From First Principles to AI

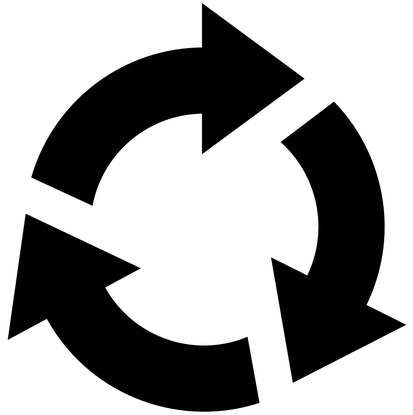
Rethinking Modelling in Sports Science

Zignoli A.
Lausanne 09.07.2026

The scientific revolution begun when we started sharing discoveries systematically.

Consistent pattern

STRUCTURE



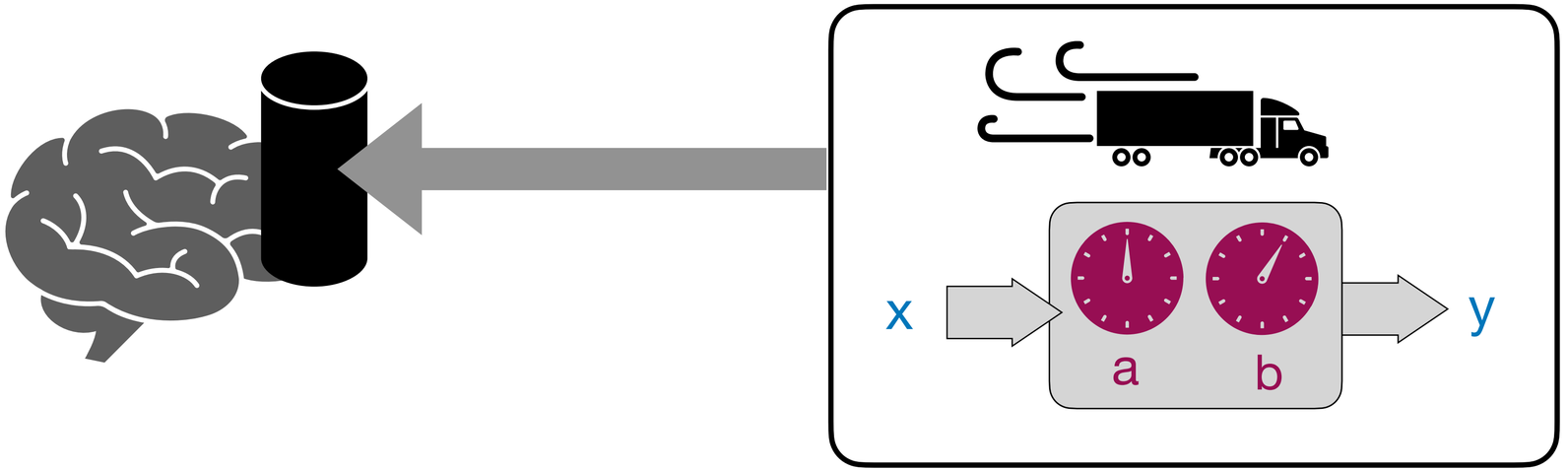
Observation

DATA

Compression

The scientific revolution begun when we started sharing discoveries systematically.

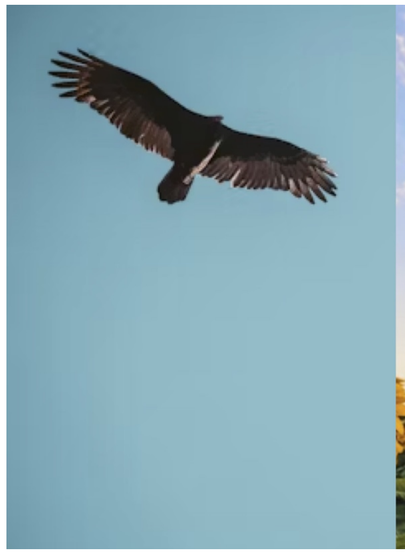
Our brains do not store examples, or observations. We store patterns, the stats, the laws, the principles, the models.

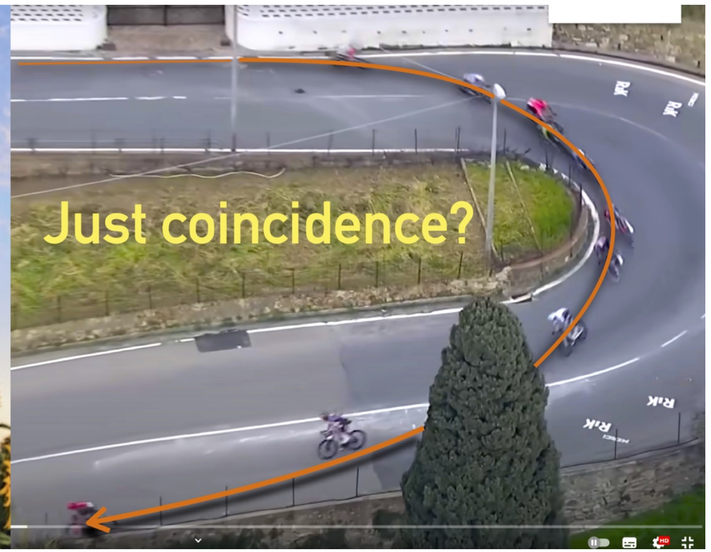


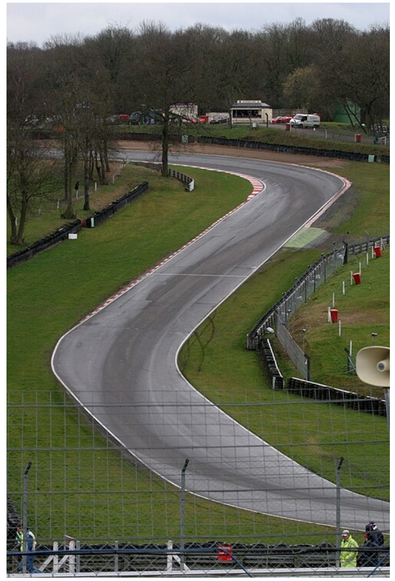
EXAMPLE #1

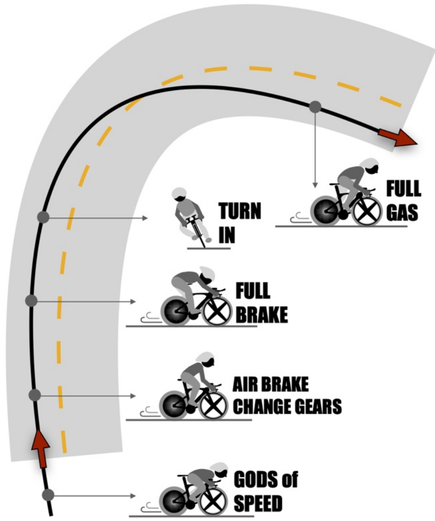
“There is a pattern.”

