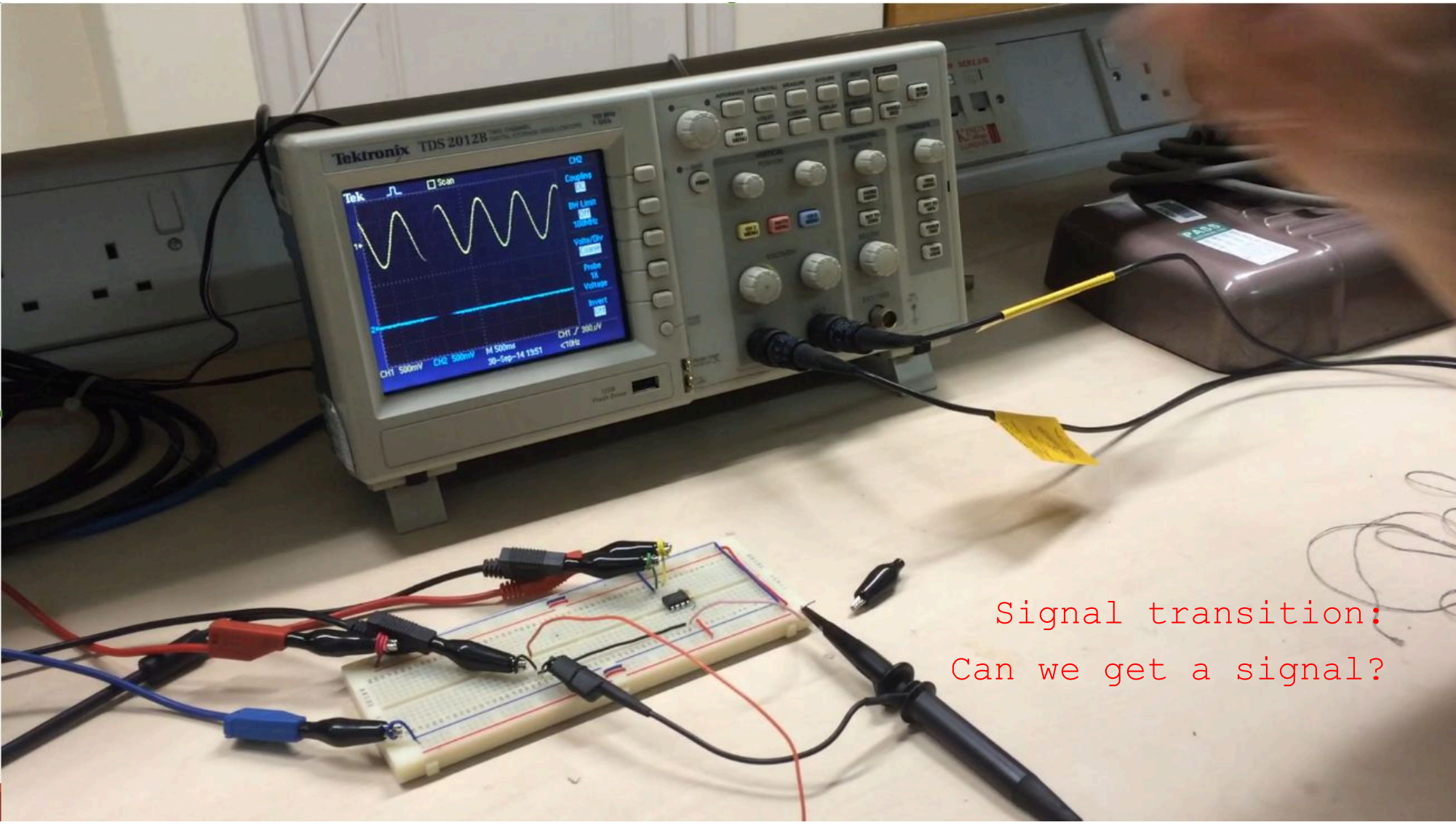
