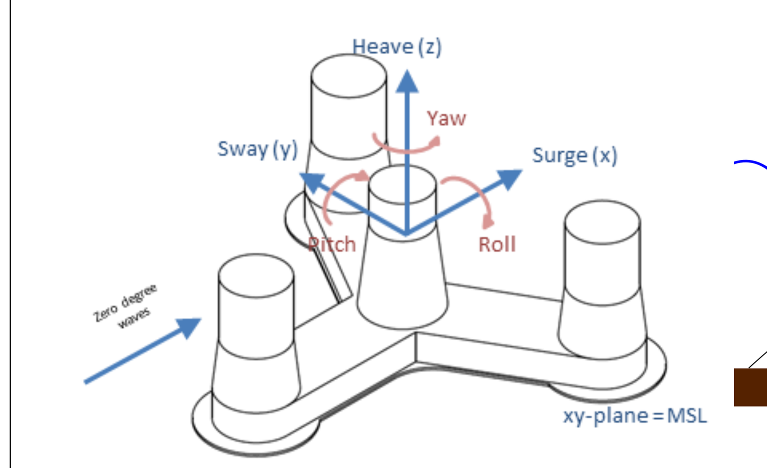
Singular Value Decomposition:

$$W_c = V\Sigma U^T = U\Sigma U,$$

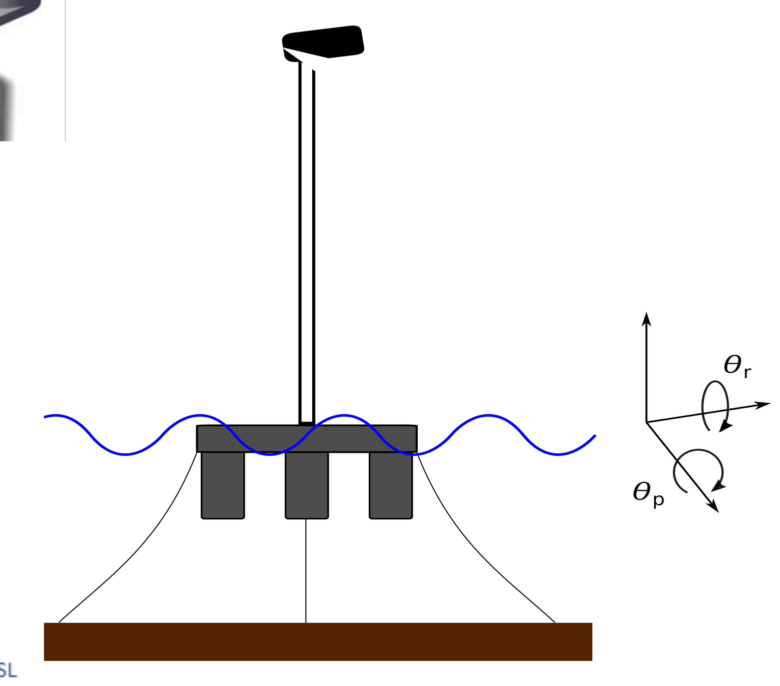
where $\vec{u_1}$ corresponds to most controllable direction




LIFES 50+ NAUTILUS-10[1]