Cornering strategies - 3D cycling dynamics







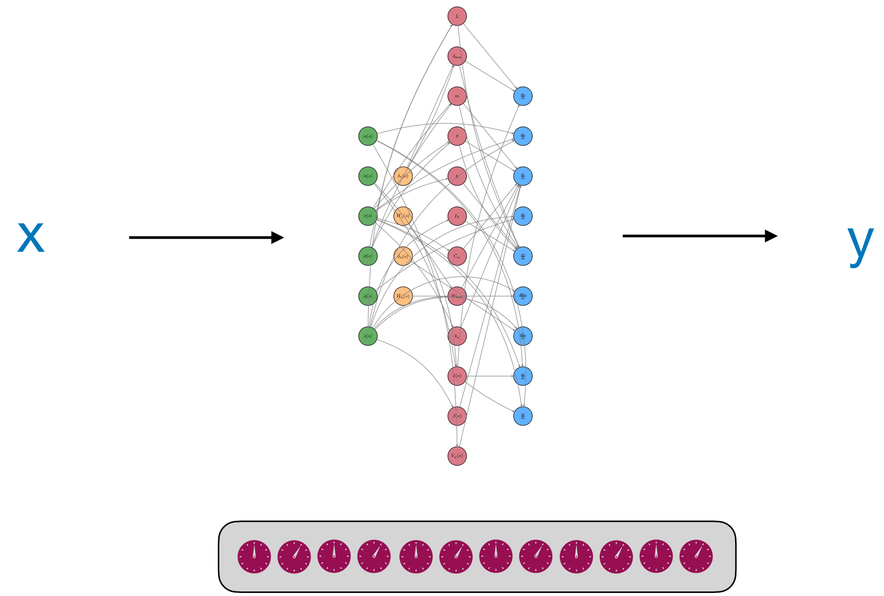


First principles

$$\frac{d\dot{s}(s)}{ds} = \frac{ds}{dt}$$
$$\frac{d\alpha(s)}{ds} = \frac{\delta_n(s)}{\delta_{\max} L}\dot{s}(s) - k(s)$$
$$\frac{dn(s)}{ds} = \frac{1}{\dot{s}(s)}\Big(v(s)\sin(\alpha(s))\Big)$$
$$m\, v(s) W_{\max}\frac{dv(s)}{ds} = W_n(s)\dot{s}(s) - v(s)\dot{s}(s)W_{\max}\Big(mg\big[C_{rr}\cos(\beta(s)) + \sin(\beta(s))\big] + k_v(v(s) - V_w(\alpha(s)))^2\Big)$$
$$\frac{d\phi(s)}{ds} = \dot{\phi}(s)\dot{s}(s)$$
$$\frac{d\dot{\phi}(s)}{ds} = \frac{h\, mg}{I_X}\frac{1}{L\dot{s}(s)}\Big(v(s)^2\delta_{\max}\delta_n(s) + Lg\phi(s)\Big)$$
$$\frac{dW_n(s)}{ds} = \dot{W}_n(s)\dot{s}(s)$$
$$\frac{d\delta_n(s)}{ds} = \dot{\delta}_n(s)\dot{s}(s)$$
$$\frac{d\dot{s}(s)}{ds} = \frac{v(s)\cos(\alpha(s))}{1 - n(s)k(s)}$$
$$\frac{dt(s)}{ds} = -1 + \frac{k(s)n(s)\cos(\alpha(s))}{v(s)}$$

Model

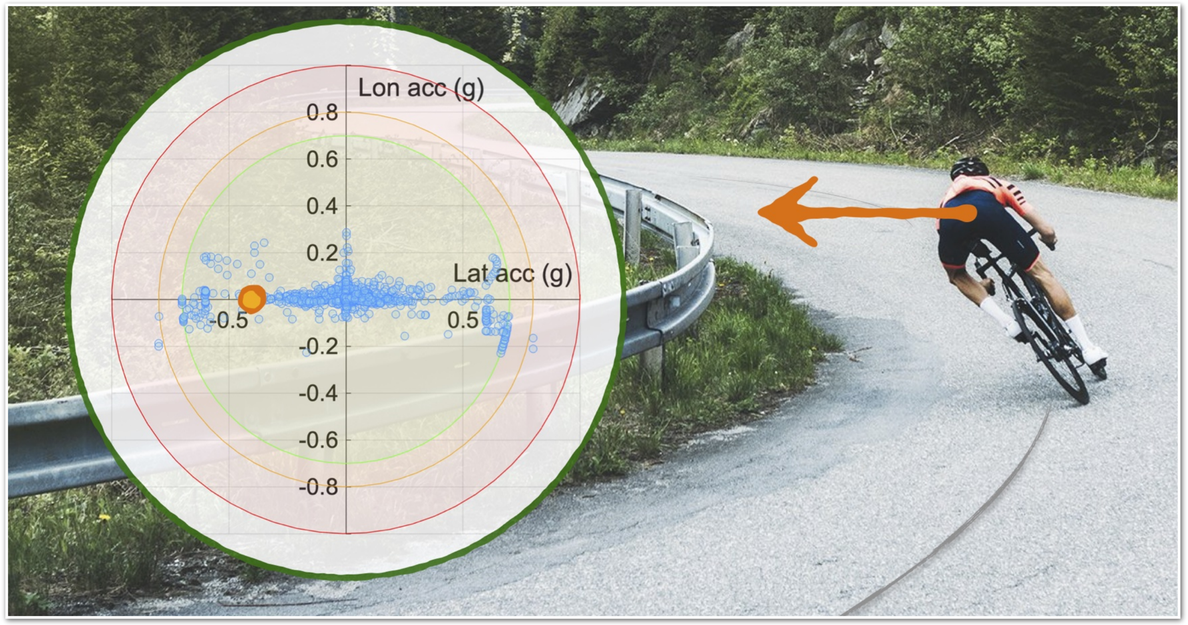
3D cycling model

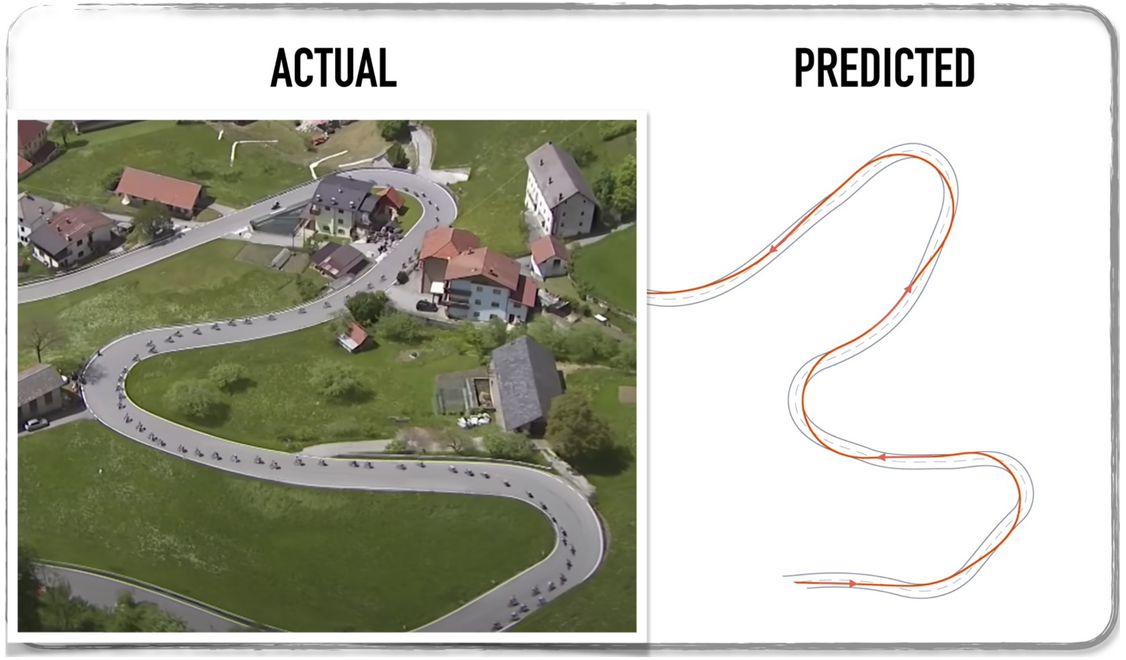


12 parameters

Zignoli and Biral, *Sports Engineering*, 2020.

