GRASP SMARTER, NOT HARDER: PROPORTIONAL CONTROL OF AN ELECTROMYOGRAPHIC PROSTHESIS WITH A TOUCH OF AUTOMATION

K. Z. ZHUANG[1], N. SOMMER[2], E. FORMENTO[1], E. D'ANNA[1], A. BILLARD[2], S. MICERA[1];
[1]Translational Neural Engineering Lab; [2]Learning Algorithms and Systems Lab, École polytechnique fédérale de Lausanne, Lausanne, Switzerland

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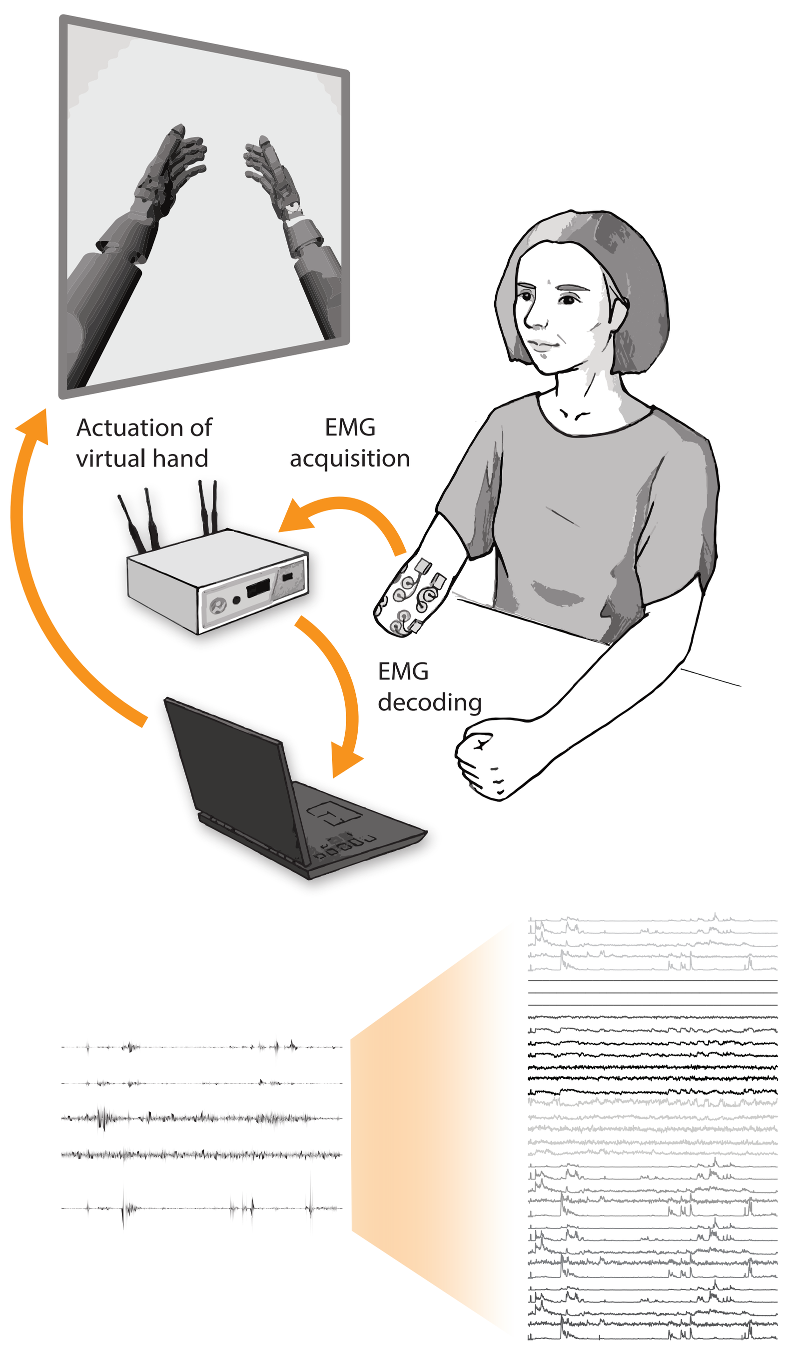
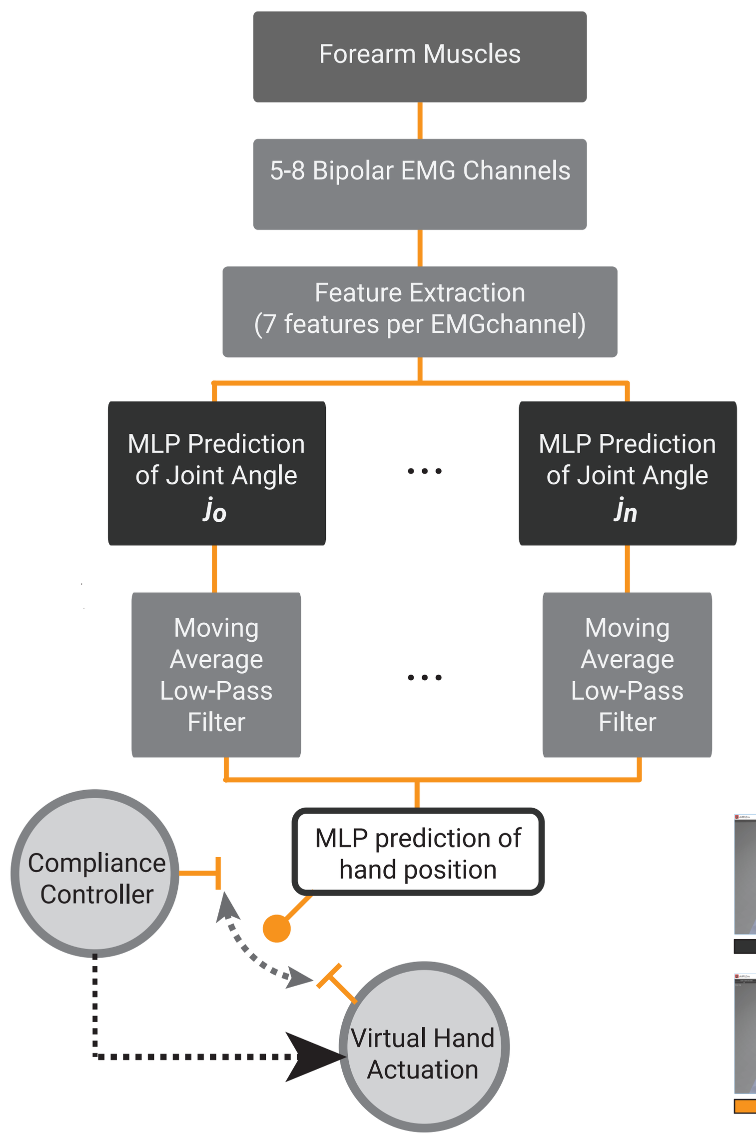
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

