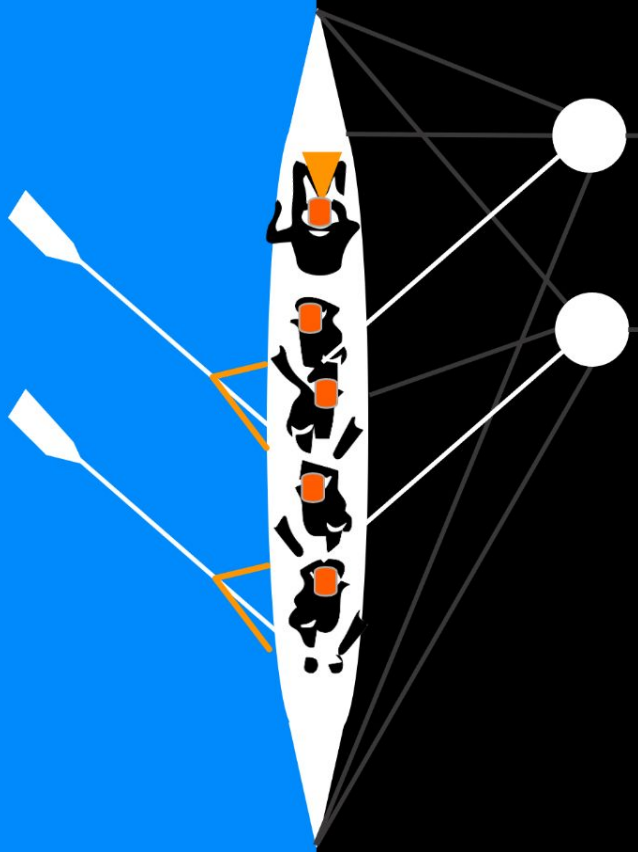


Understand the Dynamics of Para Rowing Through AI

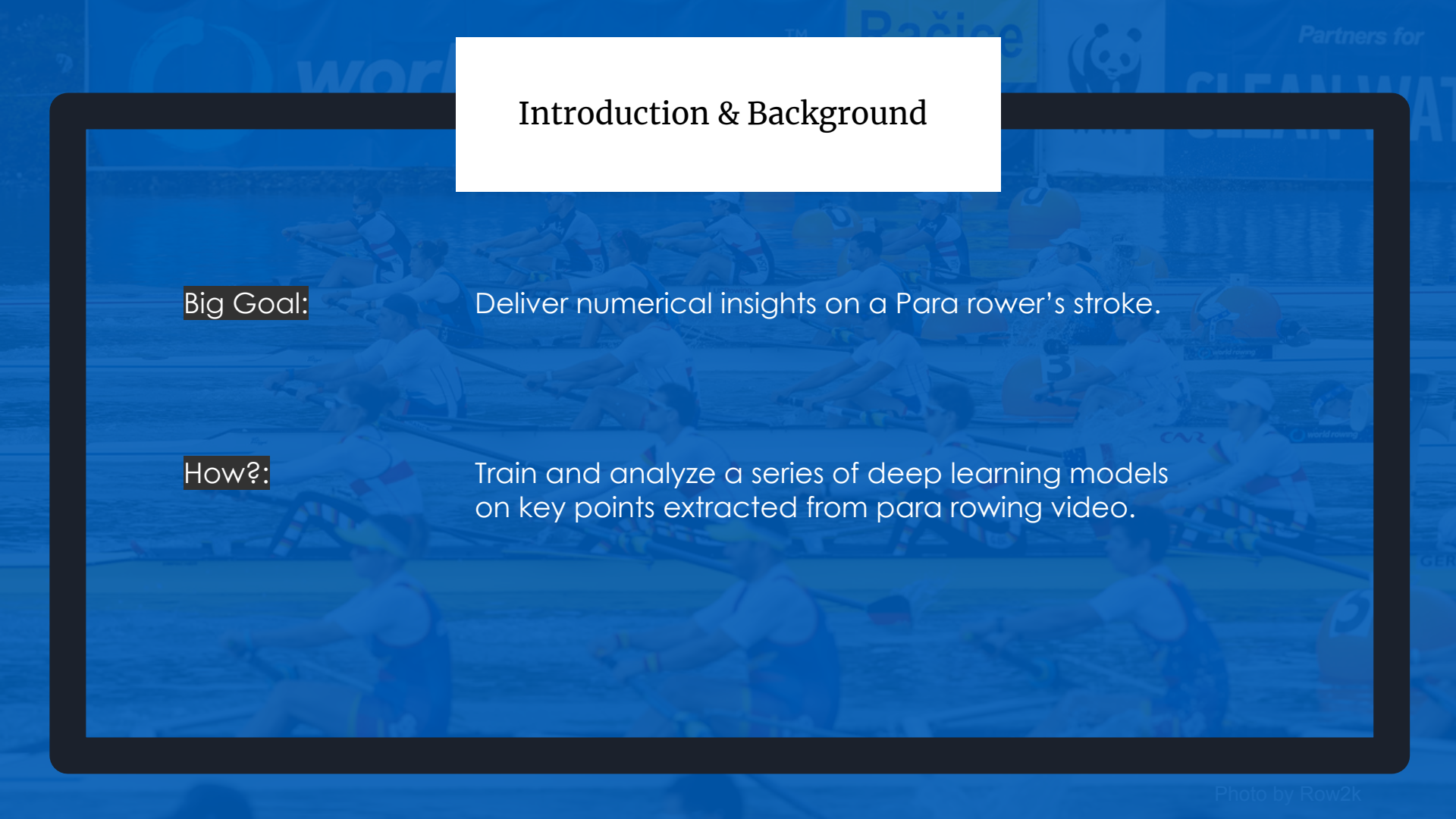
Keith, Emelie

Principles of Neural Computation

Introduction & Background

Big Goal: Deliver numerical insights on a Para rower's stroke.

How?: Train and analyze a series of deep learning models on key points extracted from para rowing video.