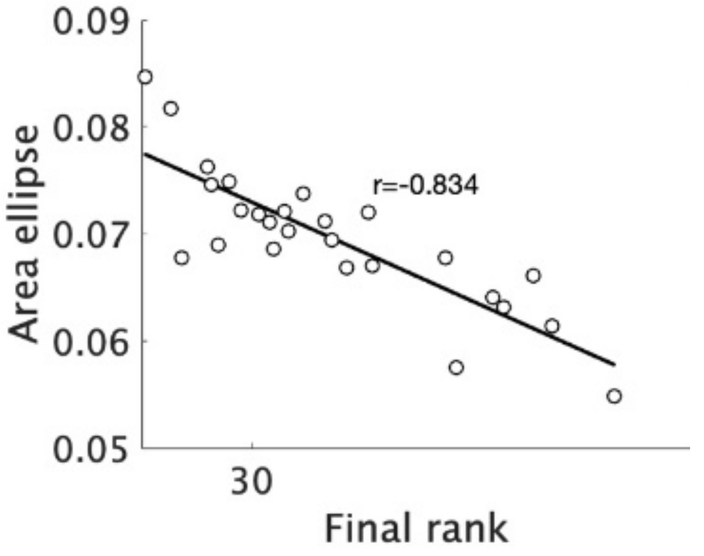
Zignoli, *Sensors*, 2025.





A 10% bigger *acceleration area*:

1) **Was associated with 20 positions in the final rank in a technical ITT (real-data)**
2) **Can result in 13” gain down a 5-km technical section (simulation).**



Zignoli et al., *EJSS*, 2022.

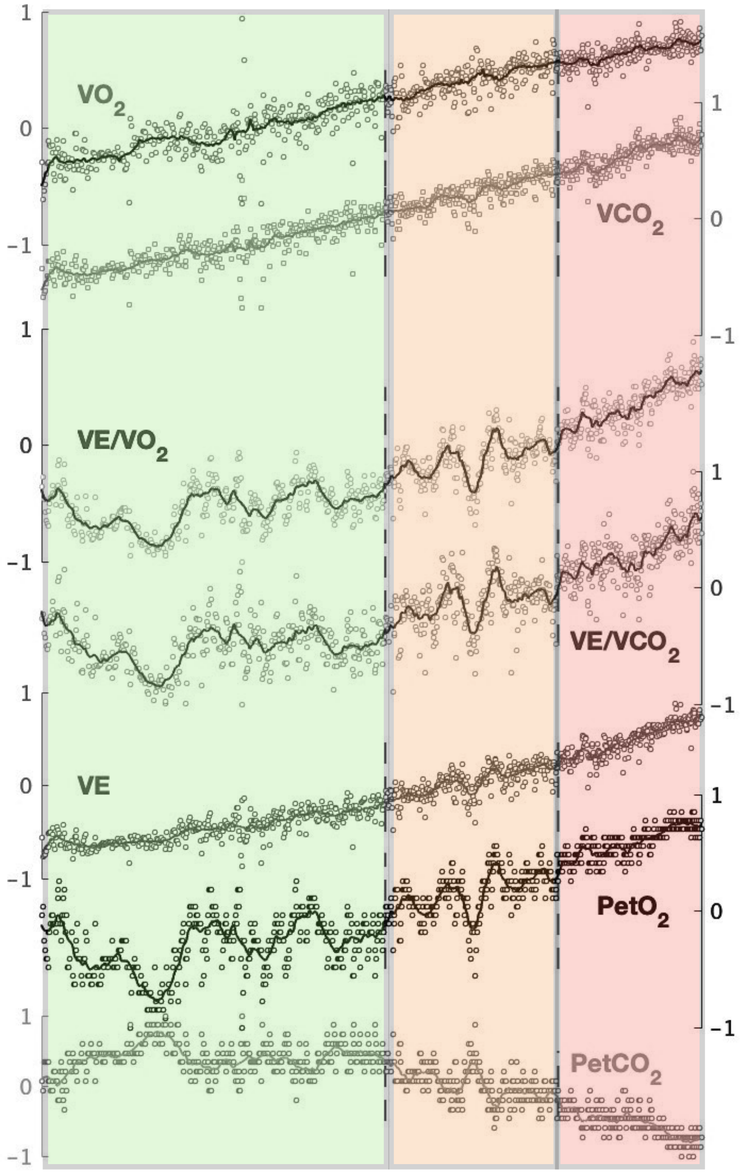
Zignoli, Journal of Sports Engineering and Technology. 2021.

EXAMPLE #2

“There must be a pattern.”

CPET (CPX)