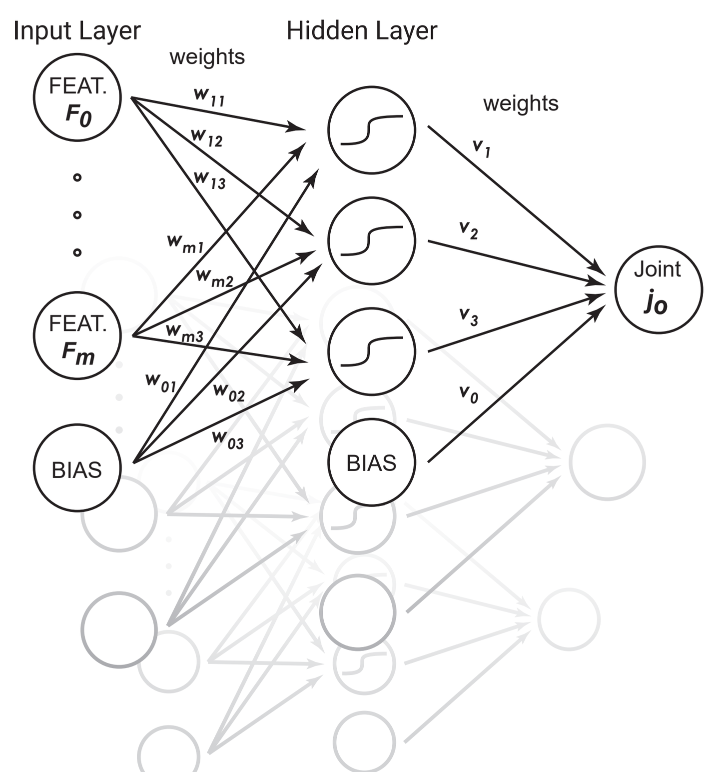
ABSTRACT

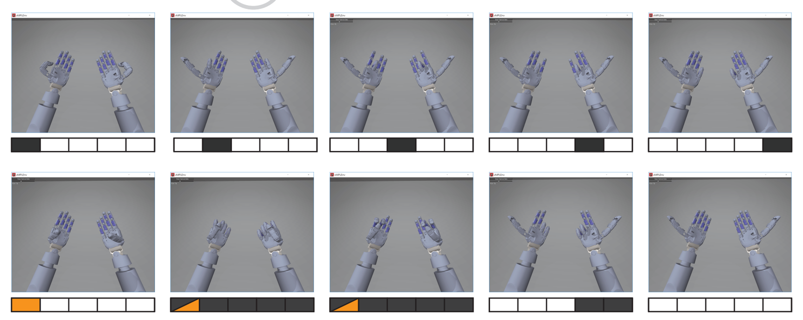
Over recent decades, myoelectric prostheses have demonstrated their potential to vastly improve autonomy and quality of life for upper-limb amputees by restoring some lost mobility. However, current upper-limb myoelectric prostheses are very limited in their number of controllable degrees of freedom, often allowing only a few discrete grasp types, while also requiring substantial visual attention. Here, we demonstrate surface electromyogram decoding of individual finger joint angles in real time using a multilayer perceptron model. The decoder is able to achieve simultaneous high-accuracy predictions of these many degrees of freedom during numerous sessions with three amputee subjects. In addition, we provide a proof-of-concept of a shared-control scheme. In this mode, the user is able to control preshaping and grasp intention while an assistive compliant controller automates fmovements to maximize object contact during actual grasping. This combination of multi-degree-of-freedom proportional control and automated grasp tuning allows for both precise positioning as well as greater grasp stability.