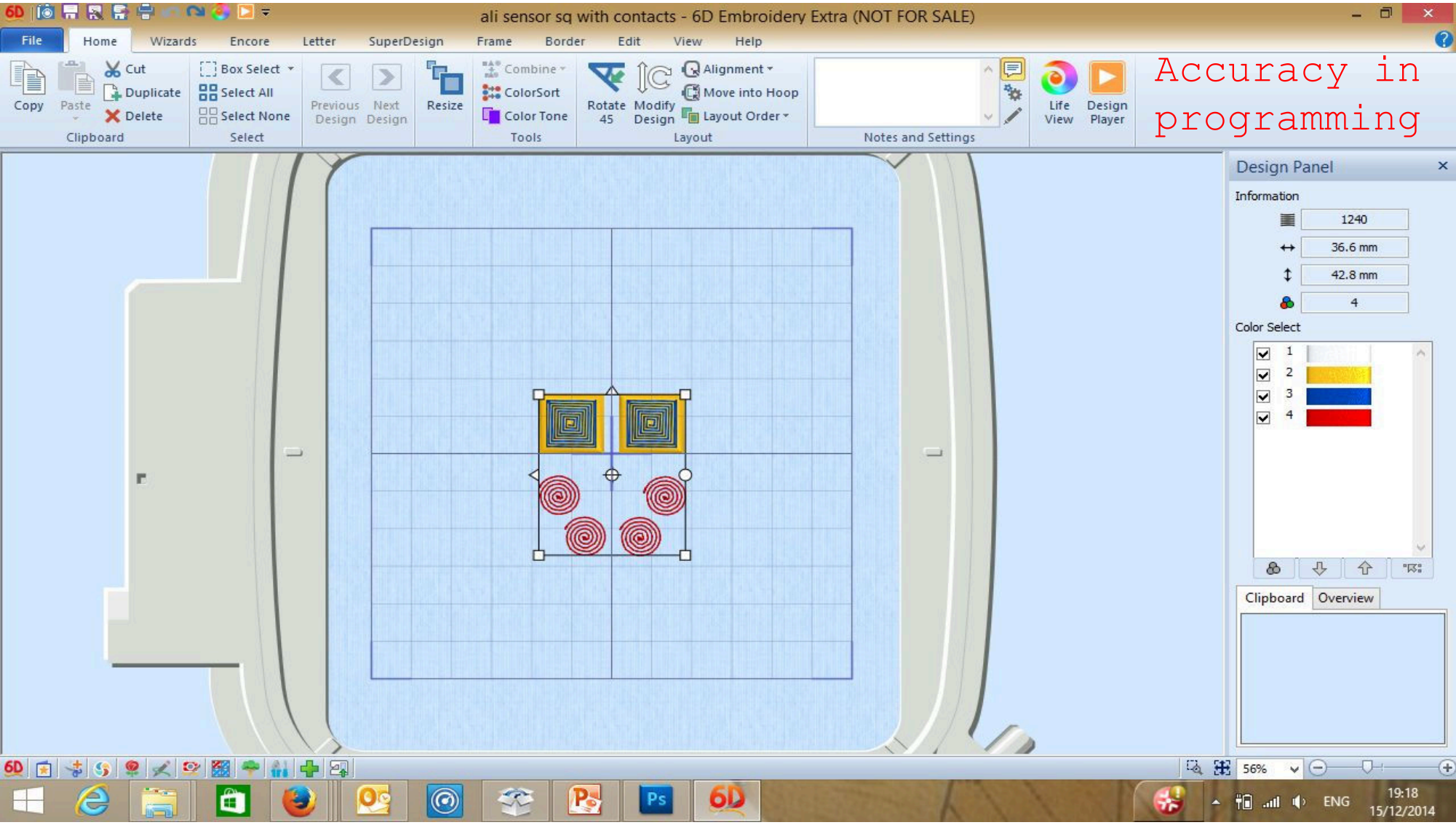
Conductive textiles