Cardiopulmonary exercise testing



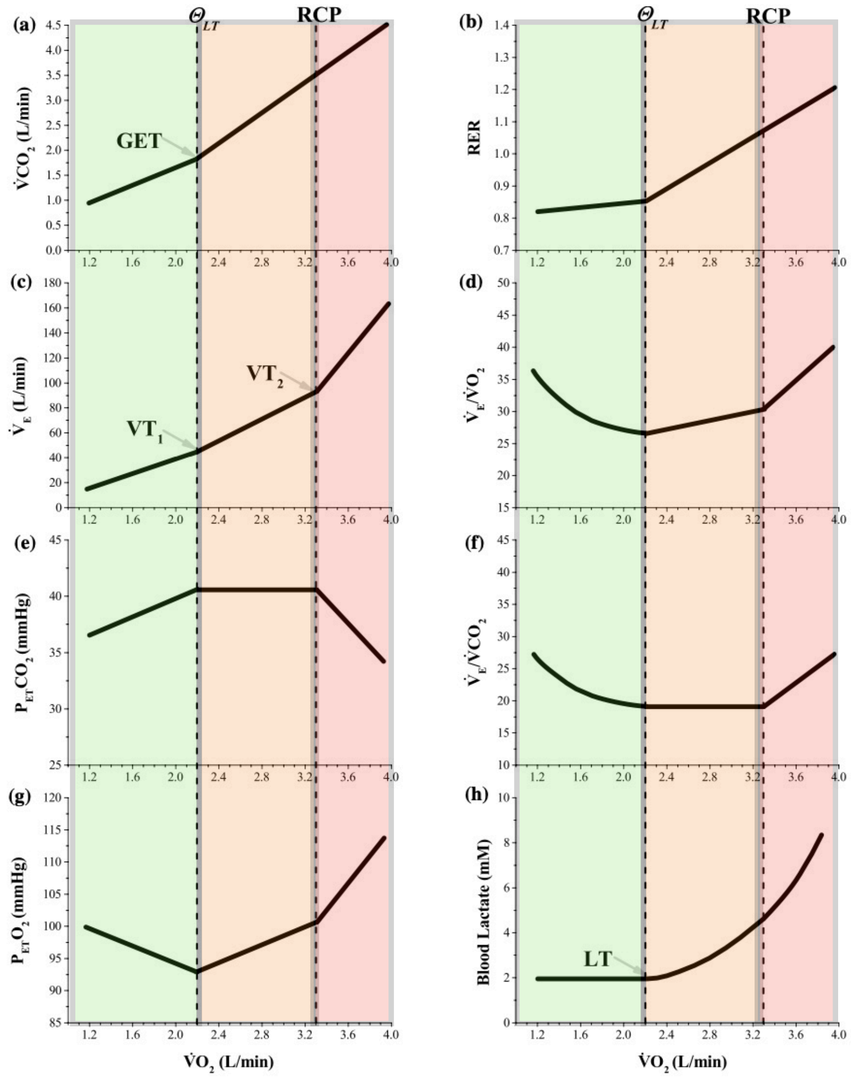
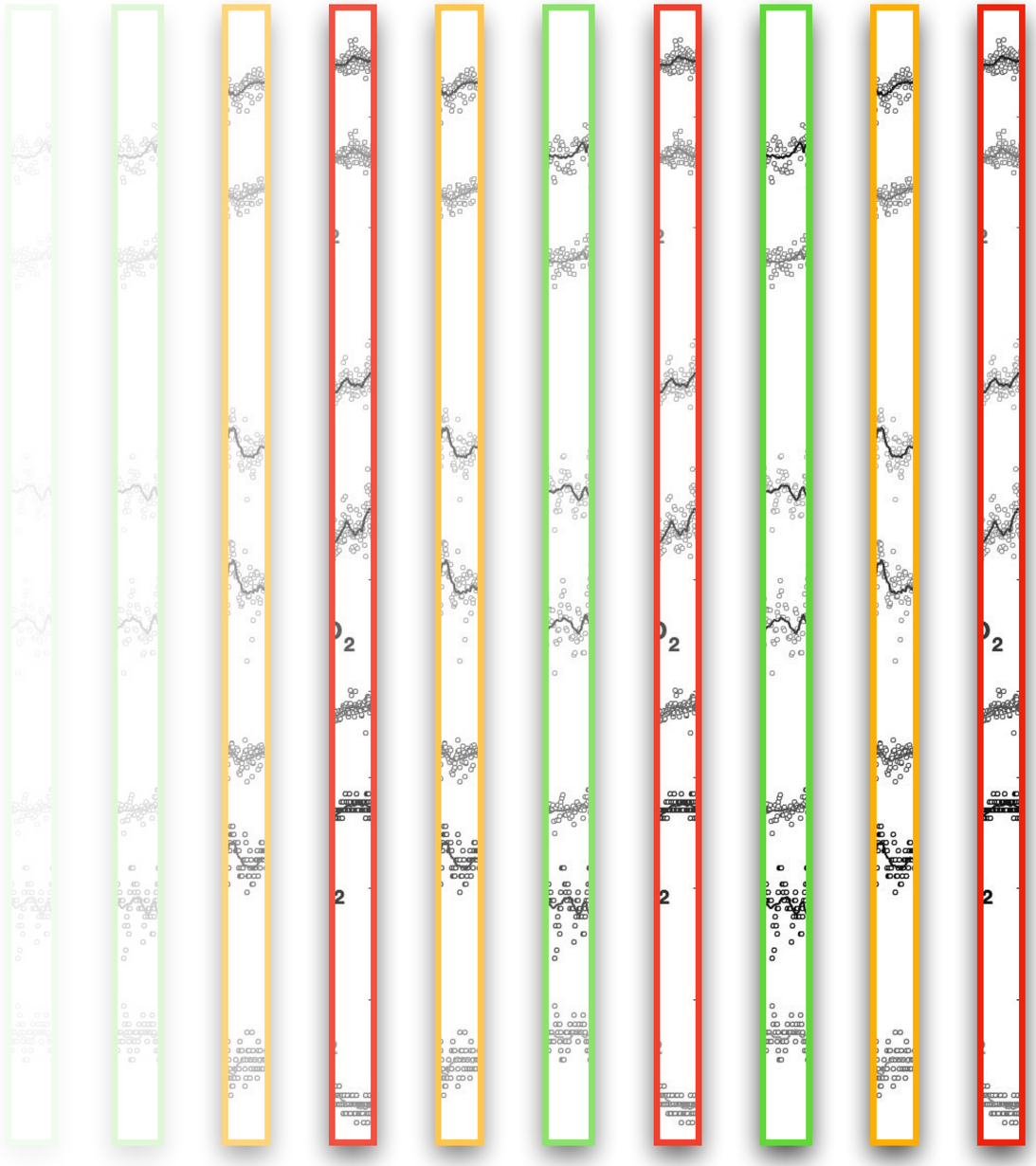
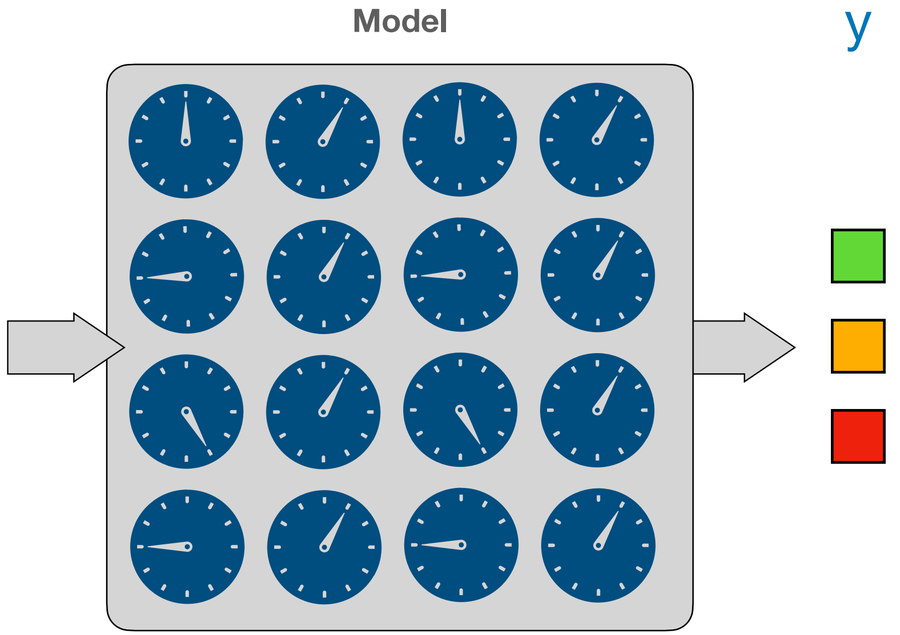


Image from: Wikipedia.
Keir et al. *Sports Med,* 2022



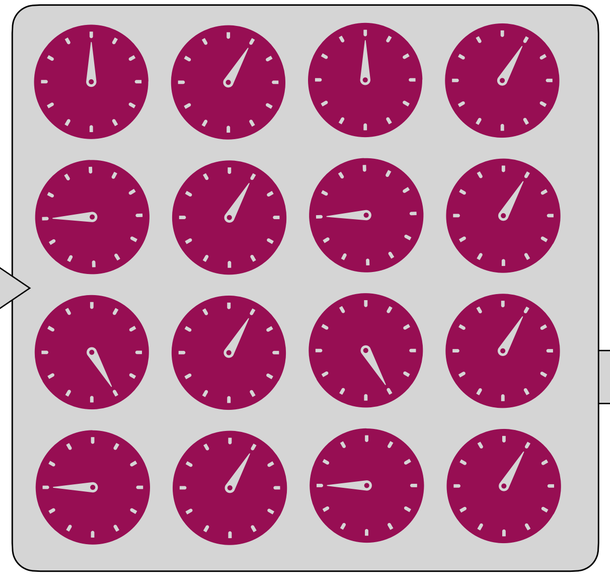

Model
y

x

?

