štúdium a dlhodobé stáže
v rámci programu ERASMUS+

Poď do sveta s ERASMUS+

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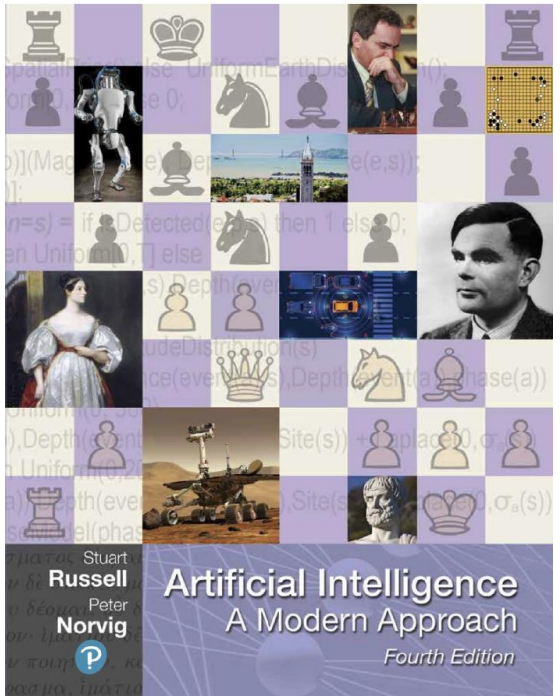
https://www.upjs.sk/erasmus-vyzvy-2026-2027/

Machine Learning

We say that a **computer program learns** from the experience described by **a training dataset** E given **a task set** T and a **performance measure** P if:

- its performance on the set T
- as measured by P
- improves based on E.



Samuel, A. (1959) Some studies in machine learning using the game of checkers, IBM J. Research and Development 3 (3): 210–229

Mitchell, T. M. (2007). Machine learning (Vol. 1). New York: McGraw-Hill Science.

How we can represent experience *E*?

Types of Data

Tabular Data

Signals

Images

Text

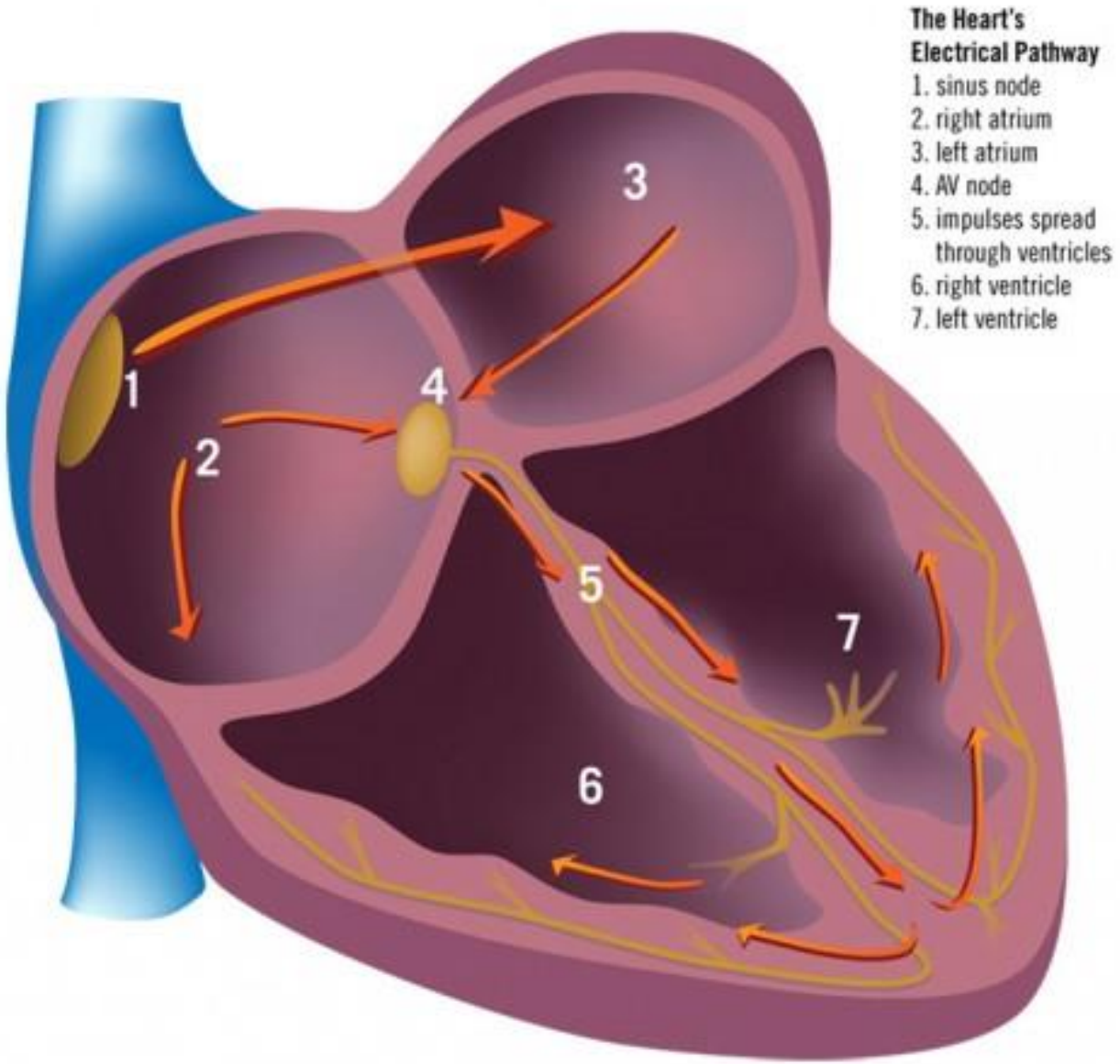
Text

Audio

Videos

How we can represent task *T*?