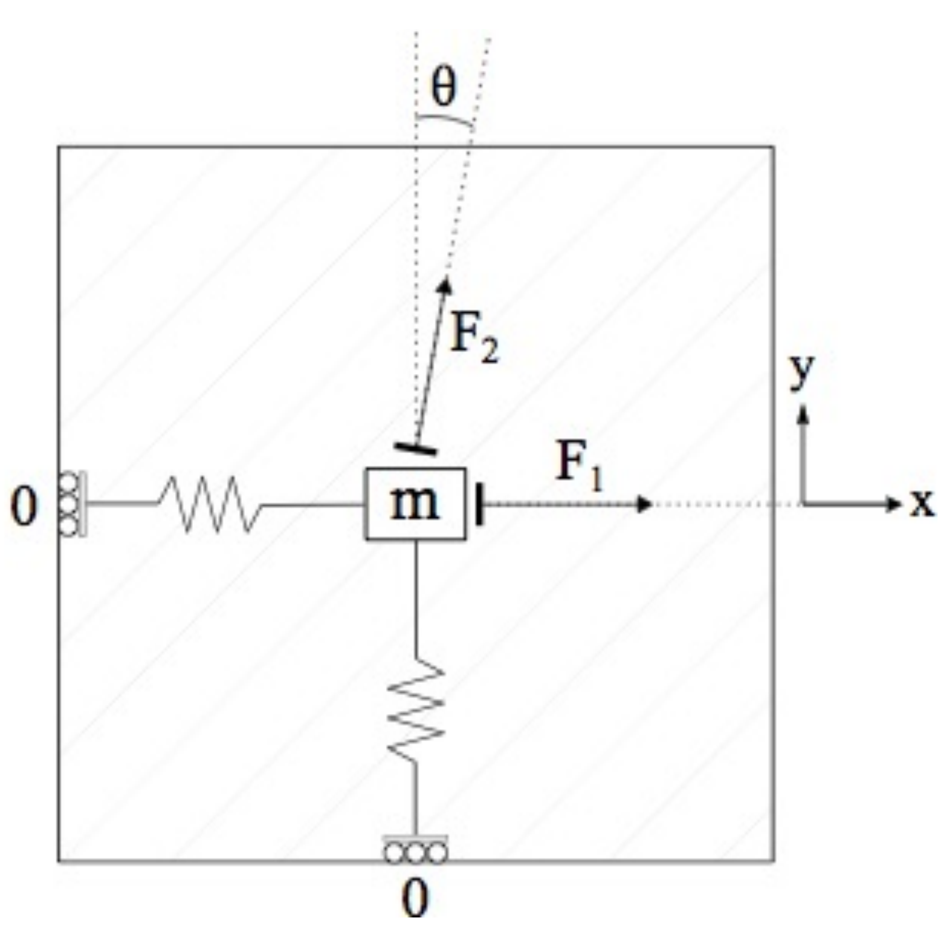


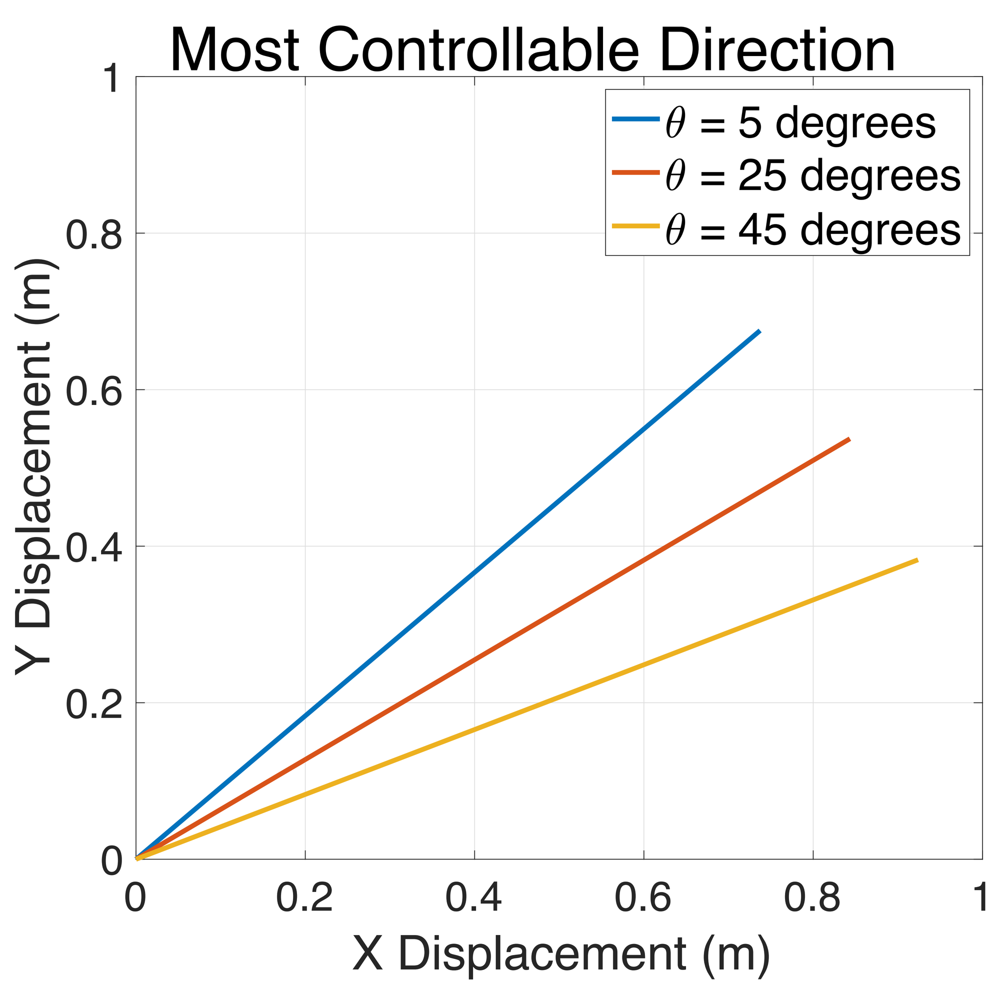

LIFES 50+ OO-Star Wind Floater[1]