OXYNET

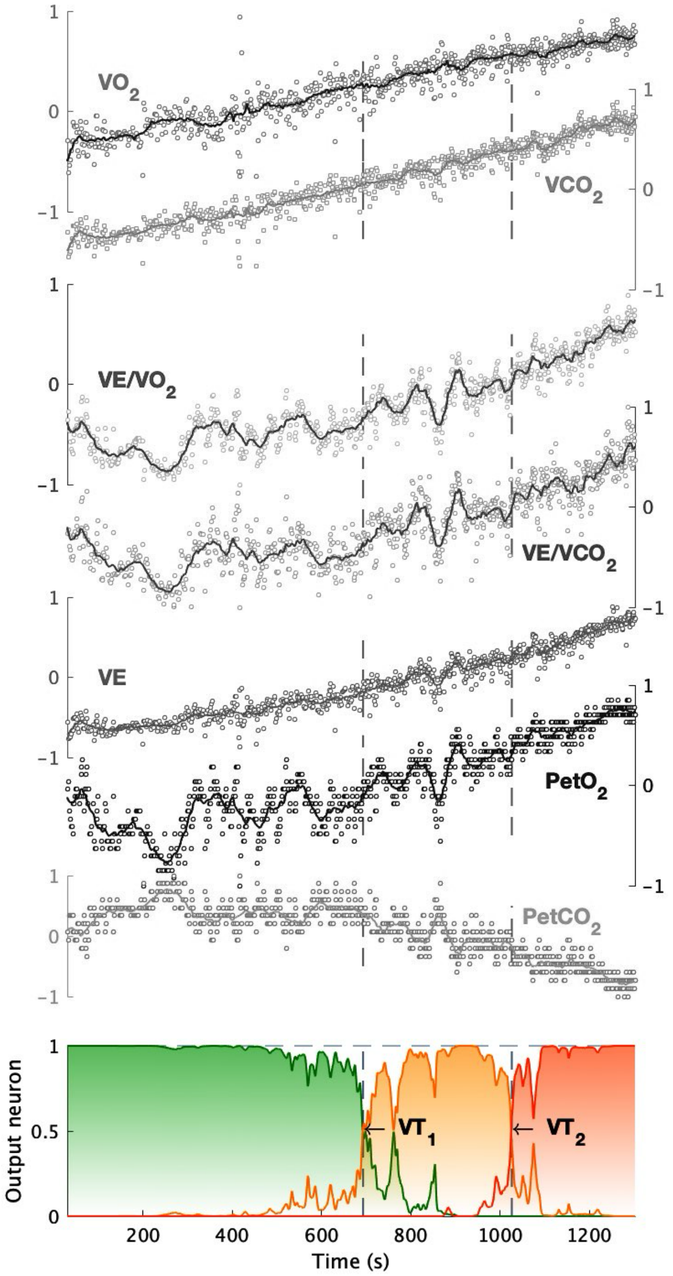
Model

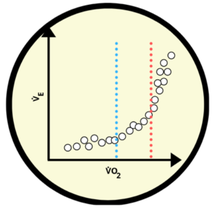


y

CNN/LSTM ~200k parameters

Zignoli et al., EJSS, 2019 and 2022, *Sensors* and *Bio. Signal* 2023.





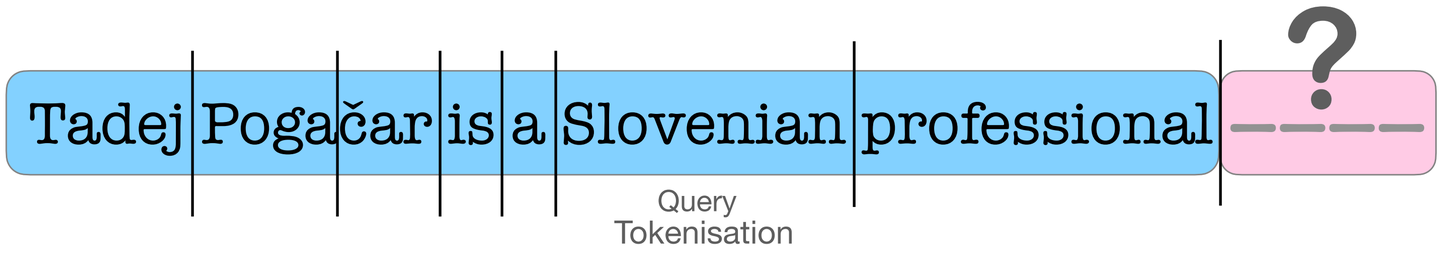
Exercise Thresholds App

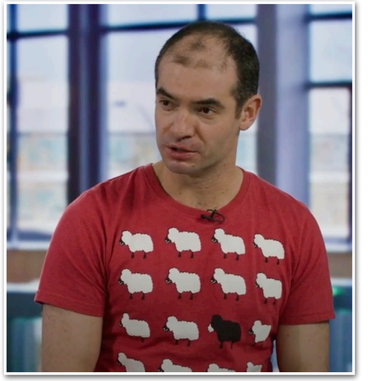
Keir and Zignoli et al., *Sports Med*. 2026.

EXAMPLE #3

“Is there a pattern?”

How does an LLM work?





By learning the structure in text, the LLM learns about the structure of the world.
Ilya Sutskever

x

Tadej

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is

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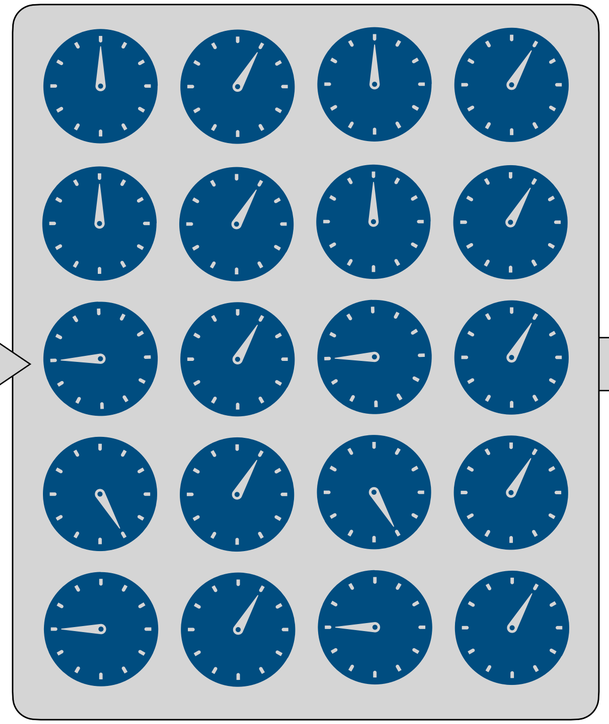
Slovenian