Heartbeat classification to 5 categories

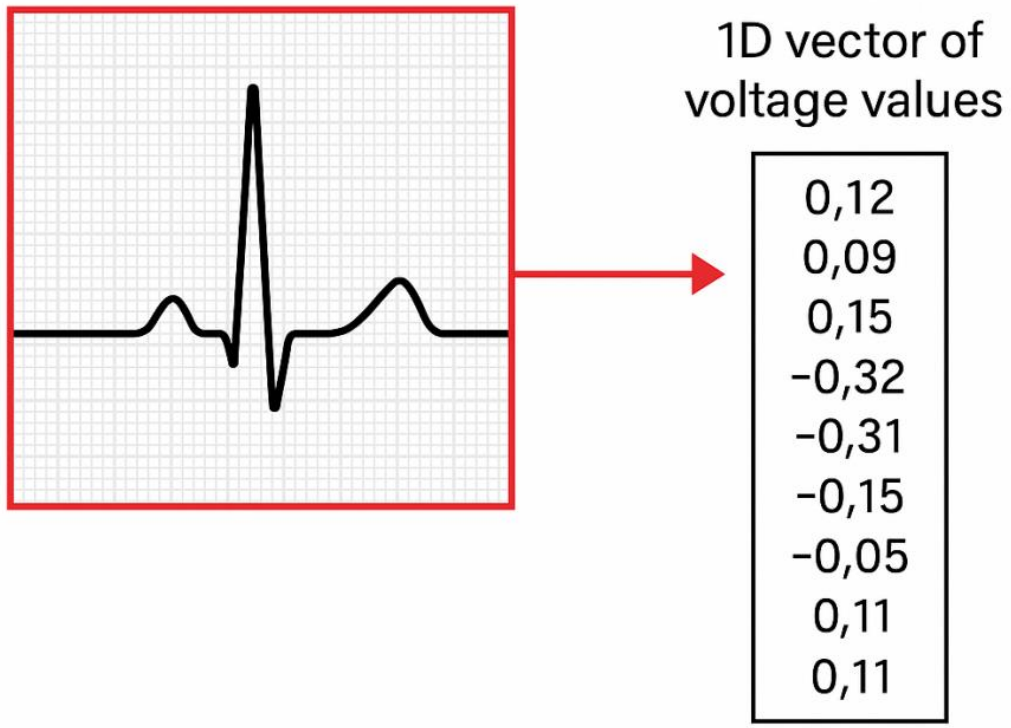


The **heartbeat** is controlled by an electrical signal.

An electrical impulse starts in the sinus node and spreads through the atria and ventricles, coordinating the heart's contraction and pumping of blood.

ECG recording

An **ECG (electrocardiogram) recording** is a measurement of the **electrical activity of the heart over time**.



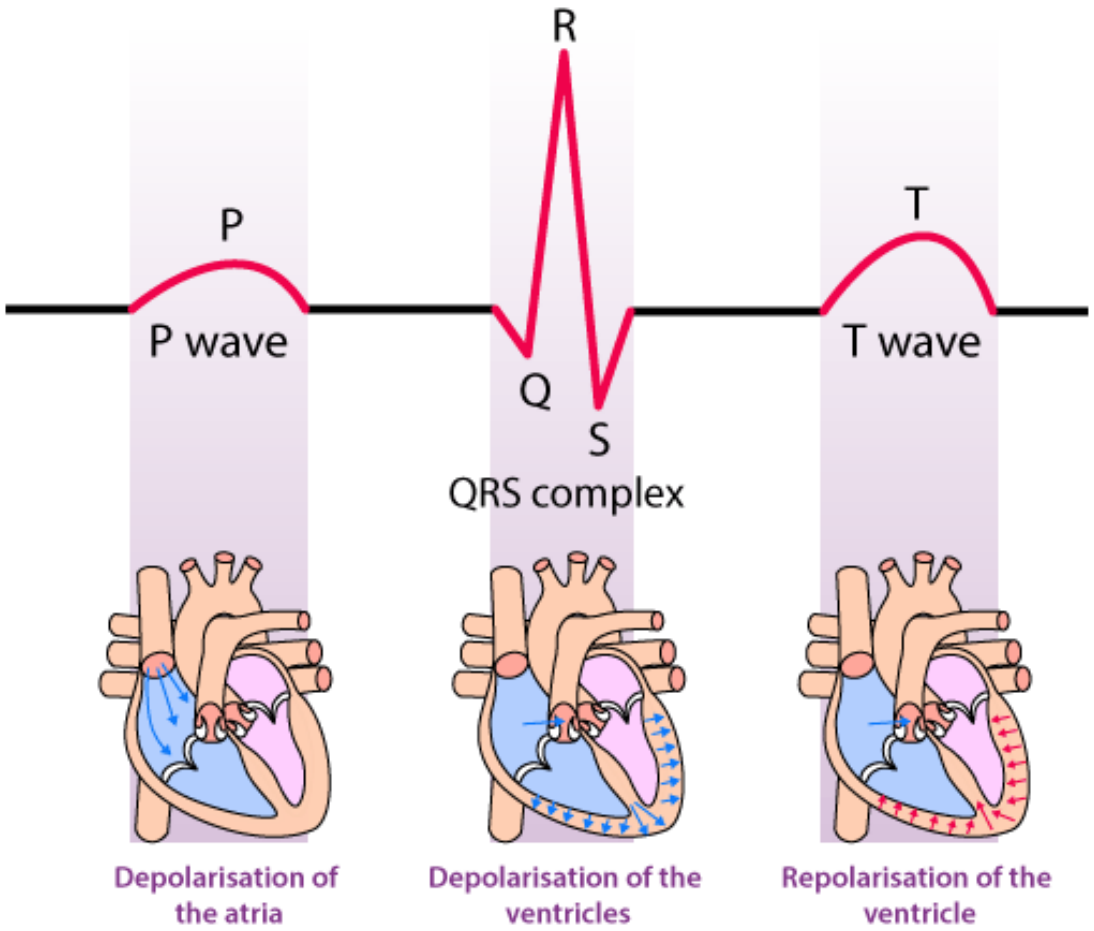
INPUT:

We can represent one lead of ECG recording by **1D vector of voltage values**.

How we can represent task *T*?

Heartbeat classification to 5 categories

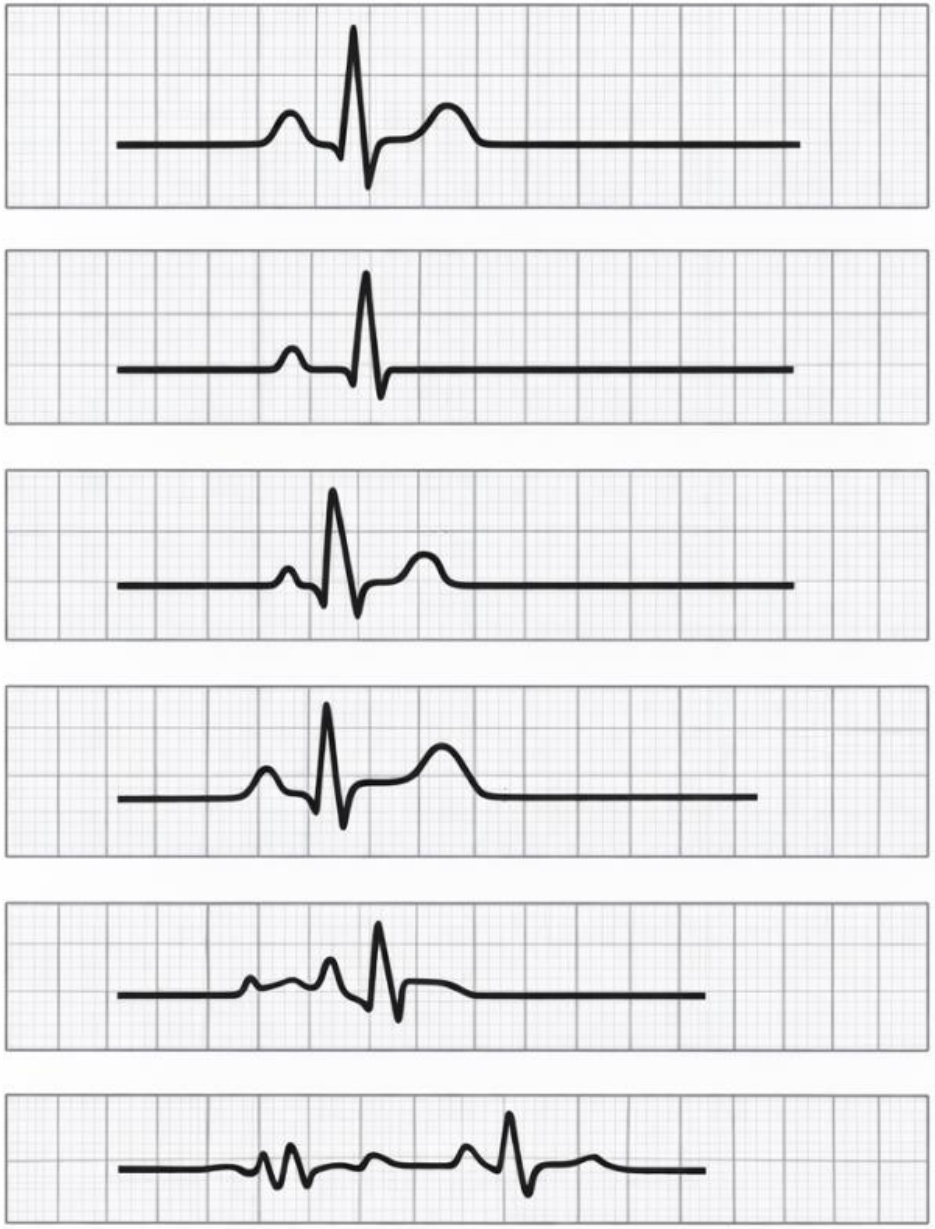
A **heartbeat** is one complete cycle of your heart **contracting and relaxing** to pump blood through your body.



Diastole: the heart muscle relaxes
The heart fills with blood again.

Systole: the heart muscle contracts
Blood is pumped out to the body and lungs.

Example of task: to train model of machine learning for classification of heatbeats to 5 different categories:



N (Normal):

- Regular rhythm, normal P wave,
- narrow QRS complex.