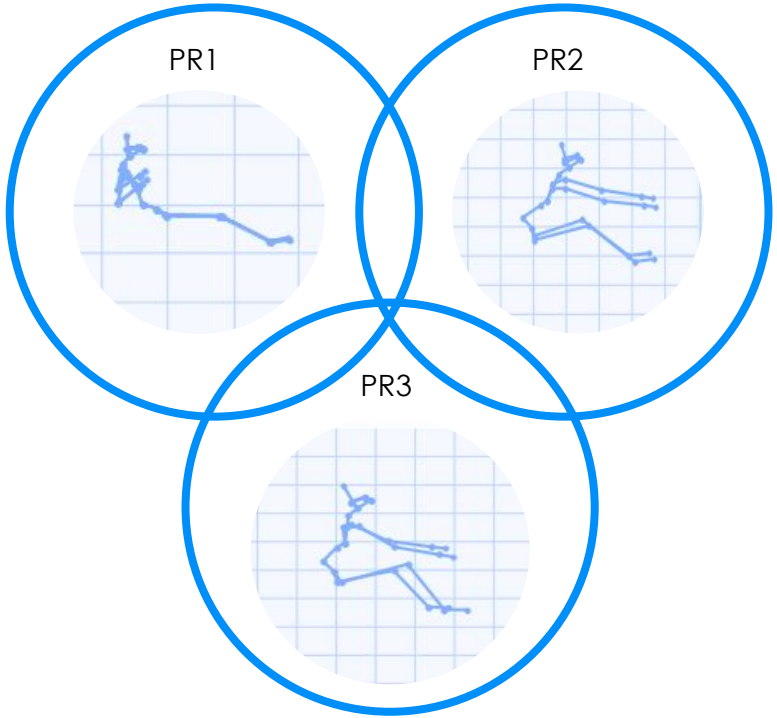


Contribution

PR1: Arms only fixed seat

PR2: Upper body fixed seat

PR3: Full body and seat use



Prior Work

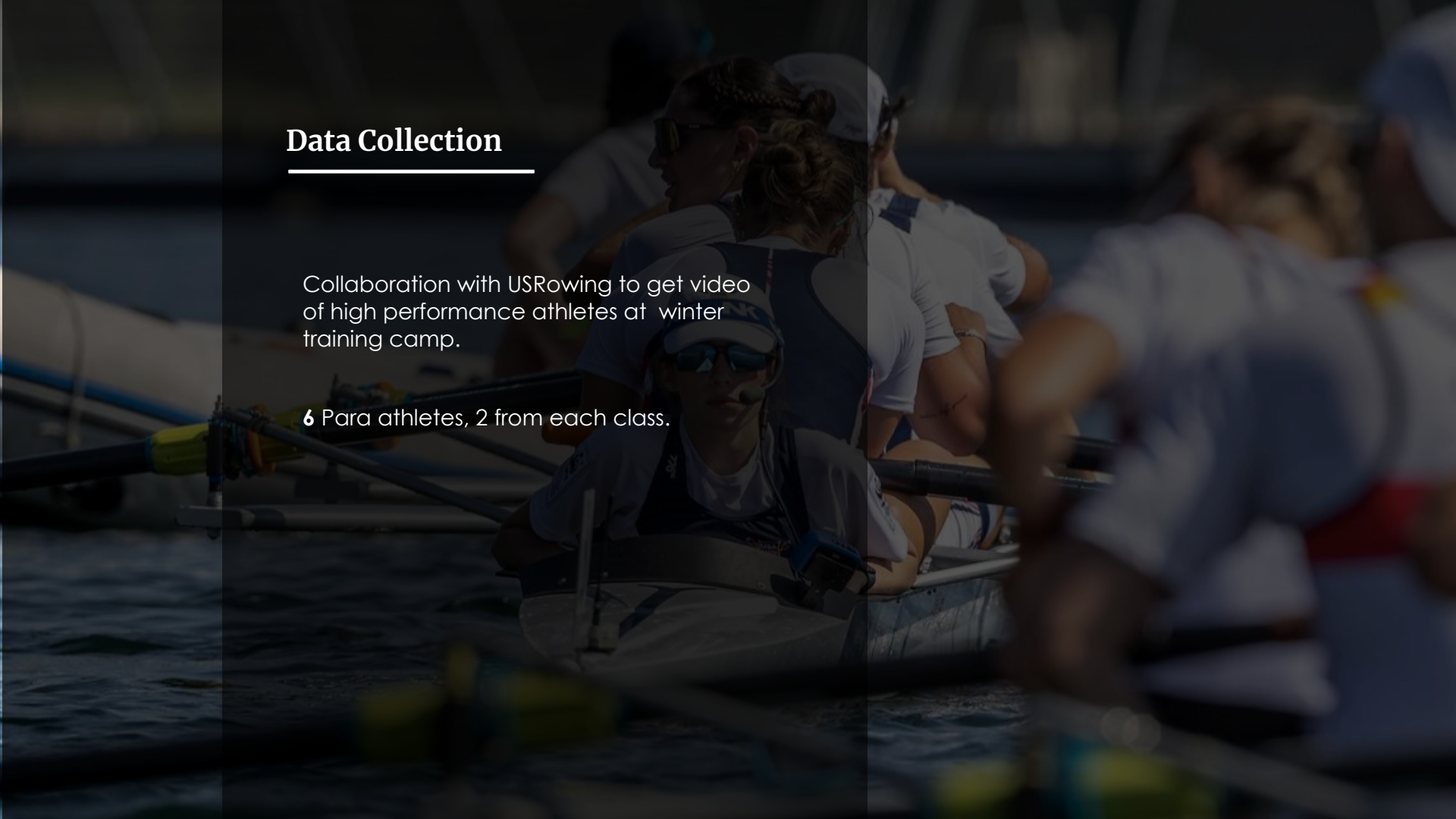
6 biomechanical studies exist for Para Rowing.

2 purely vision-based systems exist for rowing. Experts don't trust the insights.

11 Largest number of Para athletes in one study.

0 are in 3D.

0 use ML.



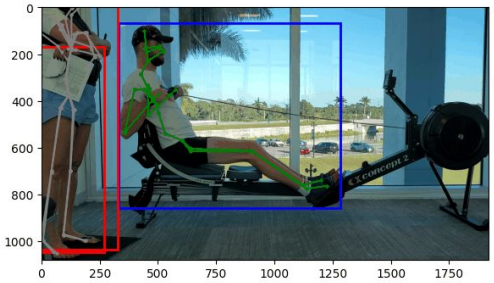
Data Collection

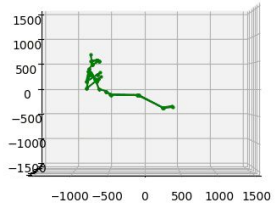
Collaboration with USRowing to get video of high performance athletes at winter training camp.