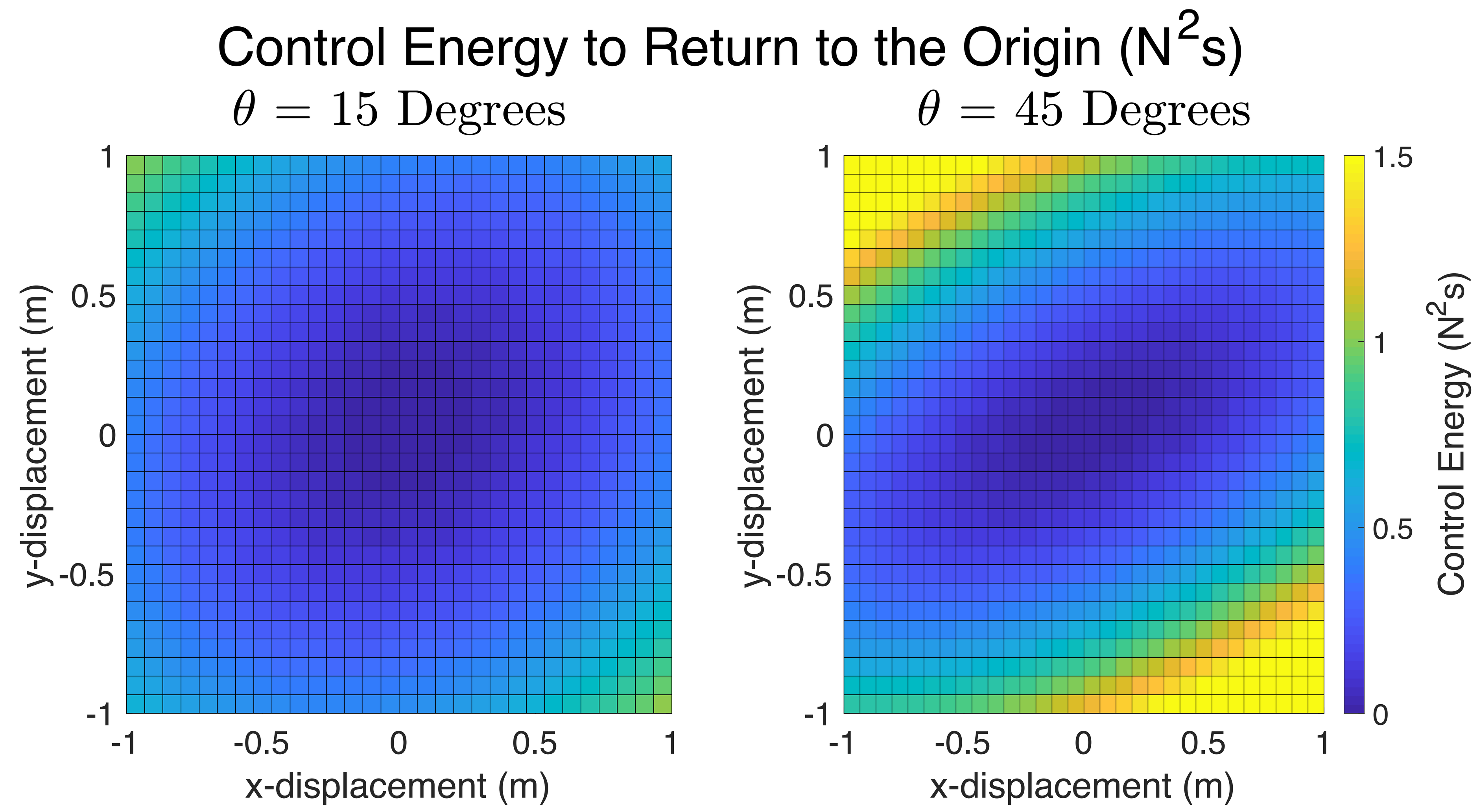



[1] Yu W, M¨uller K and Lemmer F 2018 LIFES50+ d4. 2: Public definition of the two LIFES50+ 10 MW floater concepts (University of Stuttgart)

## A Point Mass Example




## Floating Offshore Wind Turbine Analysis, DTU 10MW Reference Turbine