S (Premature AV Activation):

- Early beat from atria/AV node, usually narrow QRS, altered or hidden P wave.

P (Premature Ventricular Contraction):

- Early beat from ventricles, wide and abnormal QRS, no normal P wave.

F (Fusion Beat):

- Combination of normal and ventricular activation, mixed QRS morphology.

Q (Unclassified):

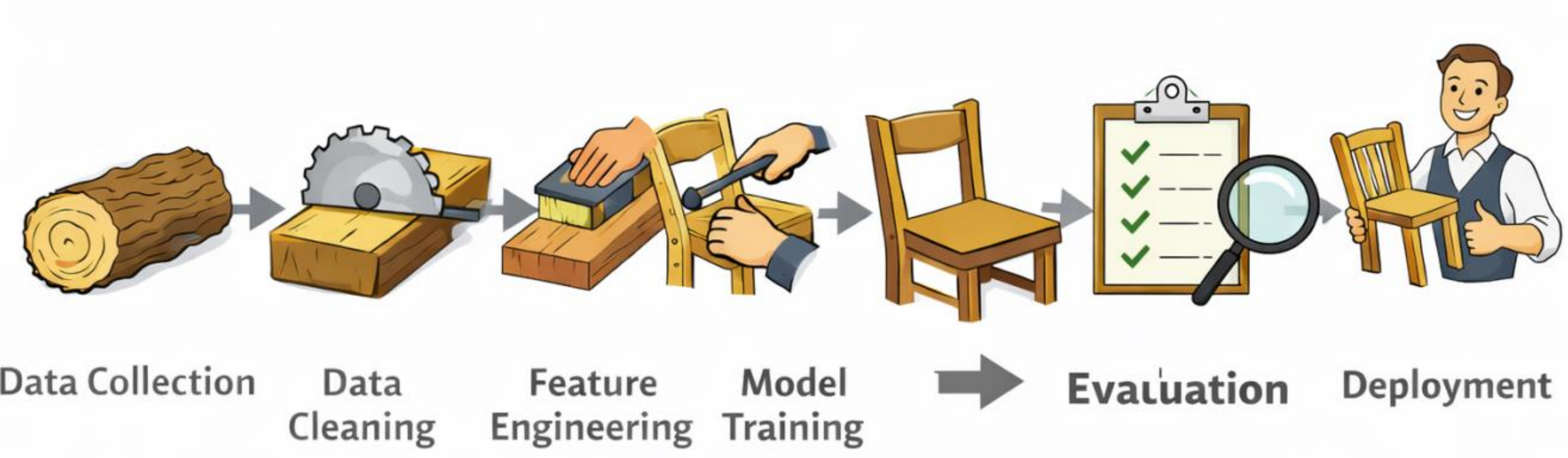
- Does not clearly fit other categories (atypical or noisy pattern).

How we can represent performance *P*?

Machine Learning Phases as Cooking

How we can represent performance *P*?