matthew.j.howard@kcl.ac.uk · nms.kcl.ac.uk/matthew.j.howard · @mhoward3210

Textile CAD



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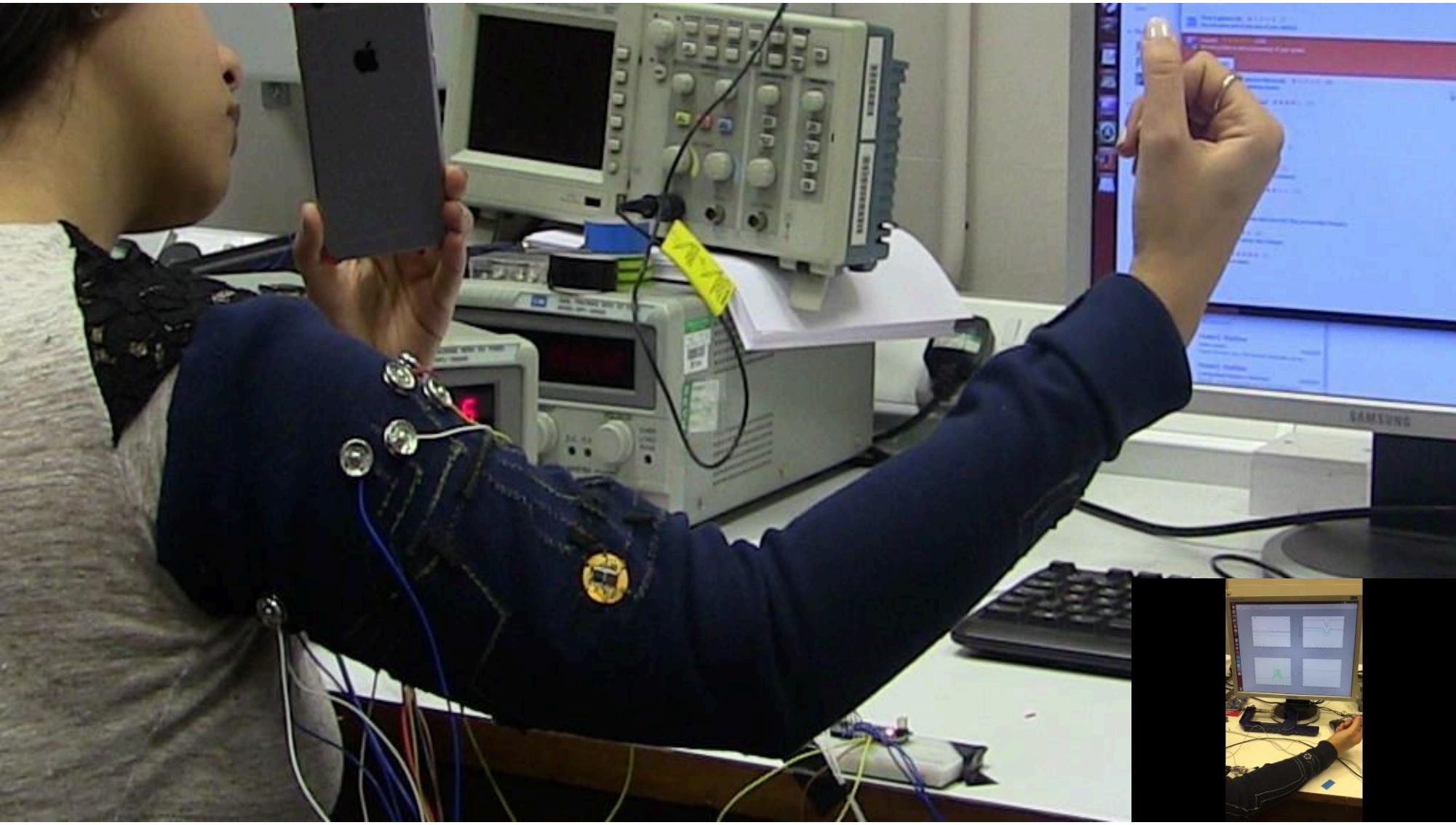
Textile Sensor Sleeve



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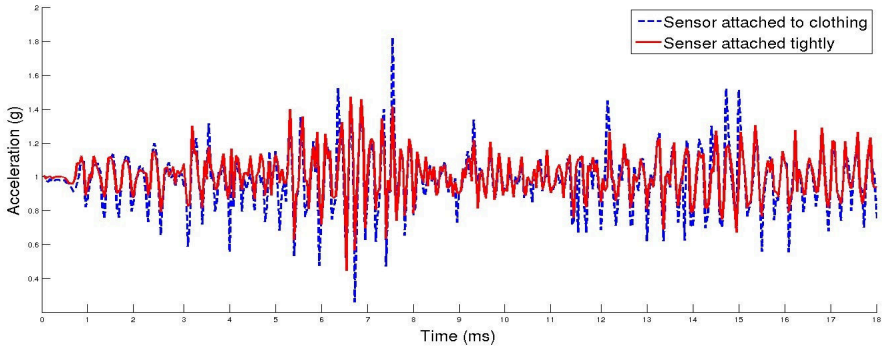
What are the issues?

Motion Artifacts in Fabric Sensors

Undesired movement of the fabric → poor quality data



Possible solutions:

- Tightly fit clothing (e.g. sports clothing)
- Explicitly model fabric dynamics (computationally expensive)

