

Controller Identification in Healthy Human Standing Balance under Random Perturbation



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Introduction

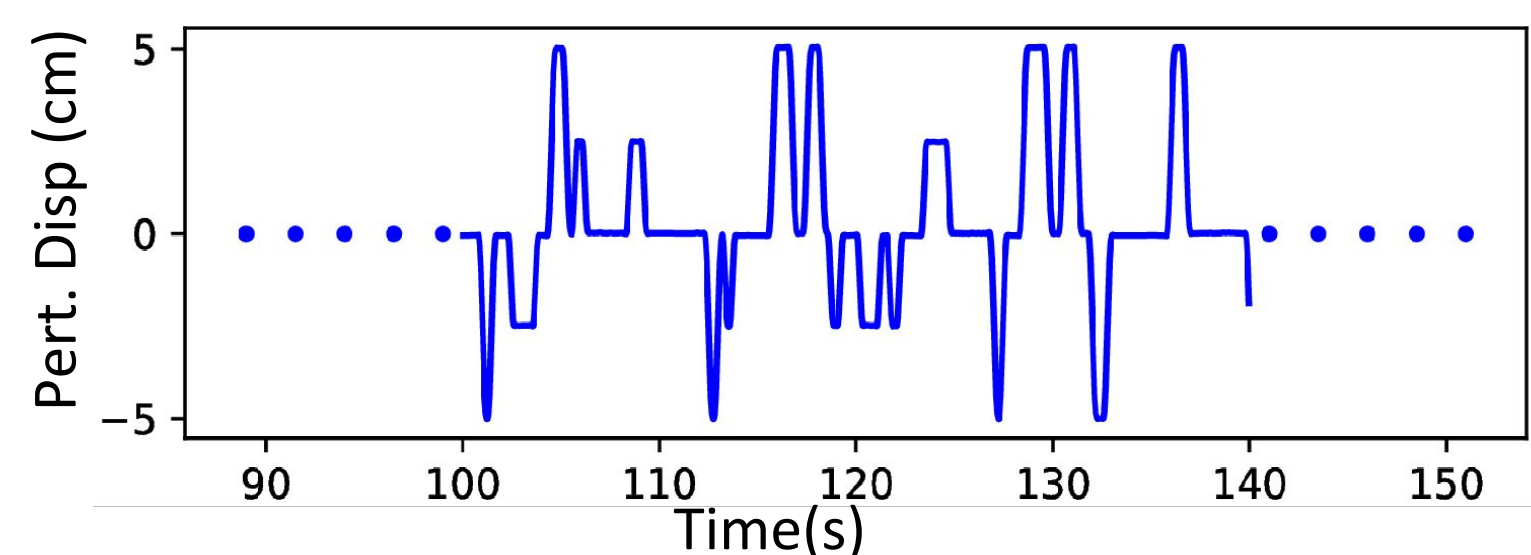
- Human use feedback control to maintain balance in standing.
- These feedback controllers had been studied and identified in specific situations. For instance, feedback controllers had been identified in standing balance under ramp perturbations [1], [2]. In frequency domain, nonparametric controller had been identified under random perturbations, which is not engineering applicable [3], [4].
- Here in time domain, we identified parametric feedback controllers in standing balance under random perturbation. We believe that these identified controllers not only can explain experiment data but also can be directly applied to robotic leg devices.