Machine Learning Phases as Woodworking

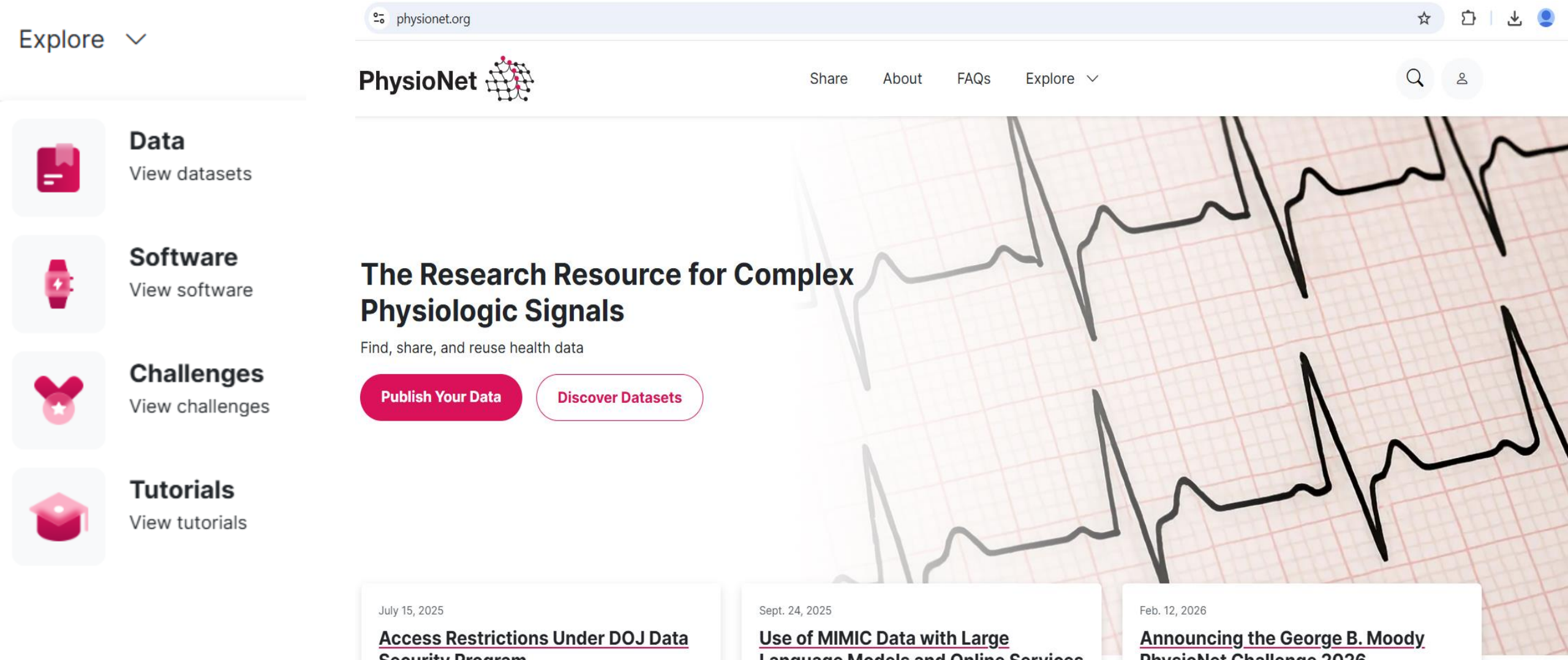


Why Biomedical Signal Analysis Matters

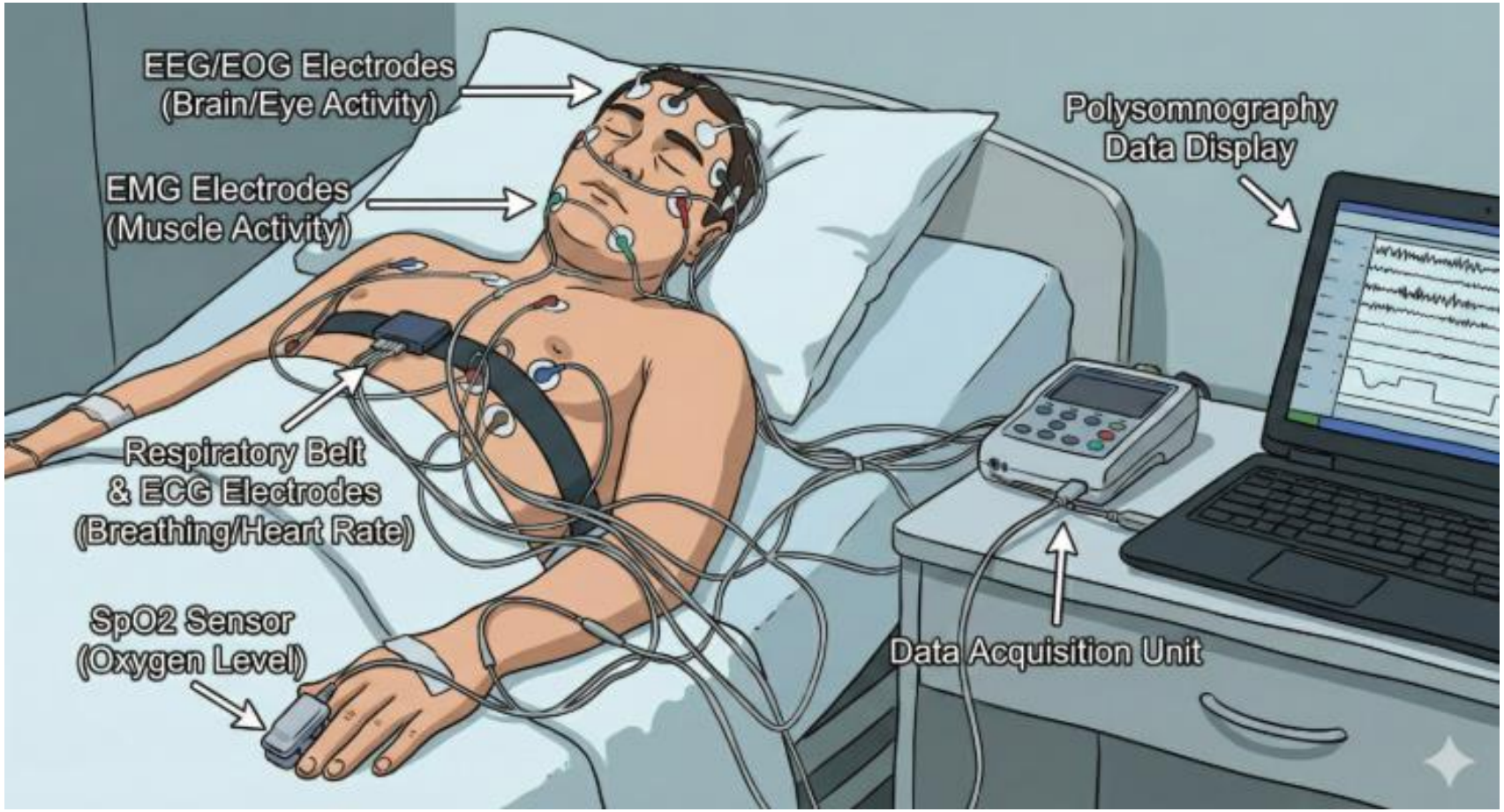
- Improving patient diagnosis and treatment
- Enabling early detection and prevention
- Advancing personalized medicine