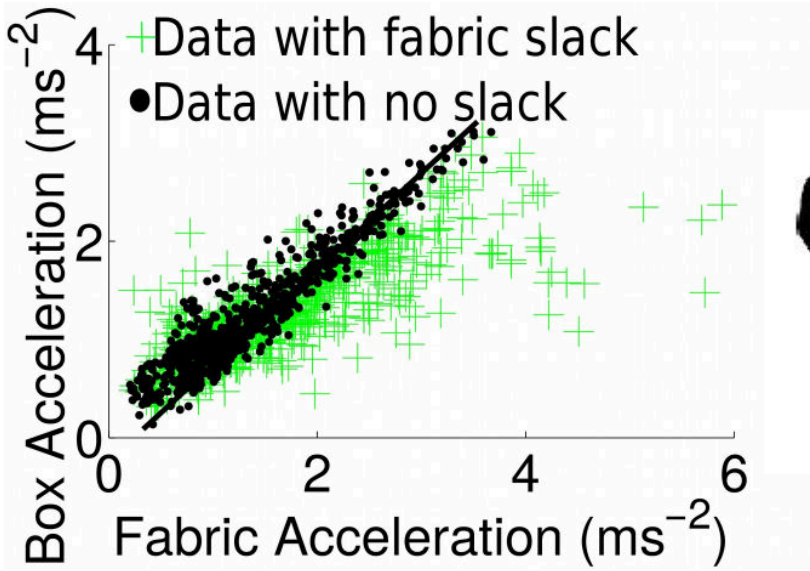
Publications

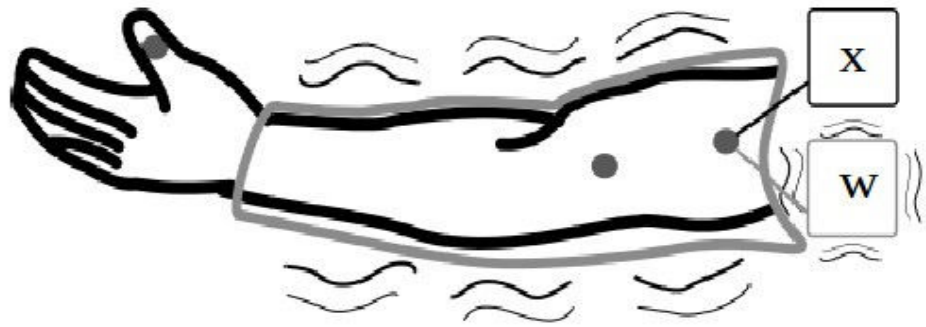
- Michael, B. & Howard, M. Eliminating Motion Artifacts from Fabric-mounted Wearable Sensors IEEE-RAS International Conference on Humanoid Robots, 2014, 868-873
- Michael, B & Howard, M .'Learning Predictive Movement Models from Fabric-mounted Wearable Sensors IEEE Transactions on Neural Systems and Rehabilitation Engineering , 2015

Solution: Predict body motions from fabric

- Given $\{\mathbf{x}_n, y_n\}_{n=1}^{N}$ estimate function f where $y = f(\mathbf{x}) + \epsilon$

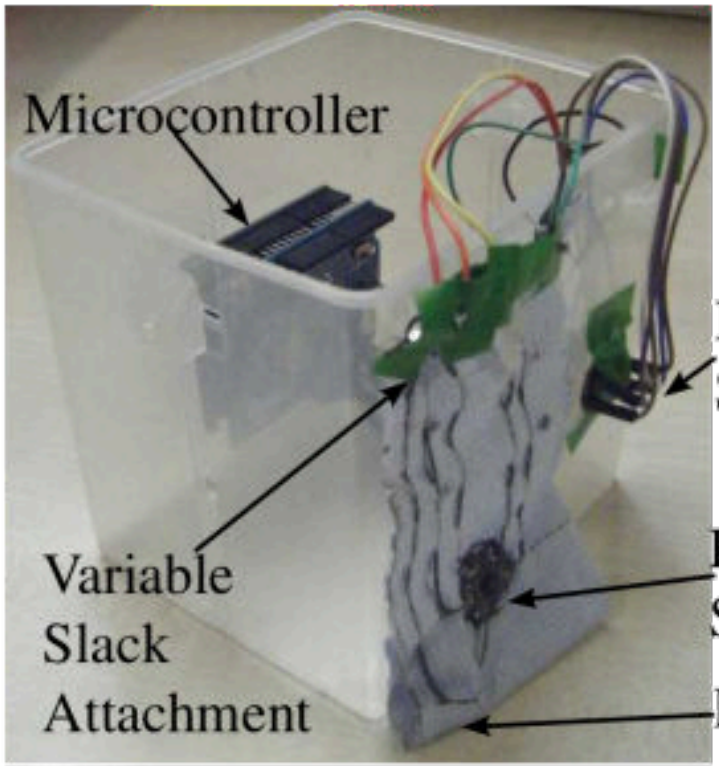
  Standard regression fails → poor model of noise