6 Para athletes, 2 from each class.

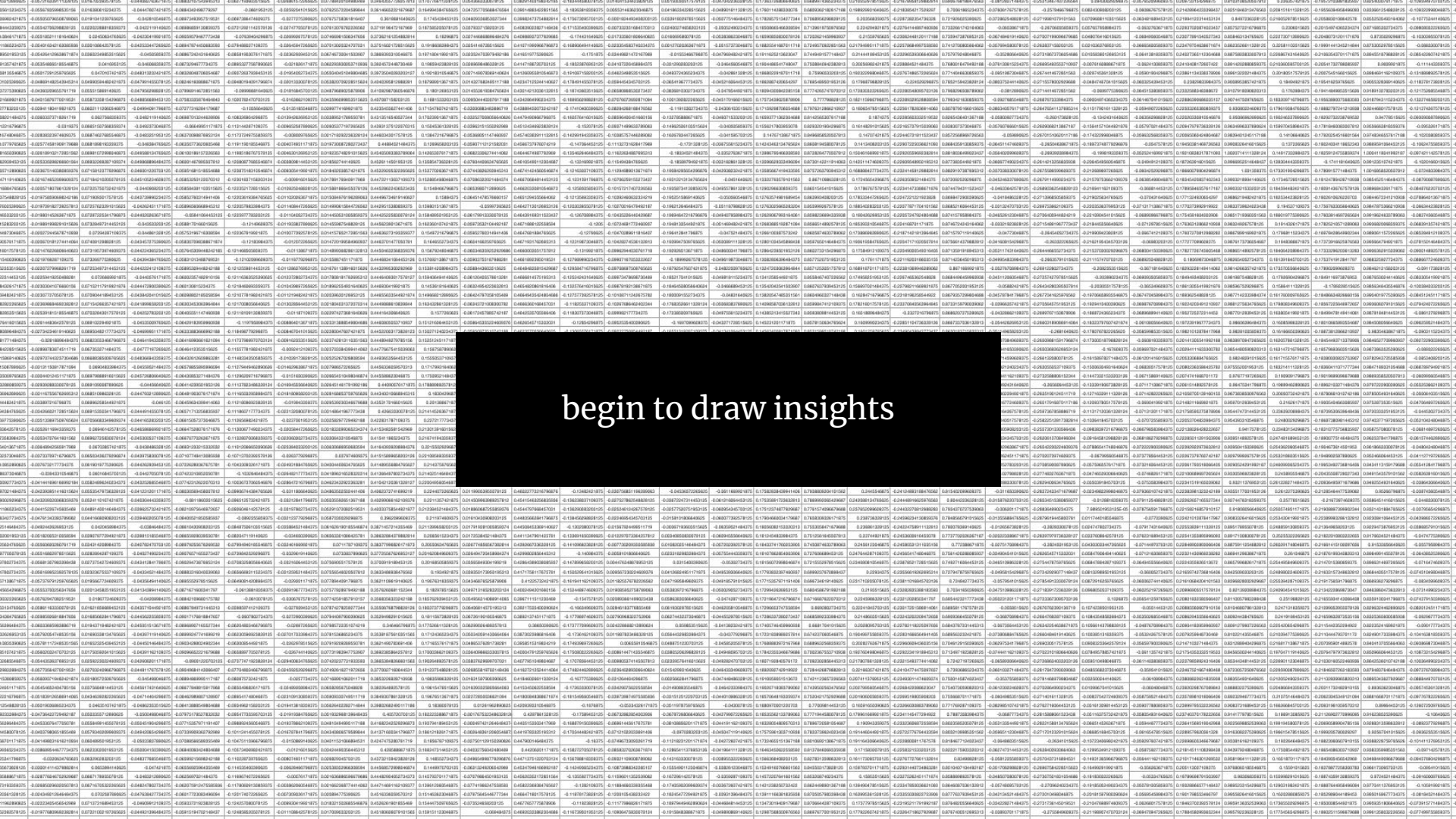
Methods Step 1

1.1: MeTRABs to preprocess frames.
Tested against strided transformers and Relative Information Encoding
Scaled metric system