Helping to improve healthcare and save lives

Platform: **physionet.org**



Bakalárska práca č. 1



Bakalárska práca č. 1

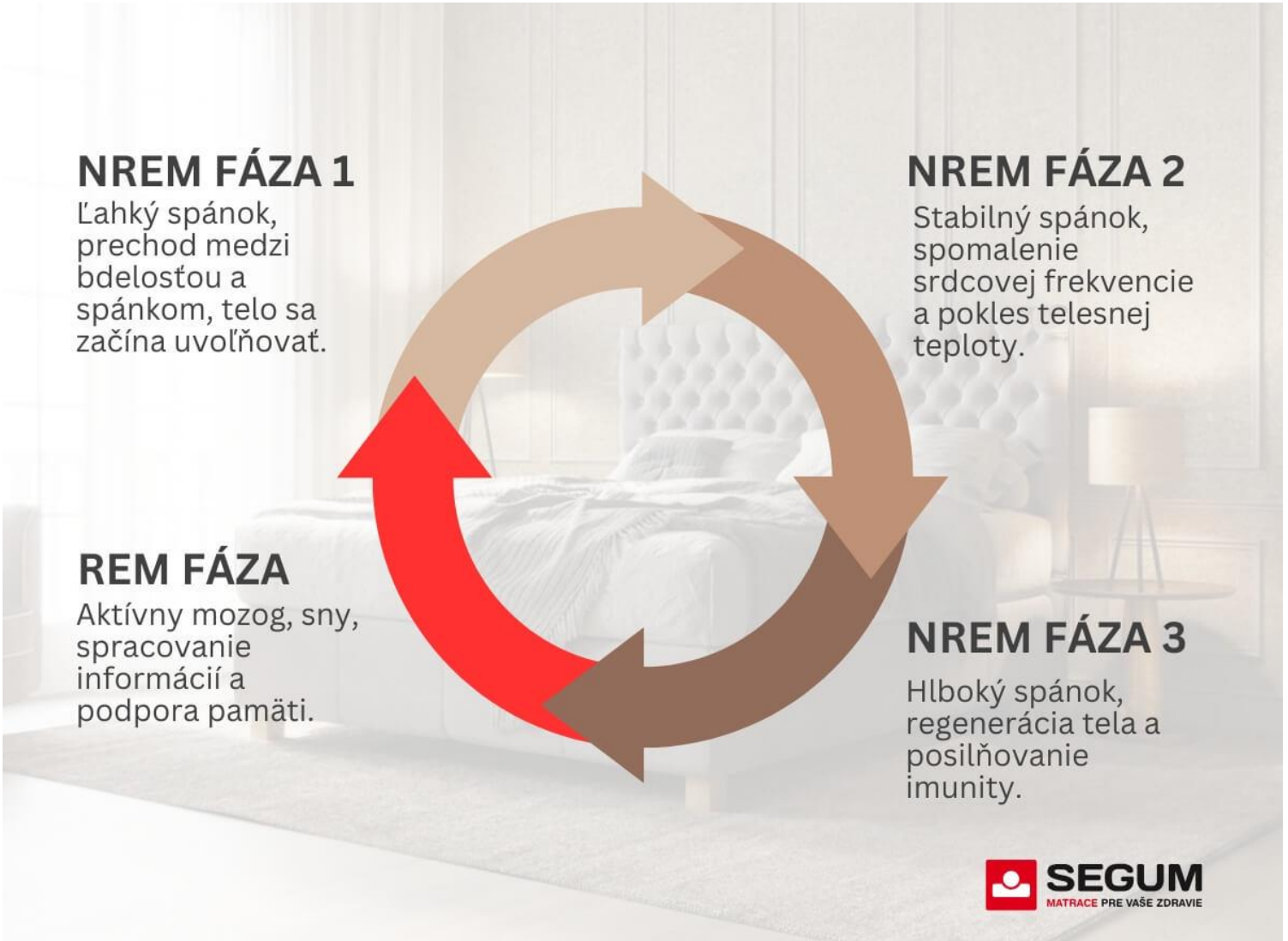
Strojové učenie pre včasnú detekciu kognitívneho poškodenia na základe klinických a fyziologických údajov
(Machine Learning for Early Detection of Cognitive Impairment from Clinical and Physiological Data)

- *Spracovať prehľad štruktúry a charakteristiky dát z PhysioNet Challenge 2026.*
- *Implementovať predspracovanie dát (normalizácia, chýbajúce hodnoty a podobne).*
- *Navrhnúť a porovnať viaceré klasifikačné modely strojového učenia (napríklad náhodné lesy, neurónové siete a iné) na skorú detekciu kognitívnej poruchy na základe multimodálnych klinických a fyziologických dát dostupných v rámci PhysioNet Challenge 2026.*
- *Vyhodnotiť modely pomocou metrík (AUC, F1-score, sensitivity, specificity) a porovnať dosiahnuté výsledky s inými štúdiami. Diskutovať klinickú interpretovateľnosť modelu a jeho potenciál pre reálnu prax.*

Literatúra:

- NASIRI, Samaneh, et al. CAISR: achieving human-level performance in automated sleep analysis across all clinical sleep metrics. *Sleep*, 2025, 48.8: zsaf134.
- Sun, H., et al. (2023). The Human Sleep Project (version 2.0). *Brain Data Science Platform*. https://doi.org/10.60508/qjbv-hg78.