professional

Embeddings/vectorisation

1.8 Trillion parameters (GPT-4-turbo)



Transformers/attention

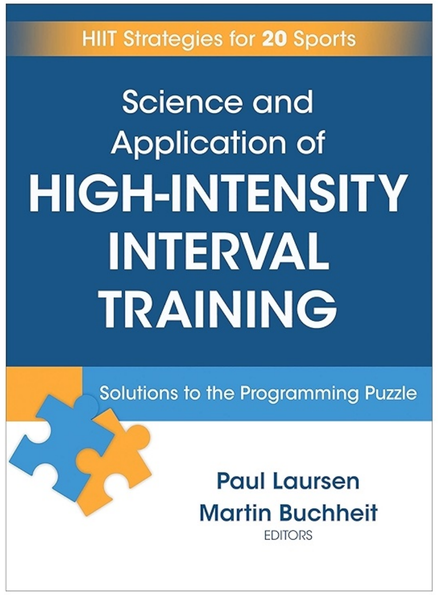
y

cyclist Most likely next word/token

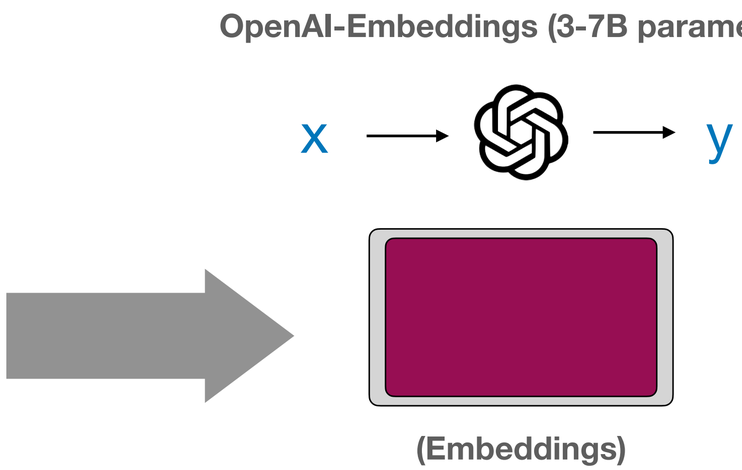
rider Less likely next word/token

athlete Less likely next word/token

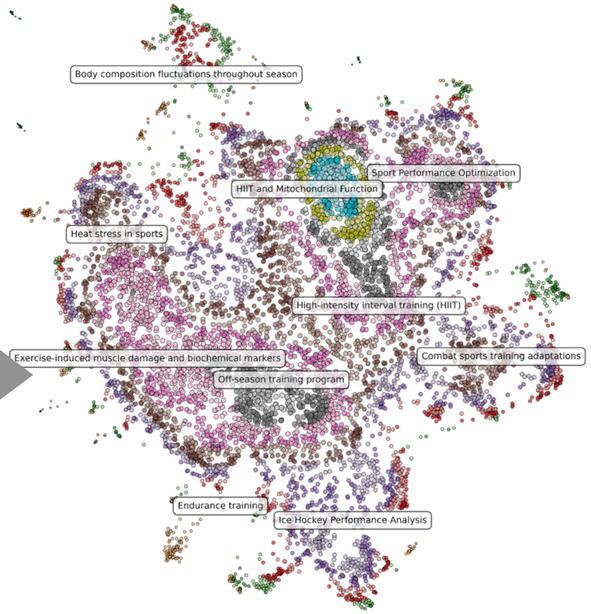
Written text



Model



“Knowledge” map



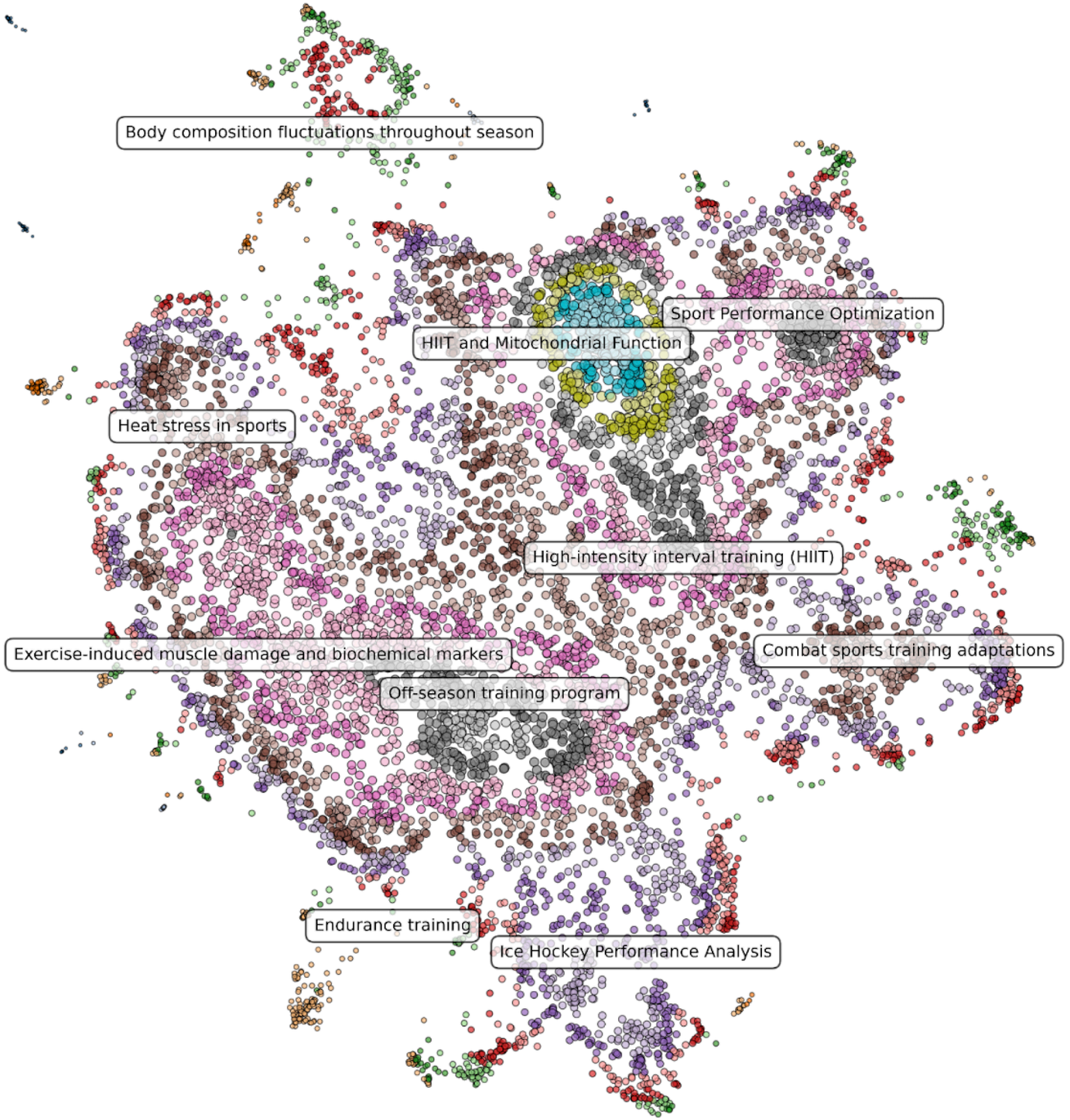
Laursen and Buchheit. *Human Kinetics*, 2019.