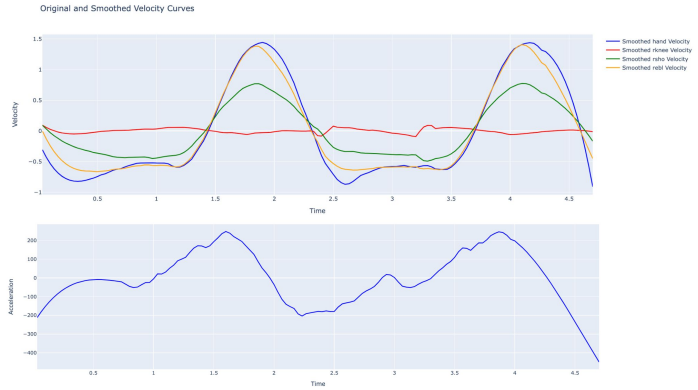


Run each frame through MeTRABs to get 30 keypoints x,y,z coordinates CSV

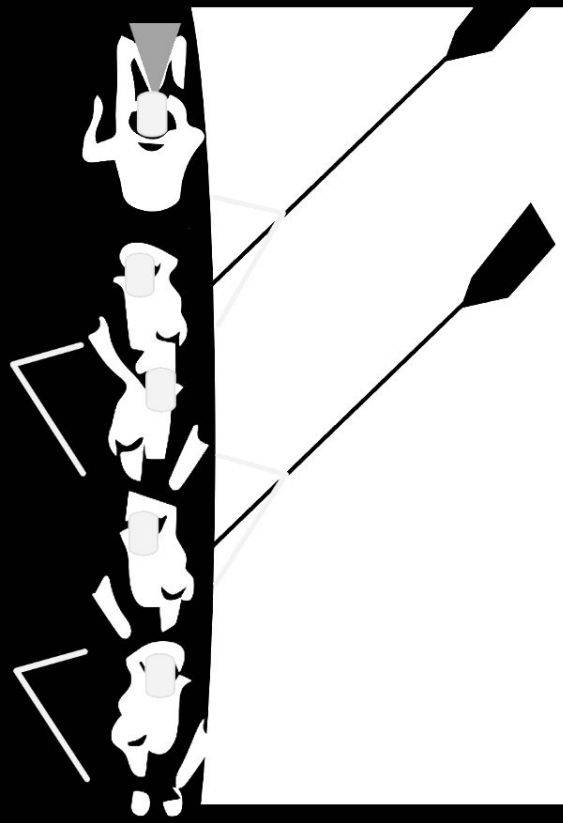

begin to draw insights

Methods Step 1

1.2: use x,y,z, frame rate to calculate velocity, acceleration, and angles between keypoints

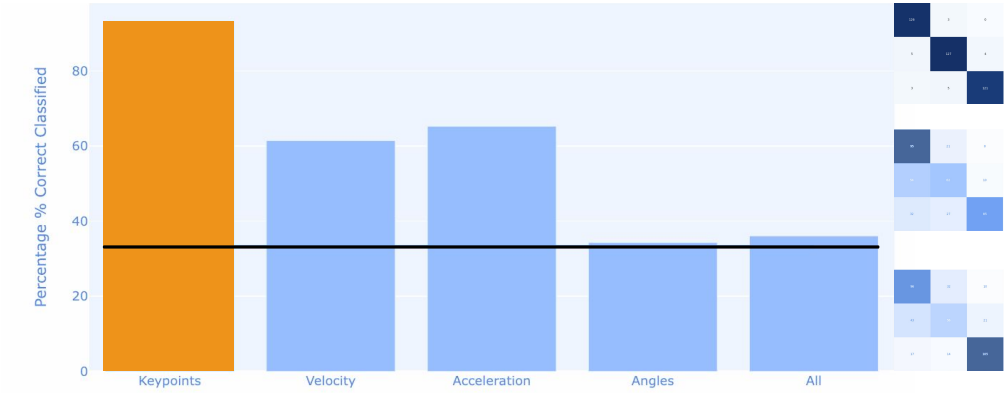


Once we have these repetitive metrics, we can dive into ML



Methods Step 2

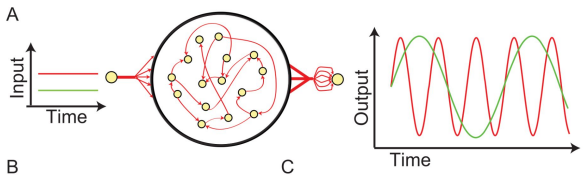
Classifier for Para Classification: 2 hidden layers (64 neurons)
10 epochs, .001 lr, 80/20 split