Bakalárska práca č. 2



Bakalárska práca č. 2

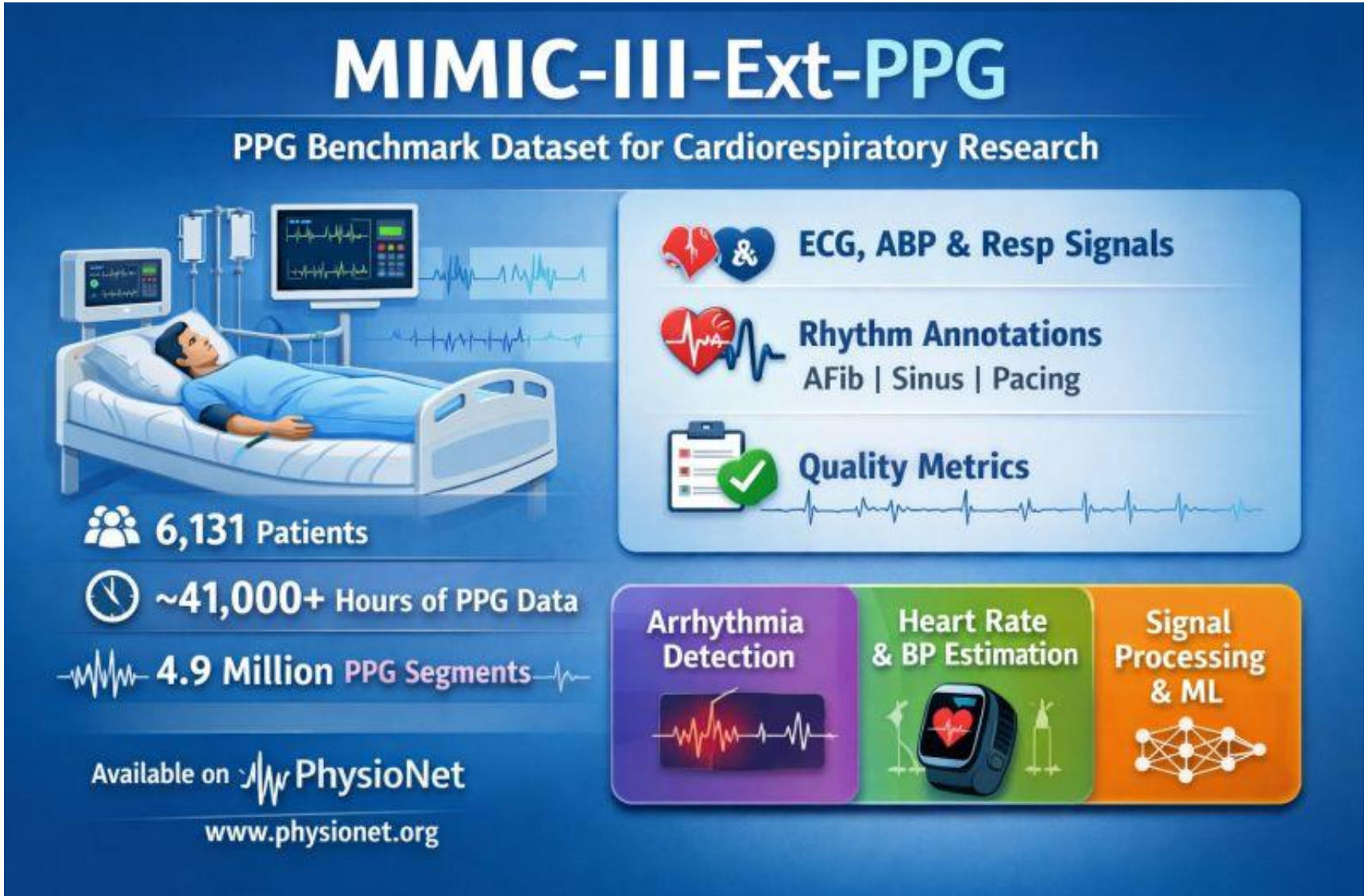
Klasifikácia štádií spánku s využitím EEG signálov a strojového učenia
(Sleep Stage Classification Using EEG Signals and Machine Learning)

- *Spracovať prehľad fyziológie spánku, jednotlivých spánkových fáz a výpočtových metód na ich klasifikáciu.*
- *Implementovať filtráciu a segmentáciu EEG signálu, extrahovať frekvenčné a časovo-frekvenčné príznaky (FFT, wavelets) z EEG signálov.*
- *Navrhnúť klasifikačný model (Random Forest / CNN / LSTM) na detekciu fáz spánku.*
- *Vyhodnotiť výkonnosť modelu v porovnaní s anotáciami expertov a inými štúdiami. Diskutovať využitie v domácich wearable zariadeniach.*

Literatúra:

- KEMP, Bob, et al. Sleep-edf database expanded. *Physionet org*, 2018.
- SEKKAL, Rym Nihel, et al. Automatic sleep stage classification: From classical machine learning methods to deep learning. Biomedical Signal Processing and Control, 2022, 77: 103751.

Bakalárska práca č. 3



Bakalárska práca č. 3

Strojové učenie pre predikciu klinického rizika s využitím databázy kritickej starostlivosti
(Machine Learning for Clinical Risk Prediction Using the Critical Care Database)

- *Spracovať prehľad štruktúry databázy MIMIC-IV (demografia, vitálne funkcie, laboratórne výsledky, liečba).*
- *Implementovať predspracovanie klinických dát (časové agregácie, riešenie chýbajúcich hodnôt) a navrhnúť feature engineering pre časovo závislé dáta.*
- *Implementovať a porovnať vybrané klasifikačné modely (Logistic Regression, Random Forest, XGBoost, Neural Network) na predikciu klinického rizika (napr. sepsa, readmisia na JIS).*
- *Vyhodnotiť model pomocou klinicky relevantných metrík (AUC, sensitivity, calibration) a porovnať dosiahnuté výsledky s inými štúdiami, diskutovať interpretovateľnosť modelu (feature importance).*

Literatúra:

- MINCHOLÉ, Ana, et al. Machine learning in the electrocardiogram. Journal of electrocardiology, 2019, 57: S61-S64.
- JOHNSON, Alistair EW, et al. MIMIC-IV, a freely accessible electronic health record dataset. Scientific data, 2023, 10.1: 1.
- NA, Yeongyeon, et al. Guiding masked representation learning to capture spatio-temporal relationship of electrocardiogram. ICLR 2024.