Methods

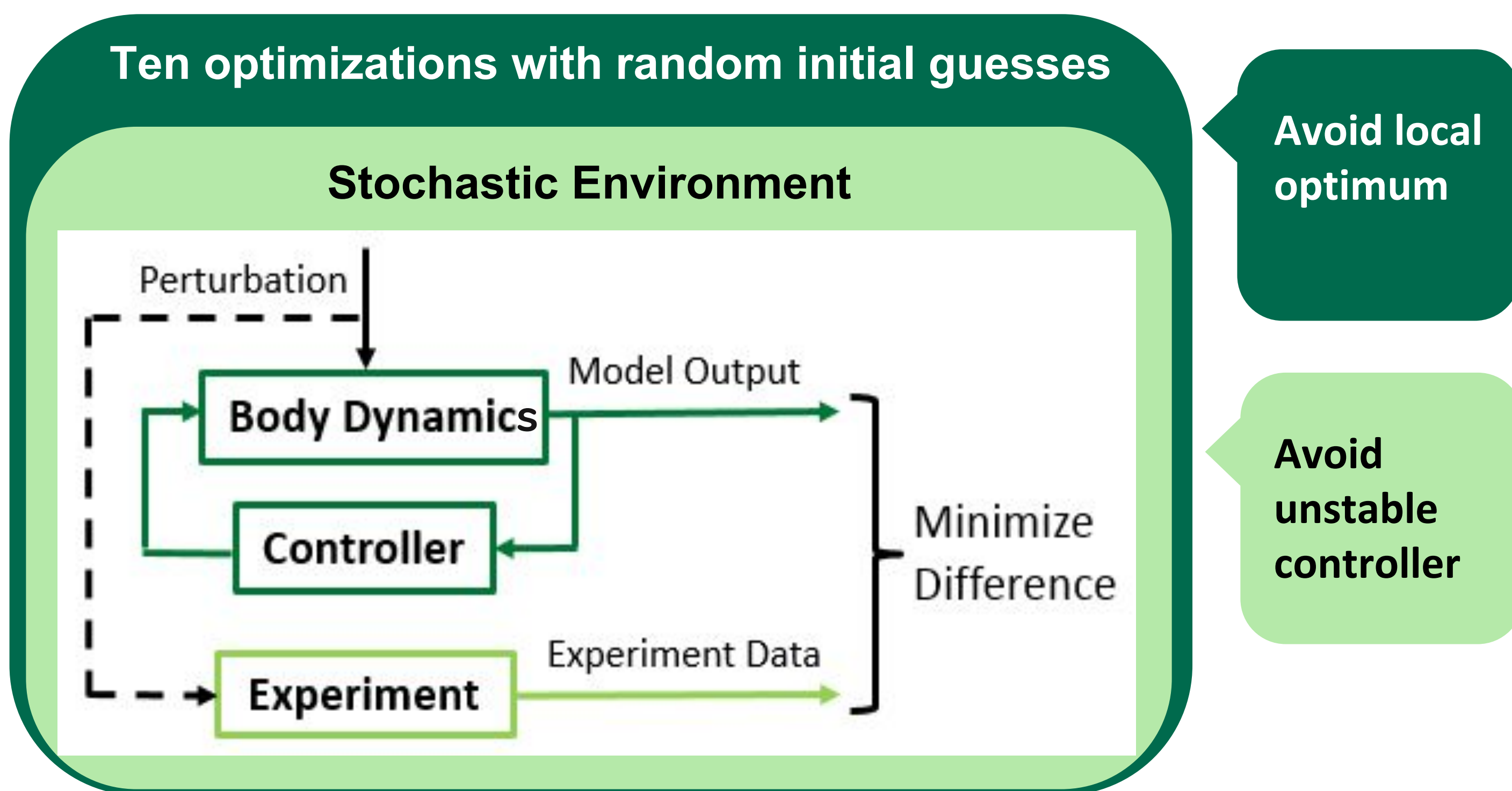
Experiment:



- Six male subjects
- Random square wave perturbation
- Perturbation applied in sagittal plane
- Five minutes long in each trial
- Each subject experienced the same perturbation twice



Indirect Identification Approach:

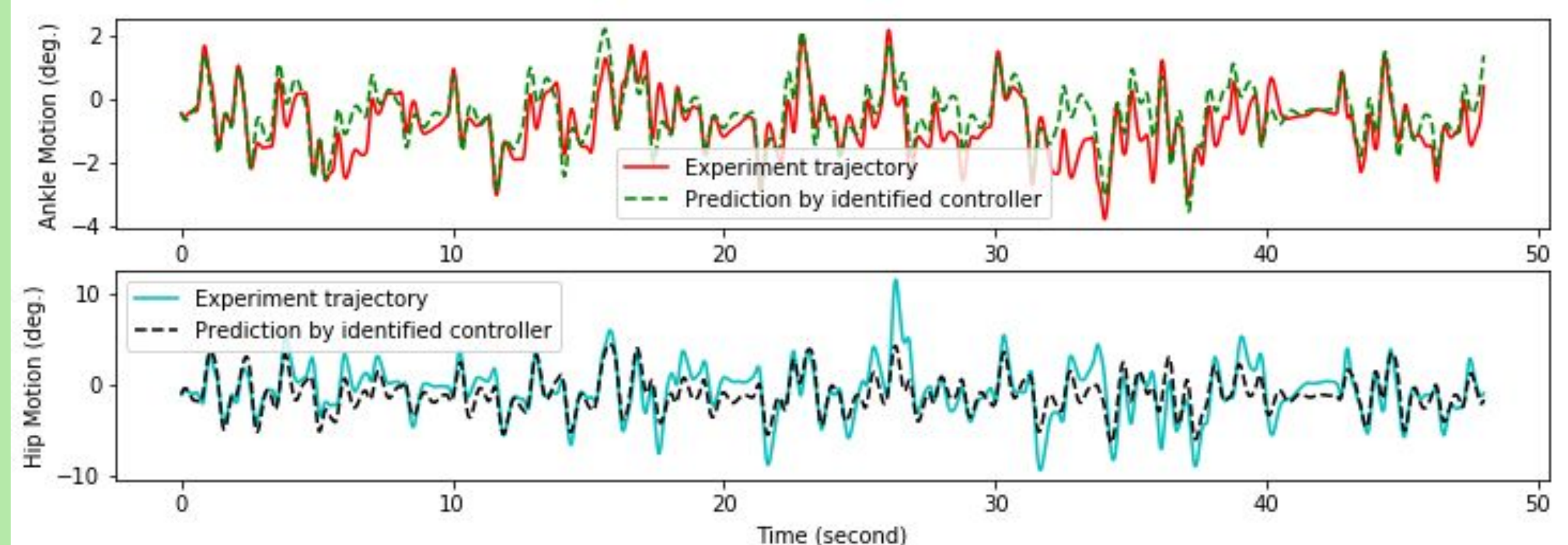


Controller Types:

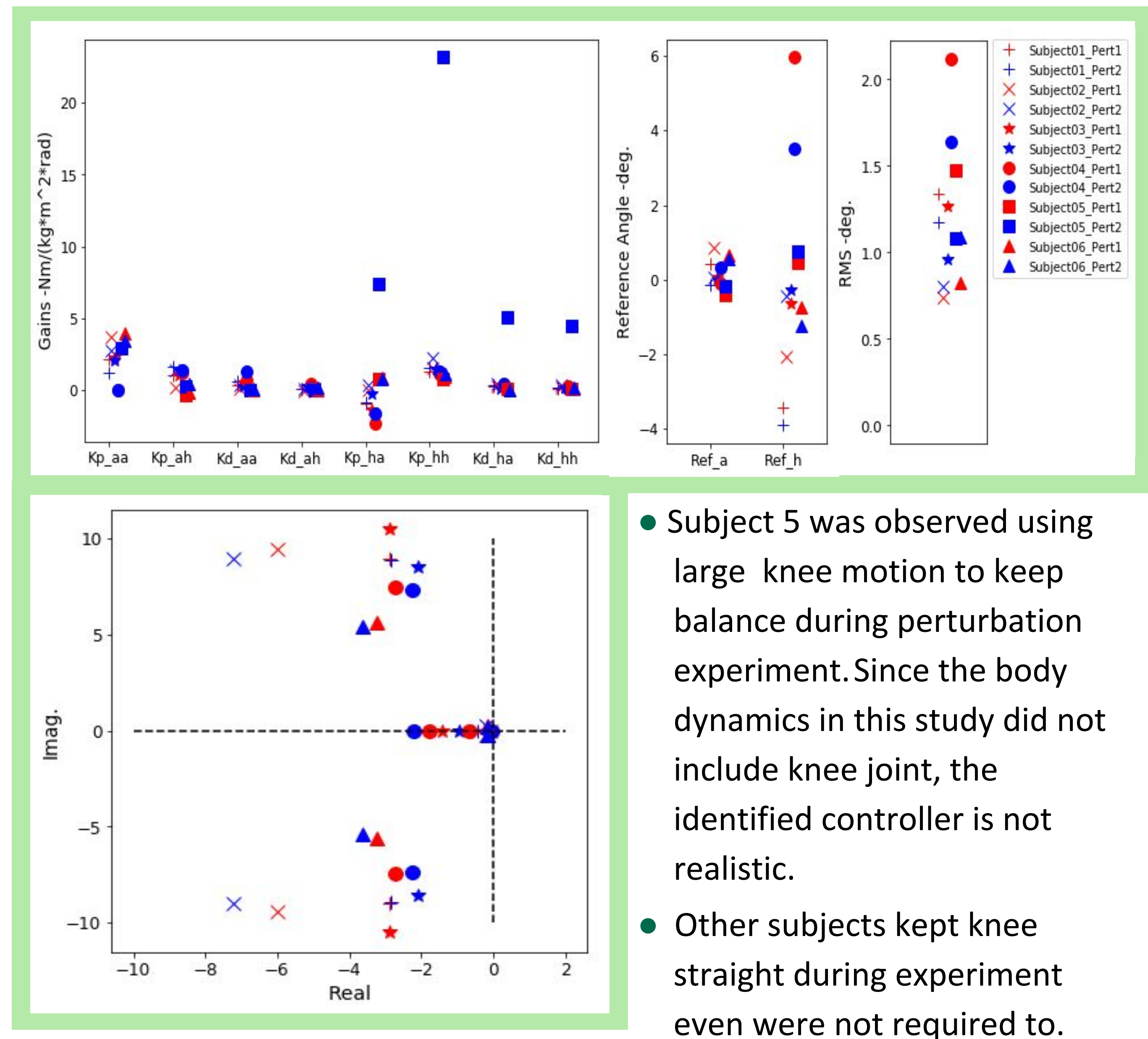
- Proportional-derivative (PD) controller
- Full state PD controller
- Neural-Network controller
 - 4 state input nodes, 1 hidden layer, 4 hidden nodes
- Neural-Network controller with two delay nodes
 - 12 state input nodes, 1 hidden layer, 8 hidden nodes
 - States of 40ms and 80ms delay time are used as input

Results

Controller Type	PD	FPD	NN 14	NN 18 with delay
R^2 of Identification	0.601	0.682	0.675	0.874
R^2 of 48 sec. Prediction	0.572	0.654	0.663	---



FPD gains and eigenvalues of 6 subjects:



- Subject 5 was observed using large knee motion to keep balance during perturbation experiment. Since the body dynamics in this study did not include knee joint, the identified controller is not realistic.
- Other subjects kept knee straight during experiment even were not required to.

Conclusion/Future Work

- Stable controllers were identified in stochastic environment.
- Identified controllers can predict balance data which was not used in identification.
- Similar controllers were found of each subject at different trials.
- Time delay has a large affect in better explaining balance data.
- Four subjects had similar eigenvalues.
- ◆ Apply this platform in walking controller identification.
 - ◆ Two layer control structure: high level controller generate joints' reference angles; low level controller tracking them [5].

References/Acknowledgments

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