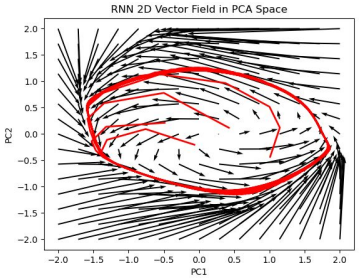


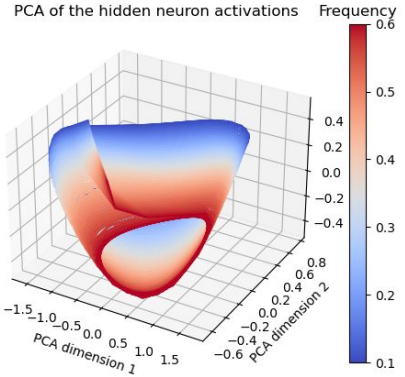
The Dynamical View

Travel back to Keith's mid-semester project,

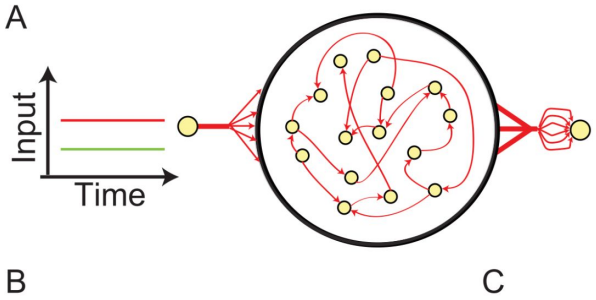
Does the rowing stroke have an underlying dynamics?

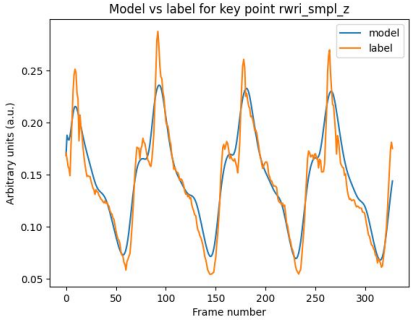






RNN setup





Input:

(F, 20) dimensional "key" vector
Each rowing dataset assigned a random "key"
Key vectors consistent throughout (F)rames
328 (F)rames

Model:

200 neuron GRU recurrent network
Output: (F, 72) dimensional vector of rower keypoints

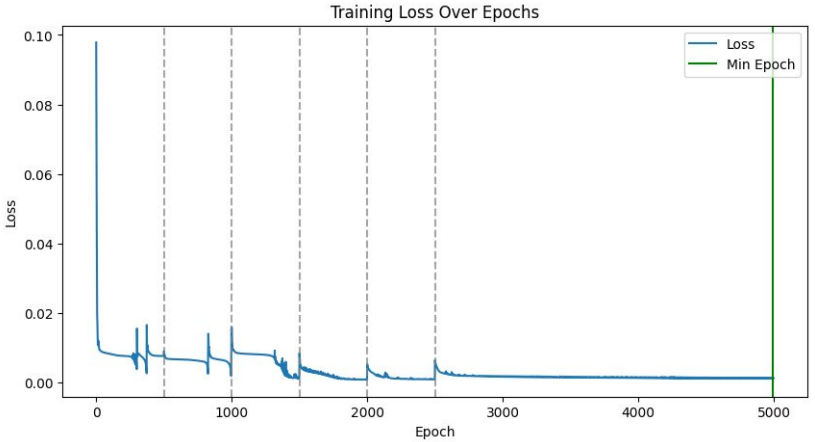
RNN training

Learning algorithm:
backpropagation through time (BPTT).

Curriculum Trained Model
A new rower's stroke key points were introduced every 500 epochs.

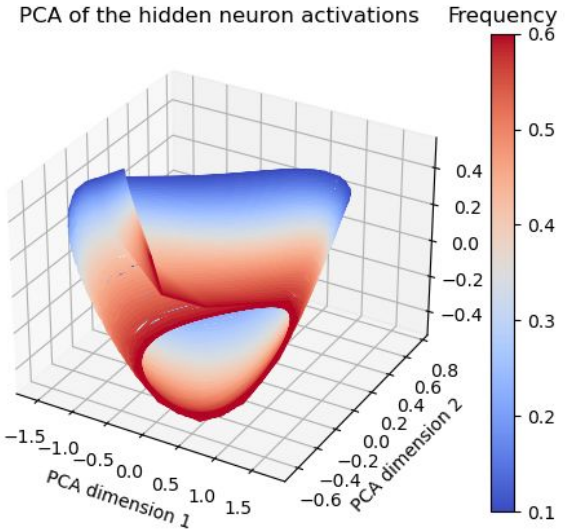
5000 total training epochs

Due to the limited size of the dataset, no testing set was used.