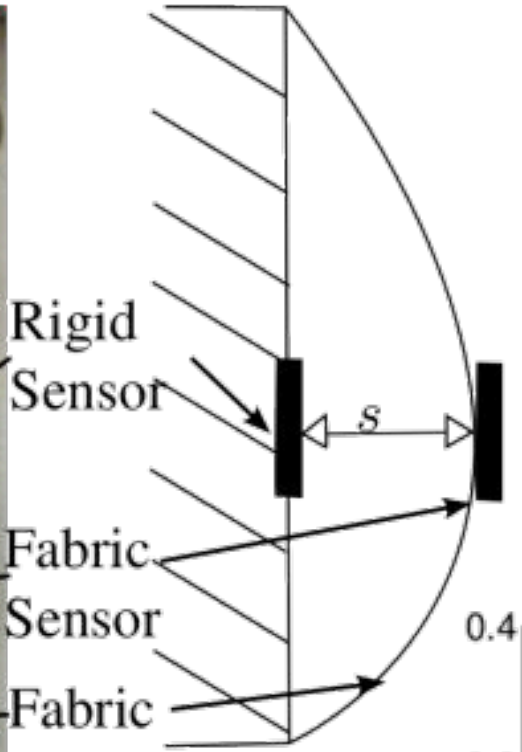


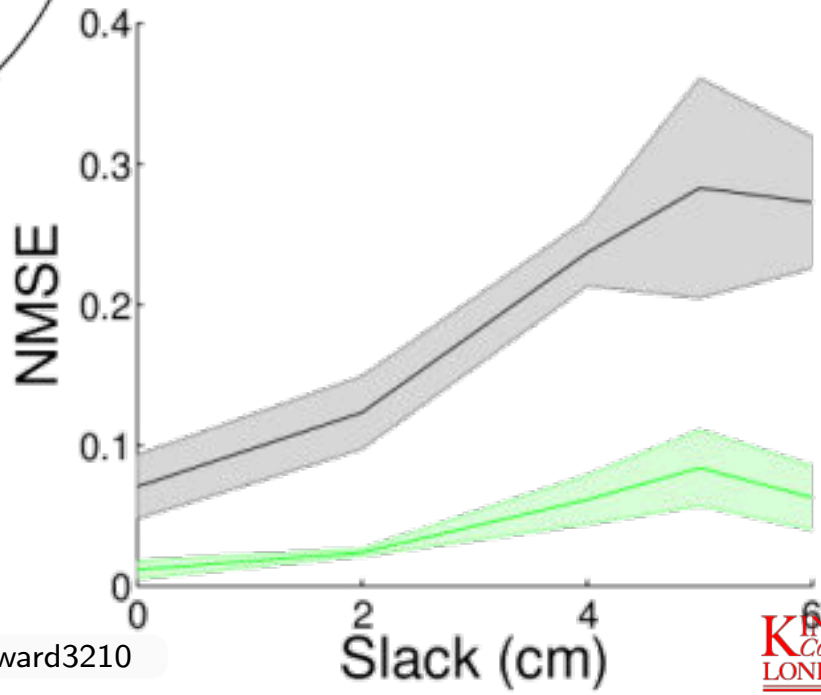


- Treat motion arctifacts as **stocastic pertubation to the sensed motion** (errors on the input **x)**

Results







B. Michael & MH. Learning predictive movement models from fabric-mounted wearable sensors. *IEEE TNSRE*, 24(12):1395-1404 2016
B. Michael & MH. Eliminating motion artifacts from fabric-mounted wearable sensors. *Humanoids* 2014

