Dijagnoza srčane insuficijencije primenom mašinskog i dubokog učenja

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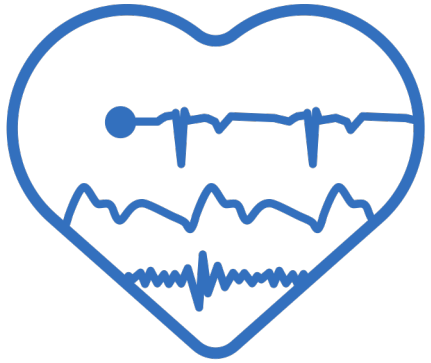


SensSmart
Program Ideje

Fond za nauku
Republike Srbije

VI (ni)je samo MU/DU

Veštačka inteligencija

- Planiranje i pretraga
- Meta-heuristike
- Zadovoljavanje ograničenja
- Ekspertski sistemi
  - Logičko rezonovanje
  - Bayesove mreže

Mašinsko učenje

- Stabla
- SVM
- RF
- XGBoost

Duboko učenje

- NN, CNN, RNN
- Transformer

MYCIN

- Dijagnoza bakterijskih infekcija i preporučivanje antibiotika
- Stanford, 1970e
- Baza od ~600 pravila

IF: 1) The gram stain of the organism is gramneg, and
2) The morpholcgy of the organism is rod, and
3) The aerobicity of the organism is anaerobic
THEN: There is suggestive evidence (.6) that the identity of the organism is bacteroides

- Zaključivanje formalnom logikom

B. Buchanan, E. Shortliffe. Rule based expert systems: the Mycin experiments of the Stanford heuristic programming project, 1984.

MYCIN

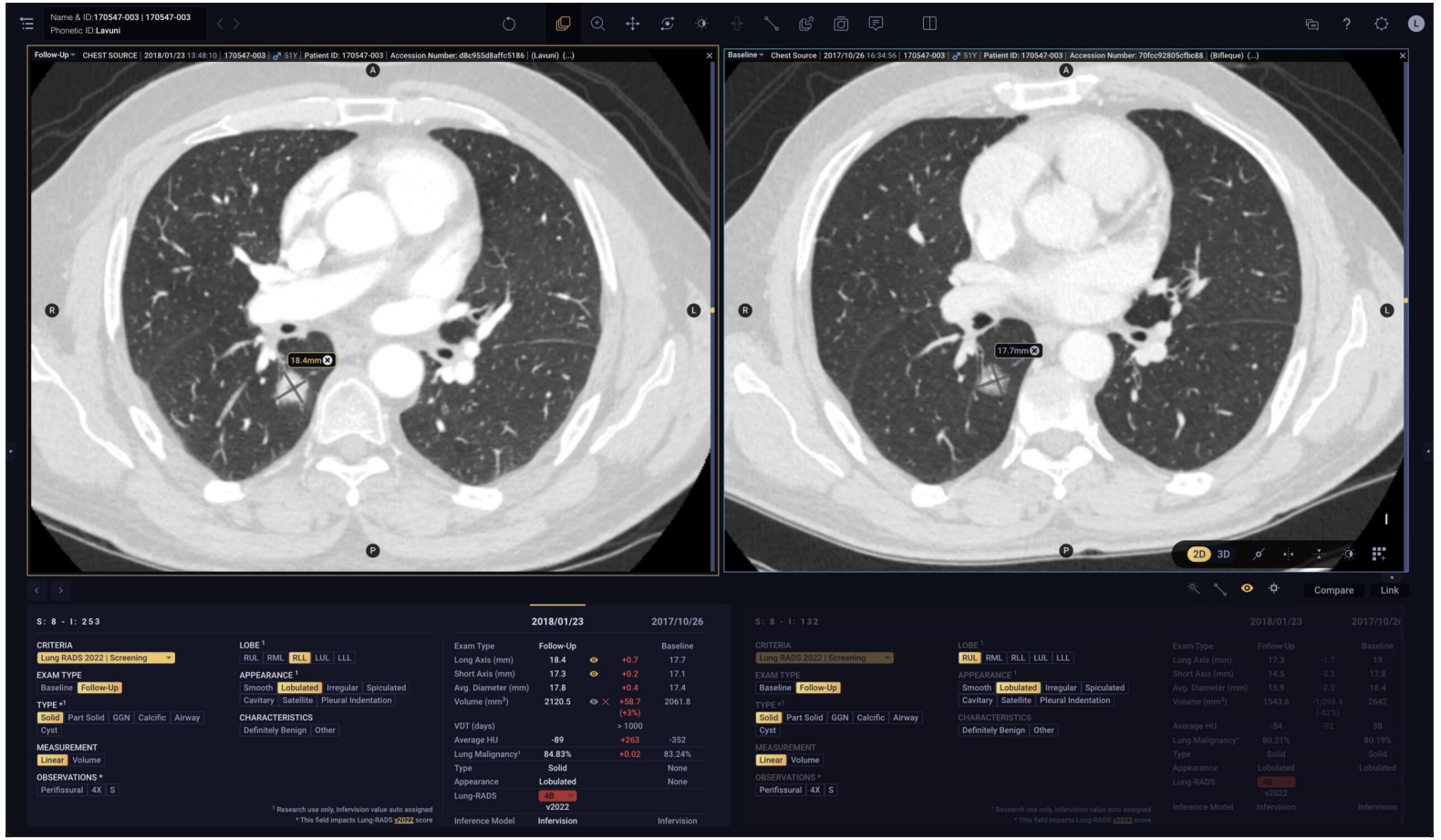
- Tačnost ~65% (bolje od stažista, lošije od eksperata)
- Objašnjivost
- Tehnološke prepreke
- Etičke i pravne prepreke
- (Ne)mogućnost uključivanja novih saznanja