Underlying dynamics

Sine wave generator



Rowing key points copier

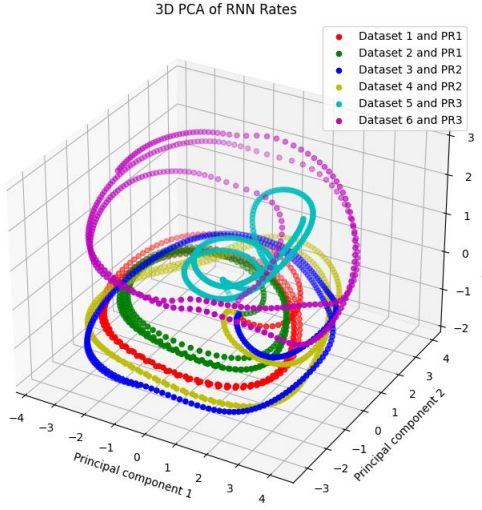
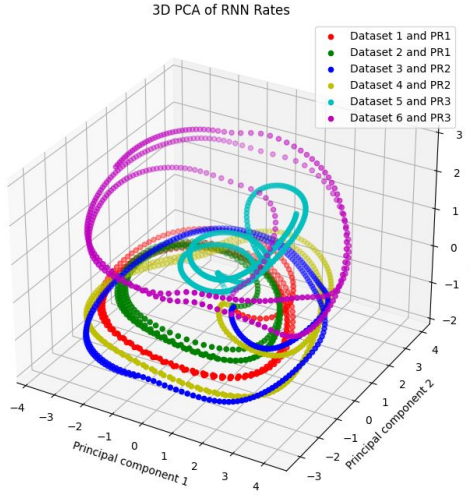
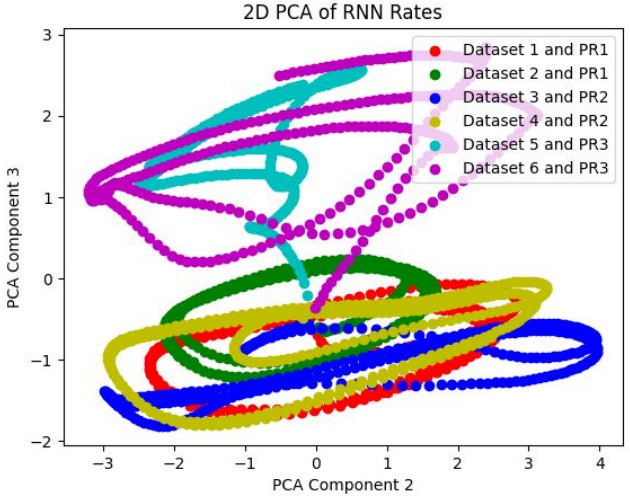


Photo by Row2k

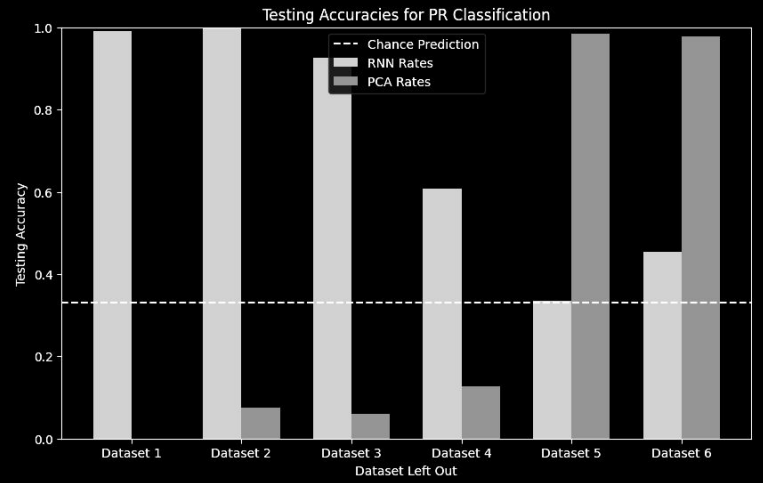
Underlying dynamics





Principle Component 3 may correspond to PR class!

Quantifying PR representation



How might we quantify PC 3 representation of PR class?

Train a linear classifier.