EXPERIMENT SETUP AND EMG DECODER



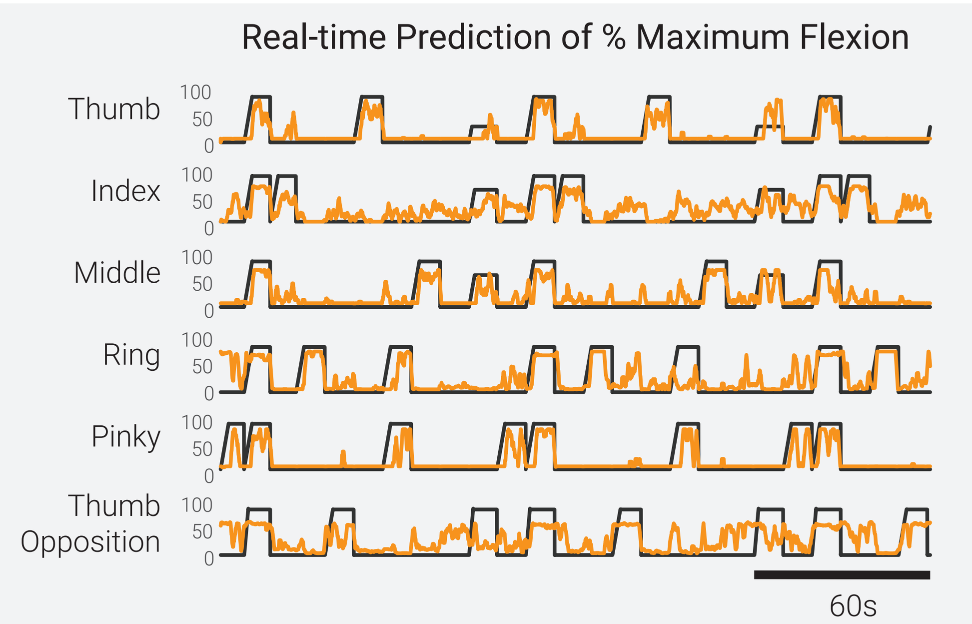


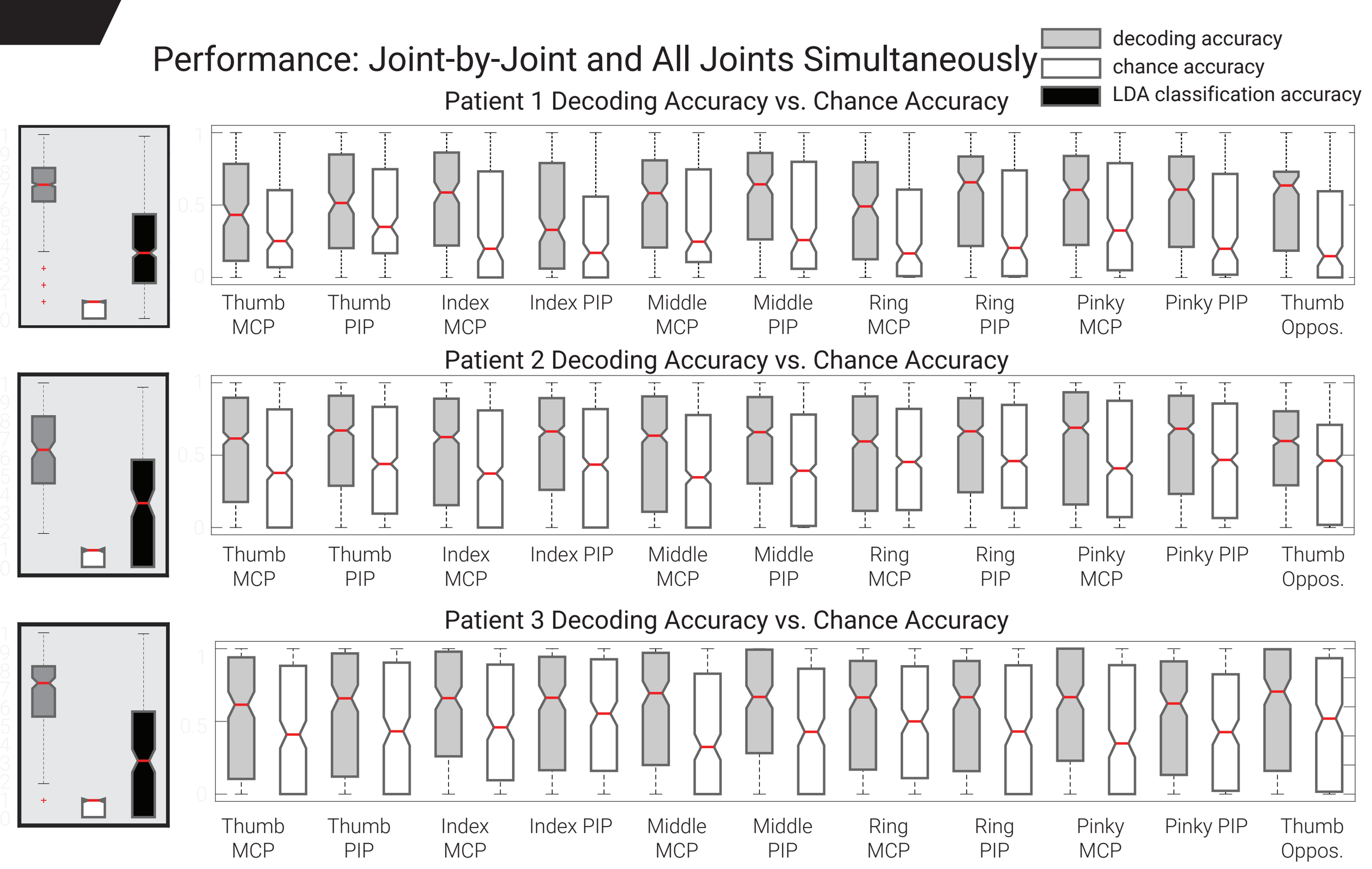




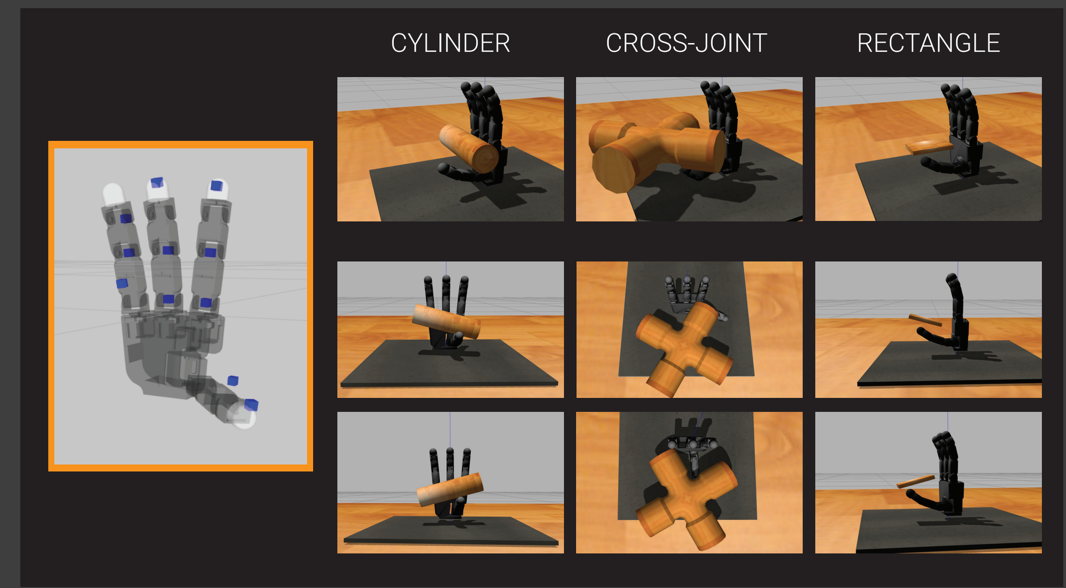
MLP DECODING PERFORMANCE

Subjects 1 & 3 were required to flex and extend each individual finger, perform 3-finger pinch, cylindrical, and ulnar grasps and open hand in random order. Subject 2 controlled index and middle fingers together. A successful trial required each of the degrees of freedom to be within 20 degrees of the desired one.