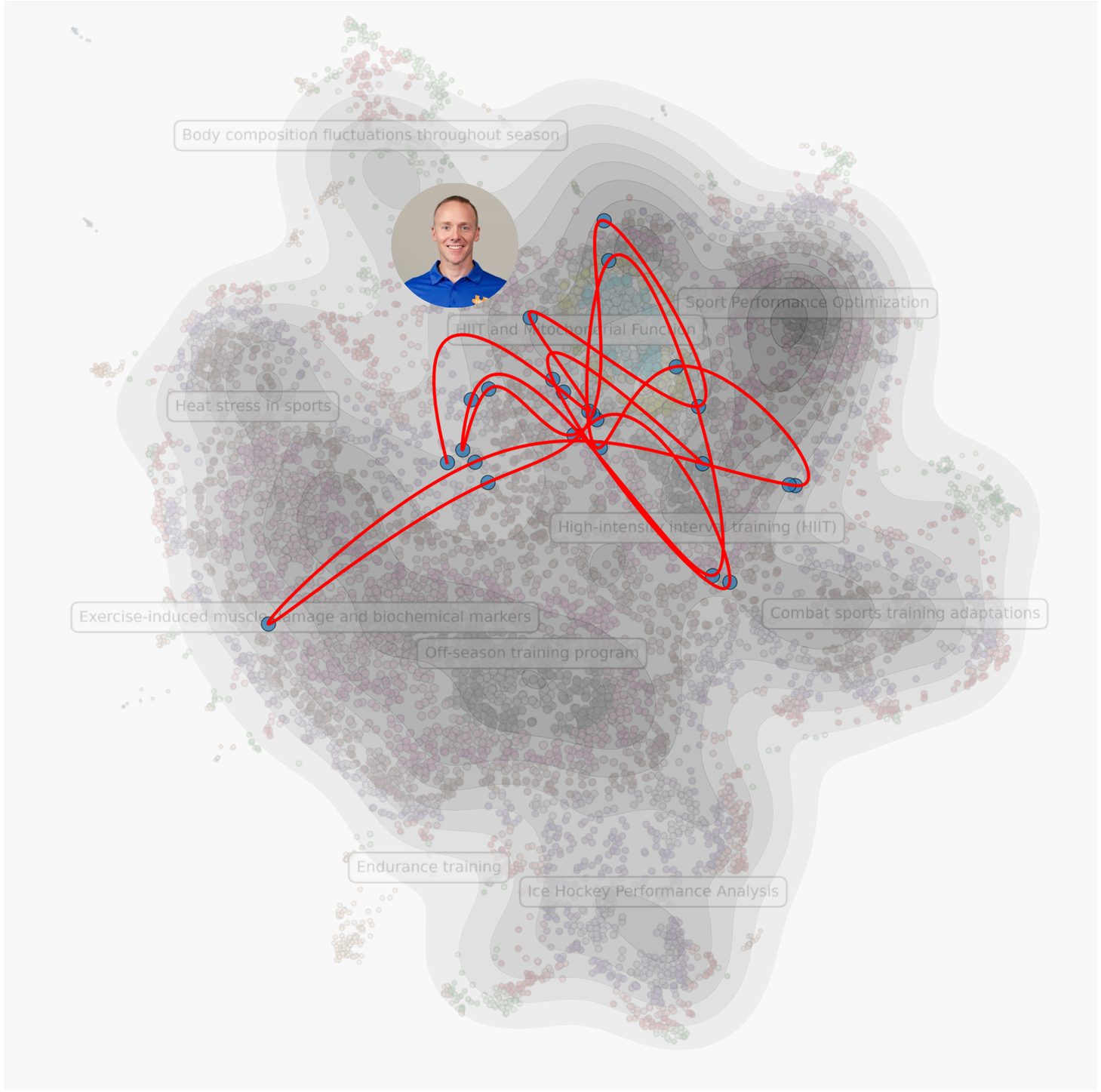
Zignoli and Laursen, *Sport Perform Sci Rep*. 2025.

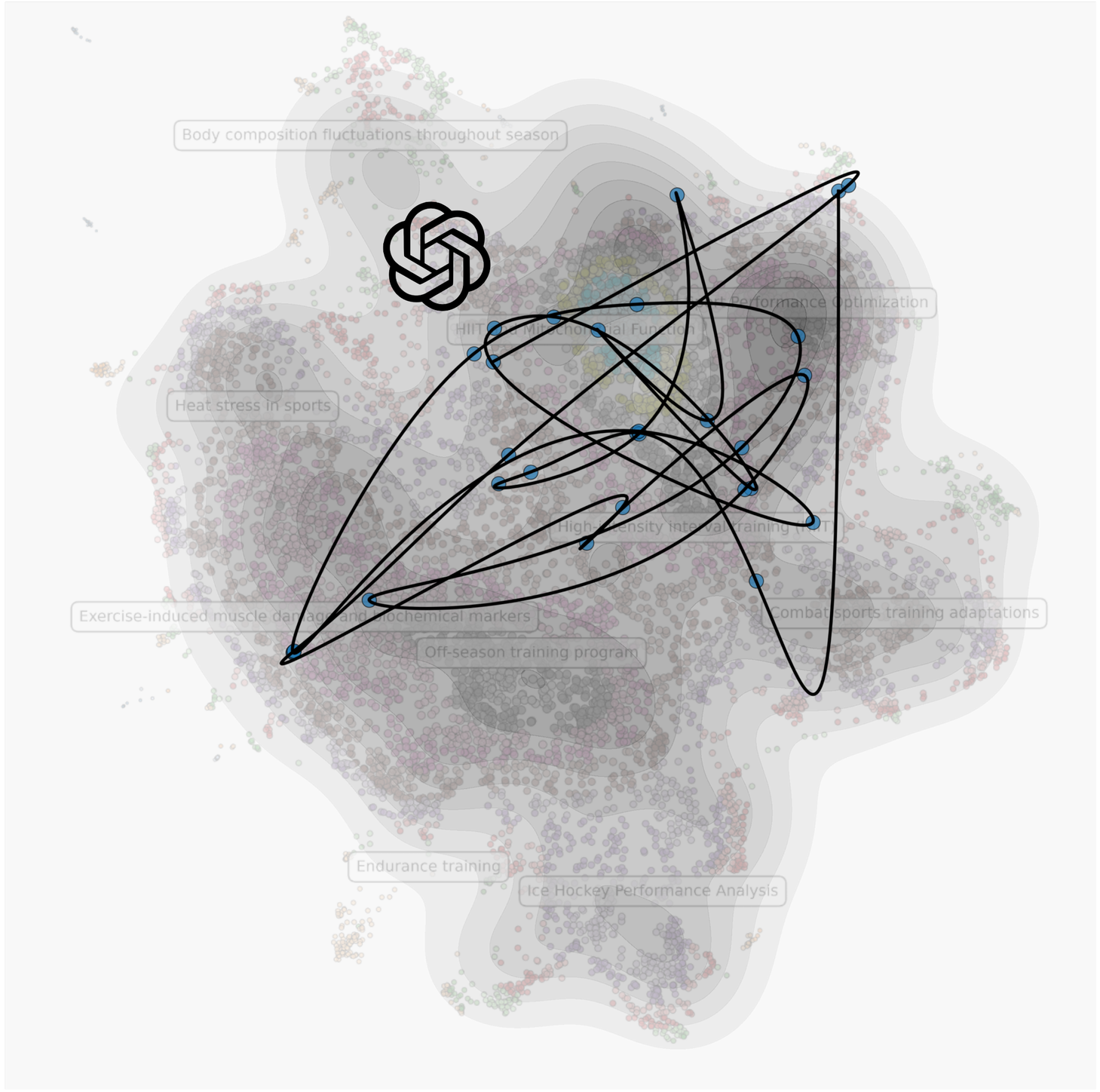
Coaching question

Vs

Given two athletes with similar VO_{2MAX} values (60 $ml \cdot kg^{-1} \cdot min^{-1}$), how would you design a 4-week high-intensity interval training (HIIT) block for each, considering their unique profiles and performance goals? […]




Body composition fluctuations throughout season
Sport Performance Optimization
HIIT and Mitochondrial Function
Heat stress in sports
High-intensity interval training (HIIT)
Exercise-induced muscle damage and biochemical markers
Combat sports training adaptations
Off-season training program
Endurance training
Ice Hockey Performance Analysis


Body composition fluctuations throughout season
Performance Optimization
Heat stress in sports
High-intensity interval training (HIIT)
Exercise-induced muscle damage and biochemical markers
Combat sports training adaptations
Off-season training program
Endurance training
Ice Hockey Performance Analysis

Part of coaching knowledge is structured enough that both humans and language models traverse essentially the same semantic landscape.