RNN rates: (6, 328, 200)
X: (1968, 200), Y: (1968)
Y is one of [0,1,2]
Leave one rower out

PCA rates: (6, 328, 3)
X: (1968, 3), Y: (1968)
Y is one of [0,1,2]
Leave one rower out

Photo by Row2k

Principle of Equivariance

Is the RNN's representation of PR class equivariant with respect to time?

$$g(f(x, t)) = f(g(x), t)$$

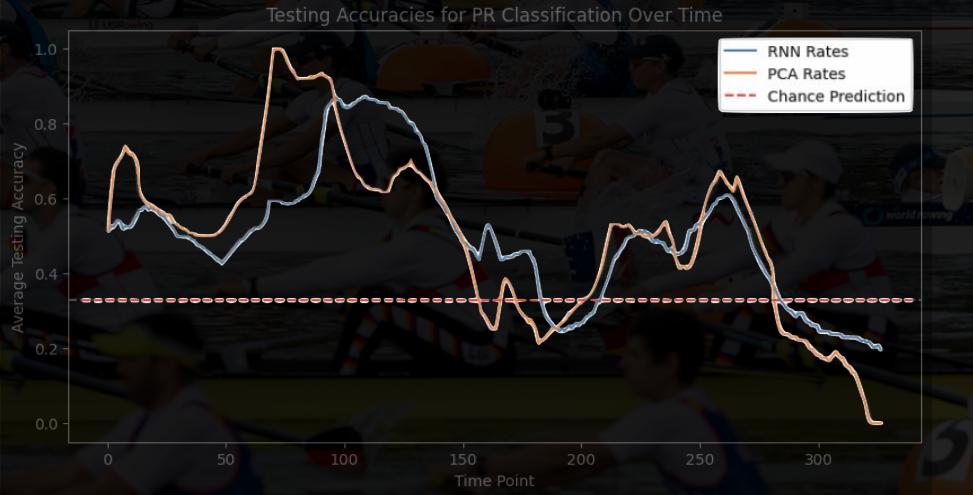
x : rowing stroke

g(x) : PR class

f(x, t) : phase of rowing stroke

Our test of equivariance through time consisted of training a linear classifier at each frame of the RNN and PCA rates.

Results are mixed, but are majority above chance performance.



Next Steps

More Data

Establish manifold of PR class. This would allow us to analyze the biomechanical differences between winning PR1 athletes.

Stroke Rate

Normalize stroke rating (strokes/minute) for total accuracy using midpoints between keypoints.

Prosthetics

Improve baseline model by adding prosthetics understanding.

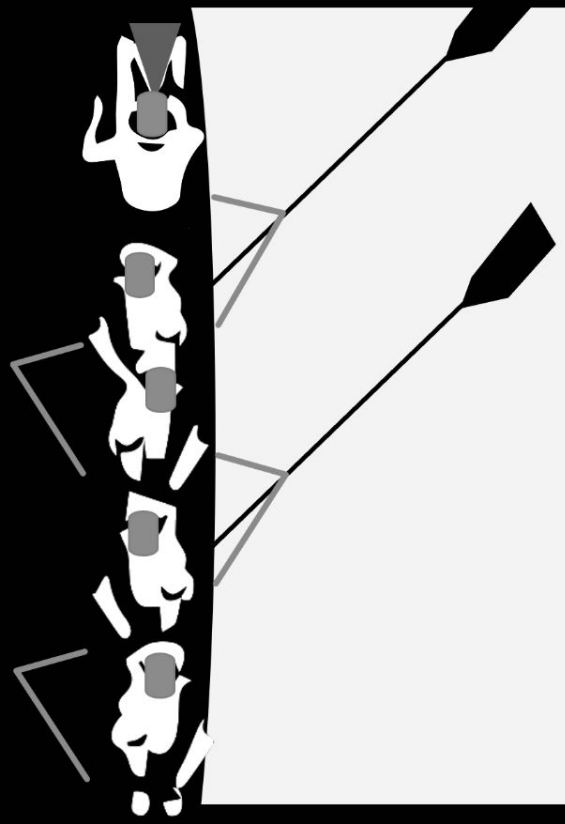
Conclusion

View Dynamics

Principle Equivariance

Manifold PR1 & PR2 convergence reveals initial insights into an elite discussion on ability.

Data Preprocessing revealed accurate capabilities in power production predictions and biomechanical application.



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WODProof App: *Wodproofapp.com*, https://wodproofapp.com/.

RowerUp App: *RowerUp*, https://rowerup.com/.