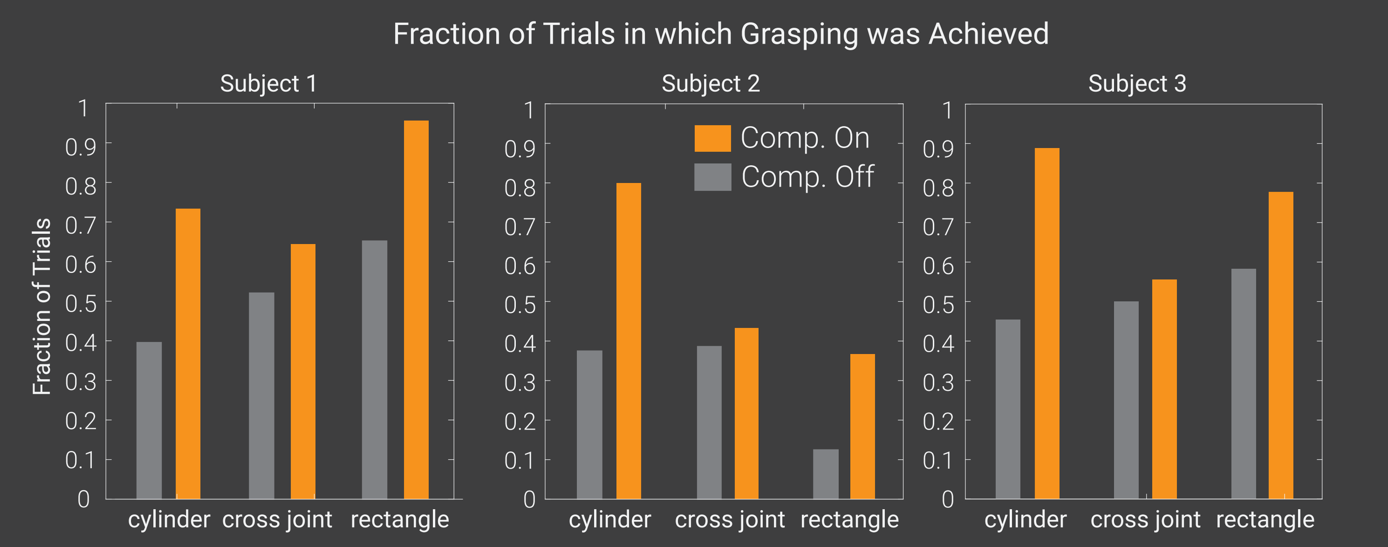


ASSISTED CONTROL FOR GRASPING OBJECTS



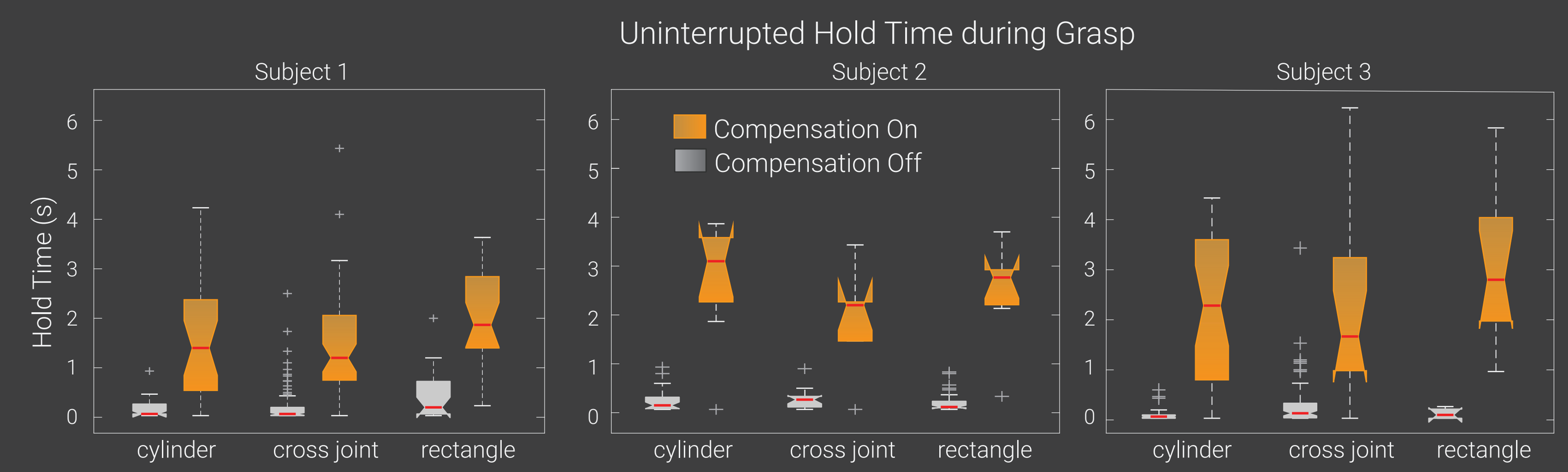
Compliance control

Attempts to maximize hand contact with the object to be grasped. Once one contact is made, the controller attempts to wrap the finger around the object.* When the difference between the assisted position and the MLP-decoded position exceeds a certain threshold, full kinematic control is returned to the MLP.