But coaching isn't only navigation.

- deciding *which* problem matters,
- understanding the person,
- interpreting context,
- accepting responsibility,
- acting under uncertainty.

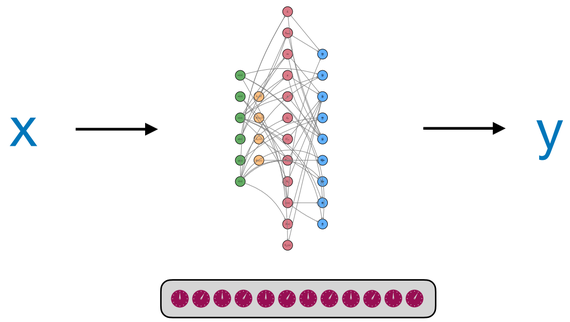
“Never send a human to do a machine’s job”
“Never send a machine to do a human’s job”

Putting it all together

Data or structure?

#1

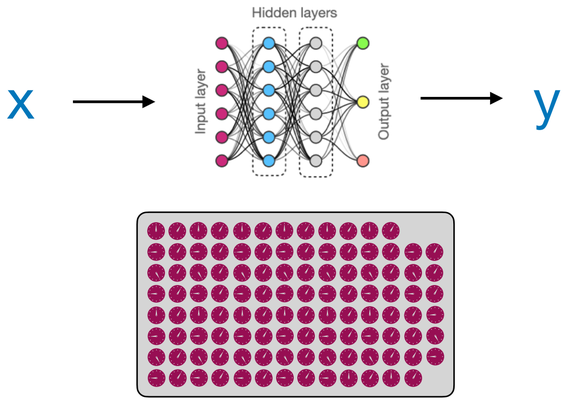
3D cycling model



12 parameters

#2

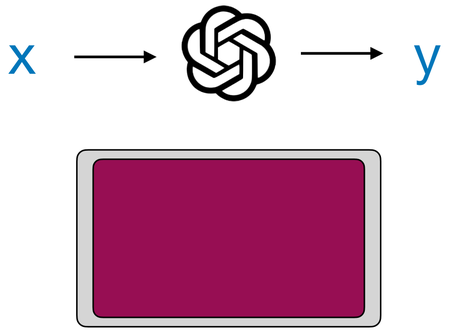
Oxynet CNN



200k parameters

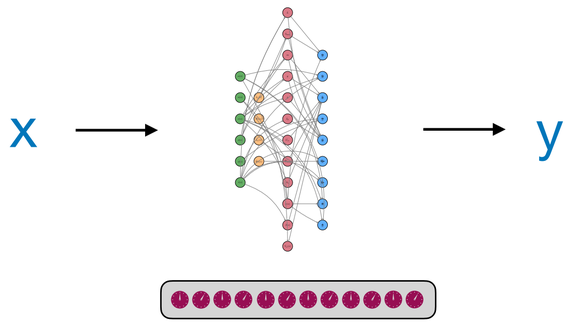
#3

GPT-4-turbo



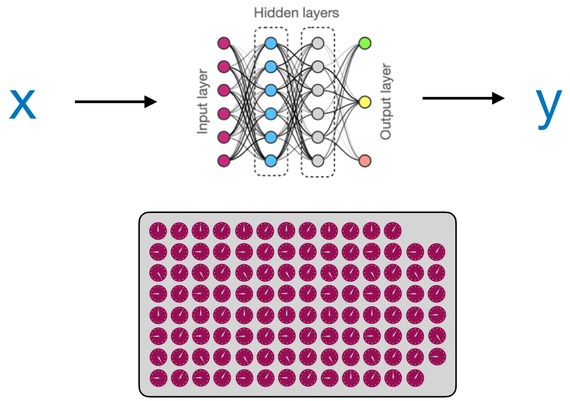
1.8 Trillion parameters

3D cycling model



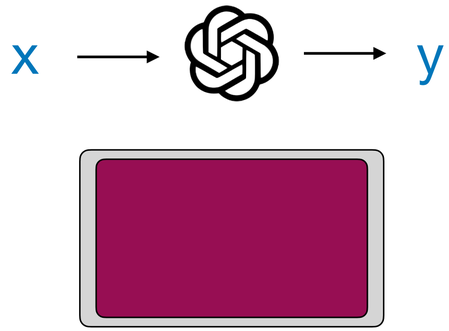
12 parameters

Oxynet CNN



200k parameters

GPT-4-turbo



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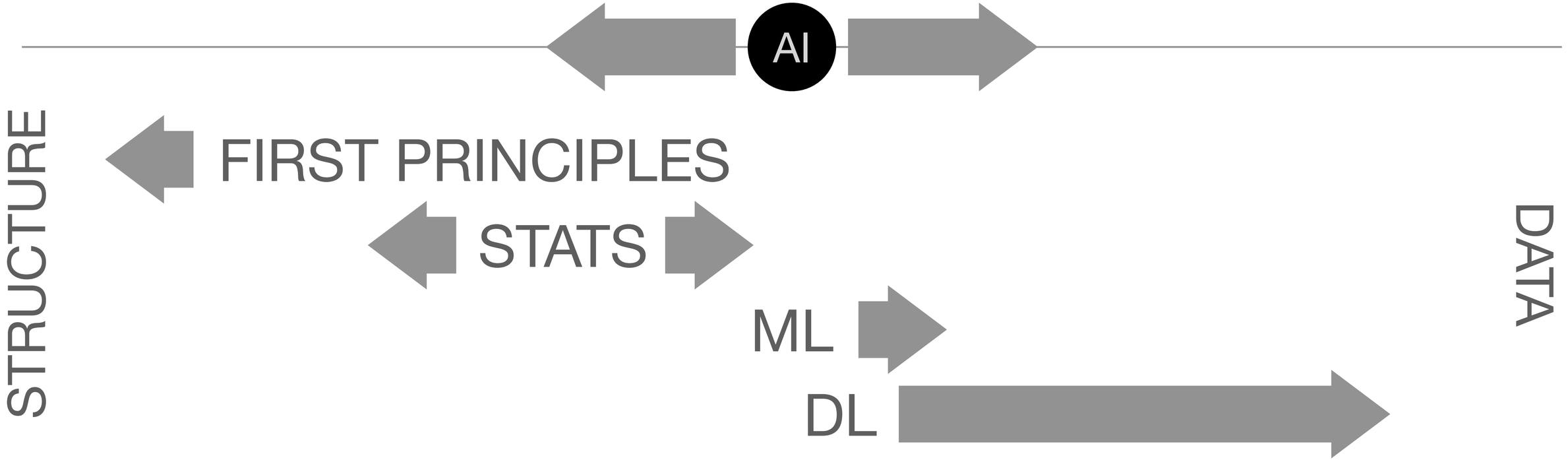

Am I using first principles or AI?
ML? Classic statistics or DL?
Is multi-linear regression ML or stats?

Am I using first principles or AI?
ML? Classic statistics or DL?
Is multi-linear regression ML or stats?

Where am I placing my assumptions?
On STRUCTURE or on DATA?

LAUSANNE 2026 ECSS

Thank you.

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tymewear

A. Zignoli, M.Eng, PhD
University of Trento, Trento, Italy - University of Verona, Verona, Italy
andrea.zignoli@unitn.it
andreazignoli.com