B. Buchanan, E. Shortliffe. Rule based expert systems: the Mycin experiments of the Stanford heuristic programming project, 1984.

Arterys / Tempus Radiology

- Prvi DU sistem odobren za kliničku upotrebu od US FDA, 2017
- Danas deo Tempus Radiology
- CardioAI: srčana ejakciona frakcija na osnovu MRI srca u par sekundi
- Analiza medicinskih slika jetre, pluća…

Nodule na CT snimcima pluća



www.tempus.com/radiology/tempus-pixel-lung/

Lezije u mamografskim snimcima

www.tempus.com/radiology/tempus-pixel-breast/

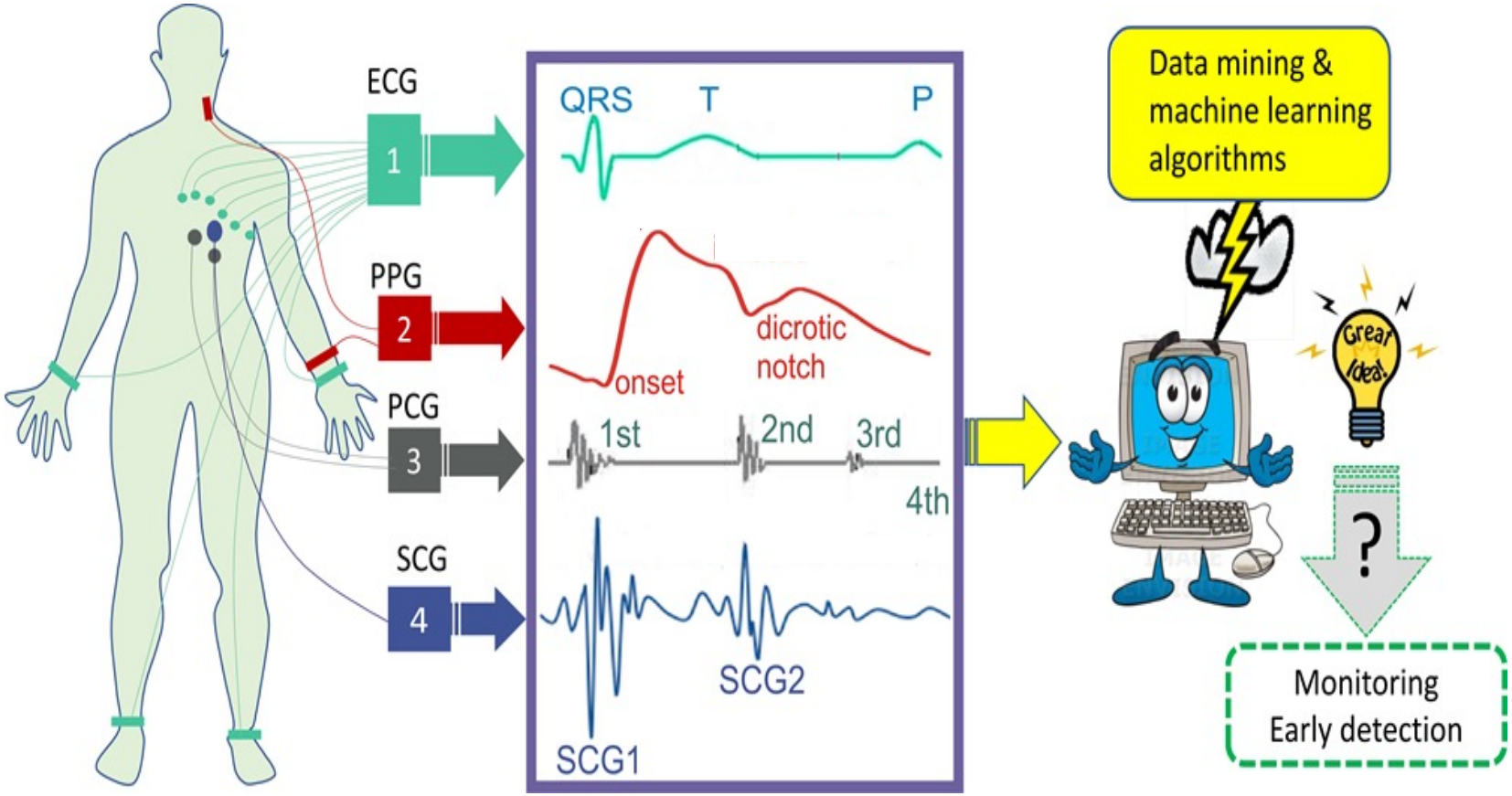
Projekat SensSmart

- Cilj: rana detekcija srčane insuficijencije