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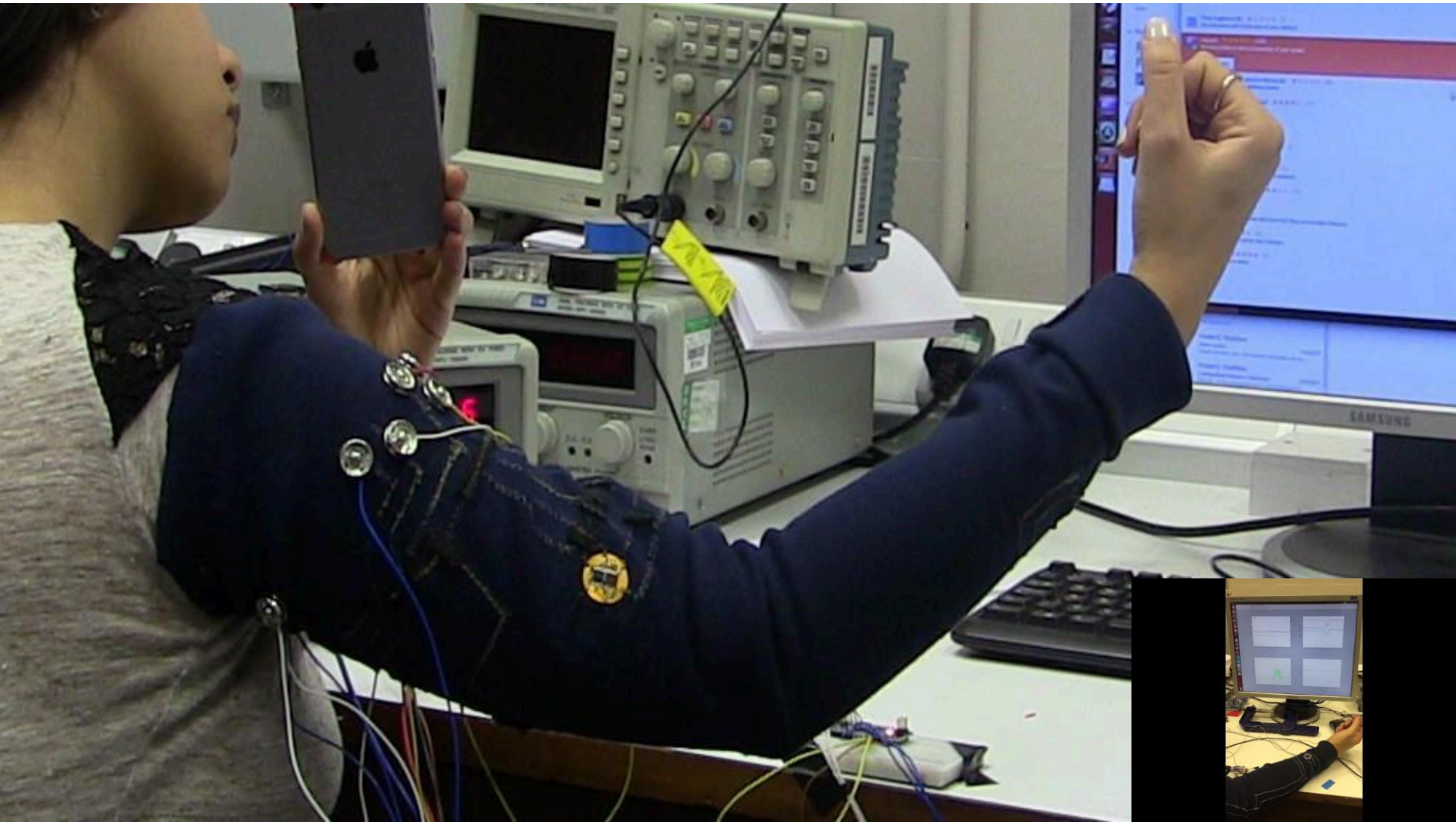

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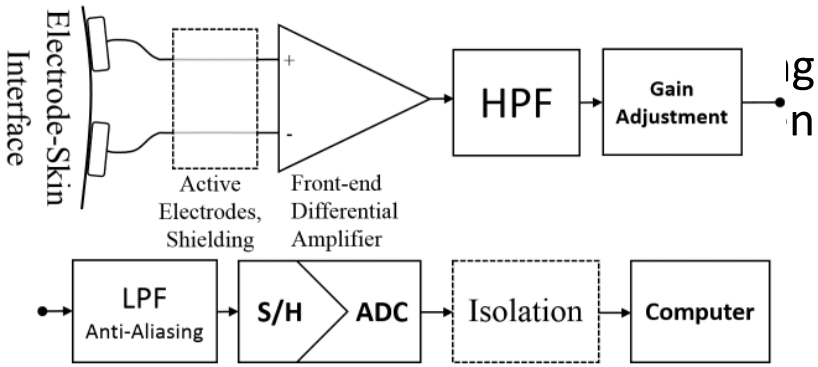
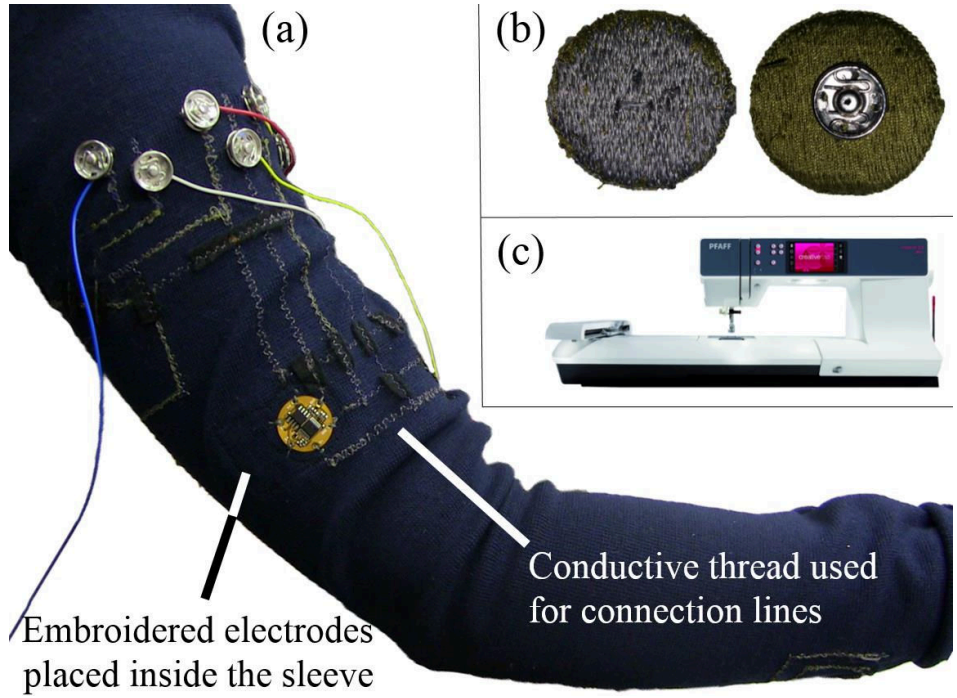
Textile-Based SEMG – Design Strategies