The proposed bachelor thesis allow students:

to work with real clinical data,

apply modern AI methods,

and contribute to solutions that may directly improve healthcare and save lives.

VSL software

Regular meetings
on Friday 1.00 pm – 2.30 pm
(present or online)

PAVOL JOZEF ŠAFÁRIK UNIVERSITY
IN KOŠICE

Thank you for your attention

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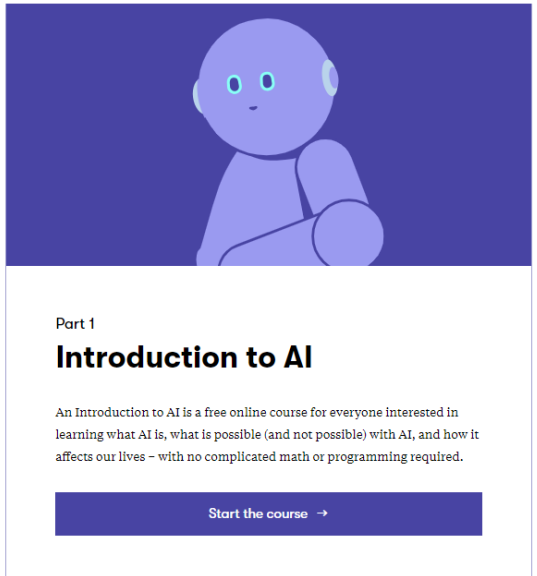


Part 1

Introduction to AI

An Introduction to AI is a free online course for everyone interested in learning what AI is, what is possible (and not possible) with AI, and how it affects our lives – with no complicated math or programming required.

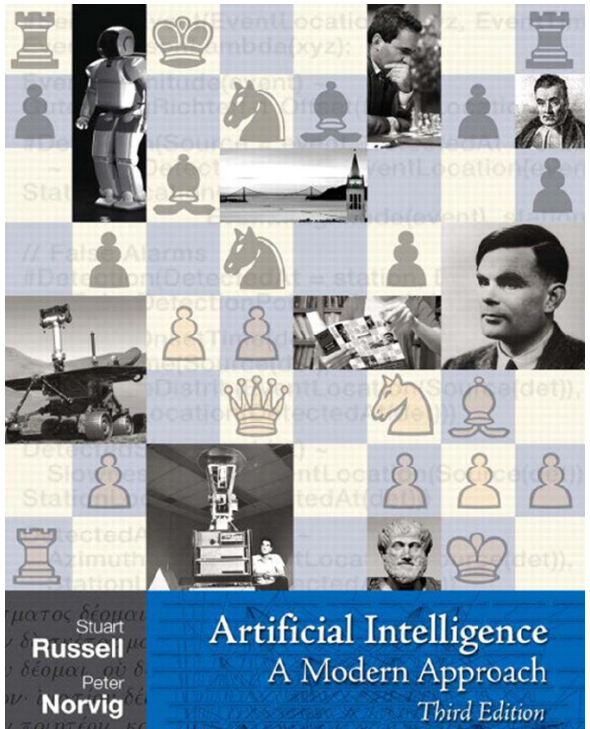
Start the course →

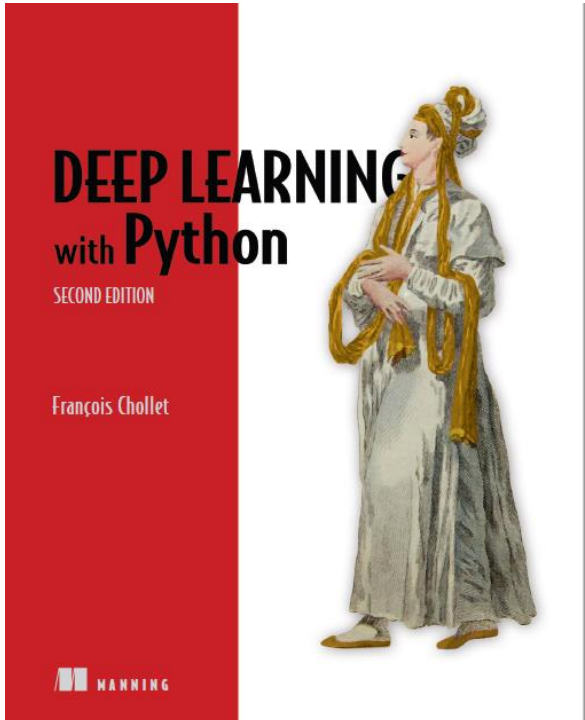
Part 2

Building AI

Building AI is a free online course where you'll learn about the actual algorithms that make creating AI methods possible. Some basic Python programming skills are recommended to get the most out of the course.

Start the course →





An introduction to Machine Learning Methods in Physics

Gaetano Salina
INFN Tor Vergata