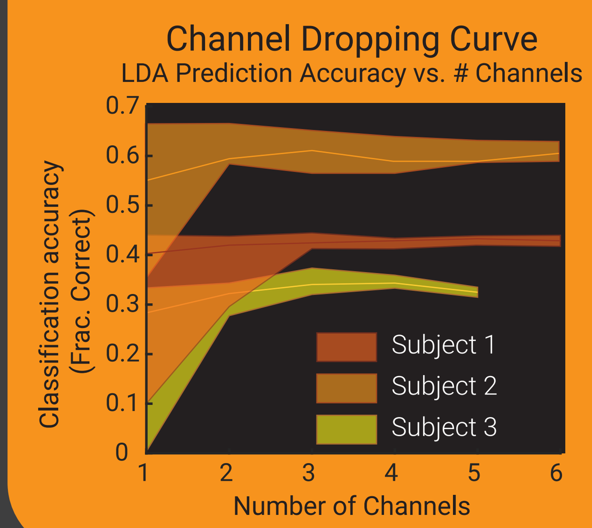
Performance Metrics

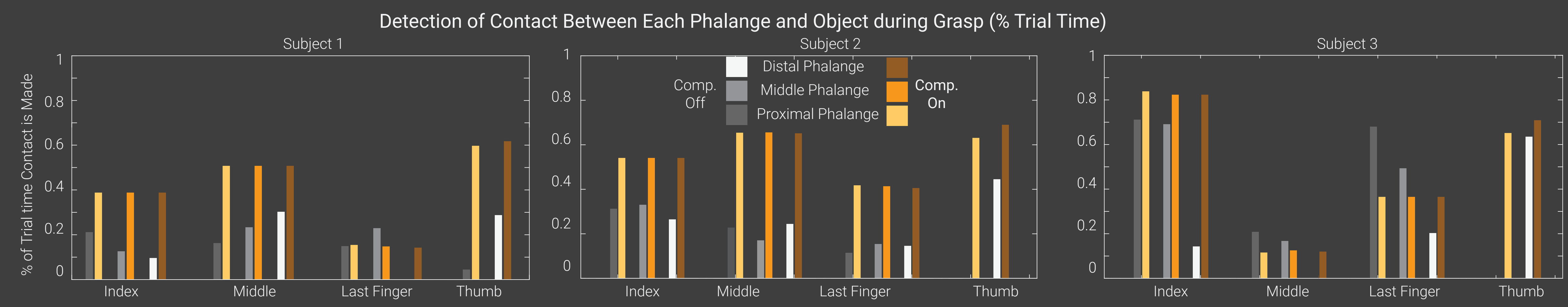
The compliance controller demonstrably allows for more correctly-grasped objects (assessed by appropriate contact points between hand and object), longer hold times per grasp, and more number of contacts between hand and object, a proxy for grasp stability.



VARIABILITY AMONG SUBJECTS

One problem with assessing performance accuracy, particularly for amputee subjects is that each subject has a different maximum level of performance based on level of injury and degree of damage to the underlying muscles and motor neurons.
Thus, a single performance metric (i.e. % correct) is not necessarily useful in assessing performance of a particular decoding method.





CONCLUSIONS AND FUTURE WORK

We believe from our encouraging results that the future of myoelectric prostheses will lie within such a synergy between robotic automation and user intention. Future work might include addition of terms for velocity prediciton which may further improve grasp stability. Implementation in a physical robotic hand would also allow for behavioral experiments with real object interactions

*Nicolas Sommer, Aude Billard (2016) Multi-contact haptic exploration and grasping with tactile sensors, Robotics and Autonomous Systems, Vol. 85 pg 48-61

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