- Digital embroidery can be used to create the same design repeatedly
- There is limited previous work on textile EMG





A. Shafti, et al. Embroidered electromyography: A systematic design guide. *IEEE TNSRE*, 25(9):1472-1480, 2016
A. Shafti, et al. Designing embroidered electrodes for wearable surface electromyography. *ICRA* 2016

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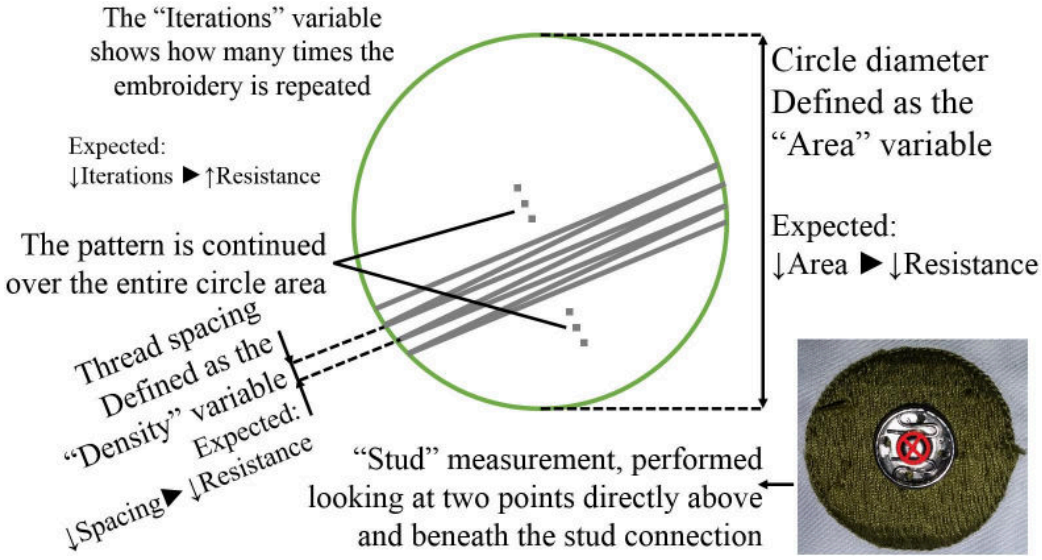
Variables and Resistance Characteristics



#	Electrode	Mean	SD	P-Value	
1	(2,2,3)	0.30	0.05	-	Baseline
2	(**1**,2,3)	0.27	0.05	6.54×10^{-2}	Area Variation
3	(**3**,2,3)	0.22	0.04	1.01×10^{-5}	
4	(2,**1**,3)	0.33	0.04	5.48×10^{-2}	Iteration Variation
5	(2,**3**,3)	0.34	0.07	2.36×10^{-2}	
6	(2,2,**5**)	0.19	0.06	2.71×10^{-7}	Density Variation
7	(2,2,**4**)	0.35	0.08	1.99×10^{-2}	
8	(2,2,**2**)	0.19	0.06	2.71×10^{-7}	
9	(2,2,**full**)	0.19	0.03	6.52×10^{-9}	

A. Shafti, R. B. Ribas Manero, A. M. Borg, K. Althoefer, M. J. Howard "*Designing Embroidered Electrodes for Wearable Surface Electromyography*", ICRA 2016

A. Shafti, et al. Embroidered electromyography: A systematic design guide. *IEEE TNSRE*, 25(9):1472-1480, 2016
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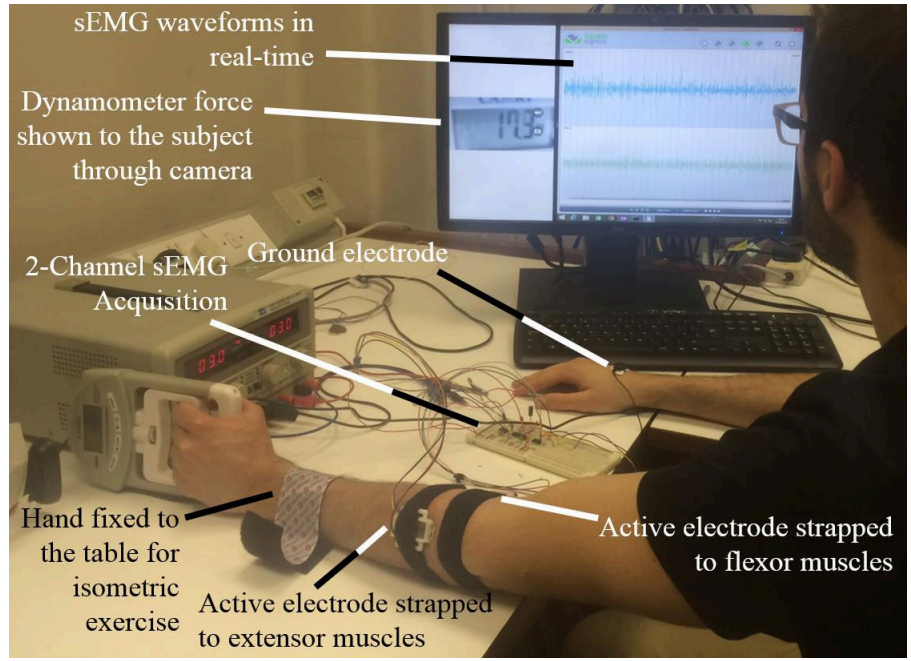
EMG Experiments

- N=12 participants tested
- They are asked to apply specific force values with their hand on the dynamometer
- Forces are kept steady for 5 seconds and EMG recorded.
- As the exercise is isometric, a linear EMG/Force relationship is expected
- Embroidered and gel based electrodes are compared.



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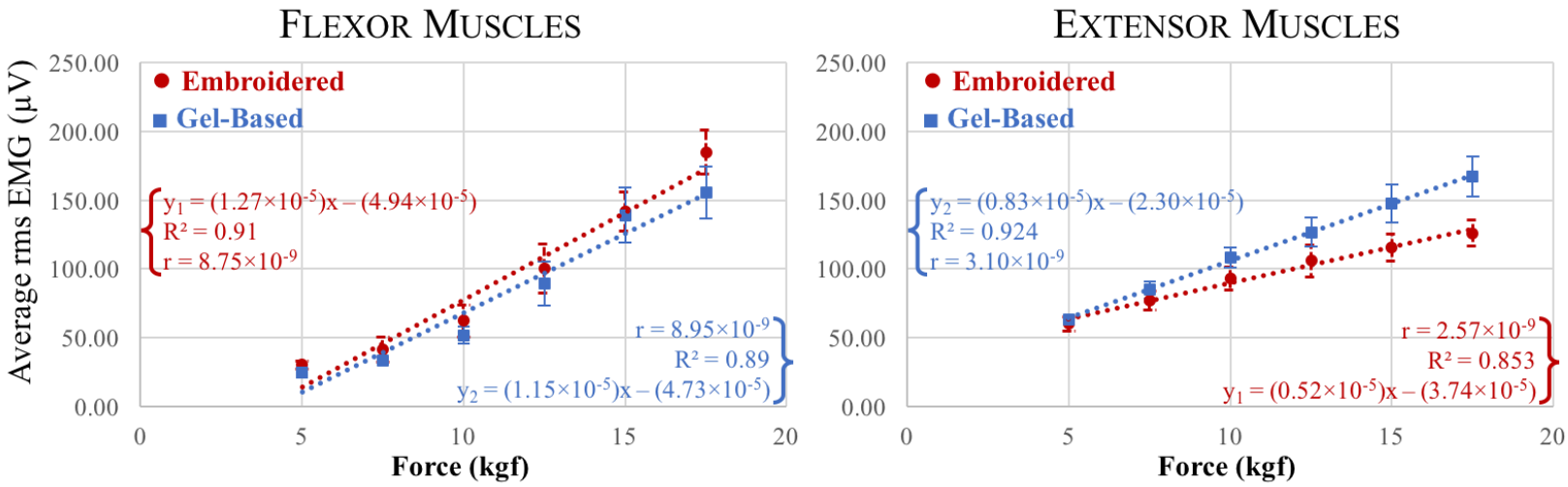
Results



Type	Flexor Muscles			Extensor Muscles		
	Gradient	R^2	r	Gradient	R^2	r
Emb.	4.75×10^{-6}	0.442	1.72×10^{-7}	4.07×10^{-6}	0.290	2.44×10^{-7}
Gel	4.31×10^{-6}	0.461	1.30×10^{-7}	5.28×10^{-6}	0.372	2.82×10^{-7}

A. Shafti, R. B. Ribas Manero, A. M. Borg, K. Althoefer, M. J. Howard "*Embroidered Electromyography: A Systematic Design Guide*", TNSRE 2016