  - Nemogućnost srca da pumpa dovoljnu količinu krvi
  - Vodeći uzrok hospitalizacije i readmisije u starijoj populaciji
  - Pogađa 2% odrasle populacije, a 10% populacije iznad 70 godina
  - Rizik od smrti u prvoj godini posle dijagnoze je 35%

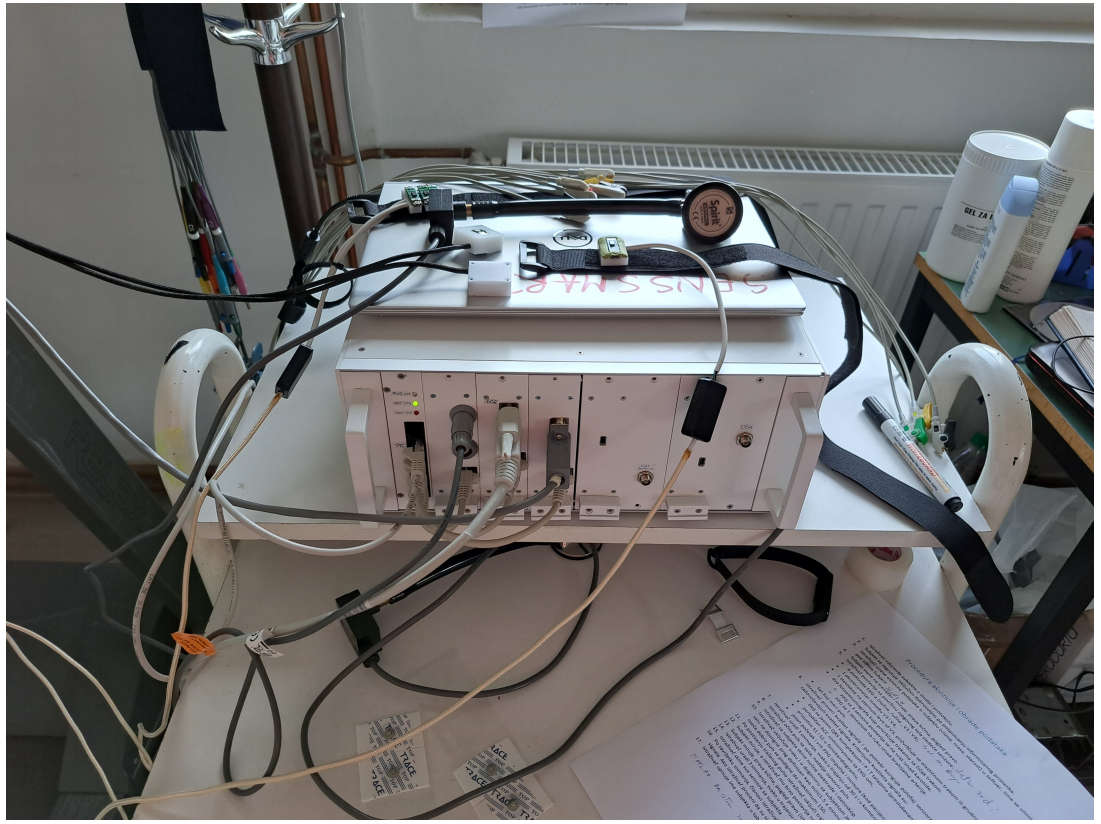
Projekat SensSmart

- Cilj: rana detekcija srčane insuficijencije
- Zlatni standard: ehokardiografija
- Metodologija: polikardiograf + mašinsko/duboko učenje
- Učesnici: Univerzitet u Beogradu
  - Institut za nuklearne nauke Vinča
  - Medicinski fakultet
  - Elektrotehnički fakultet
- April 2022 -> April 2025
- Fond za nauku Republike Srbije (Program IDEJE)

SensSmart: osnovna ideja

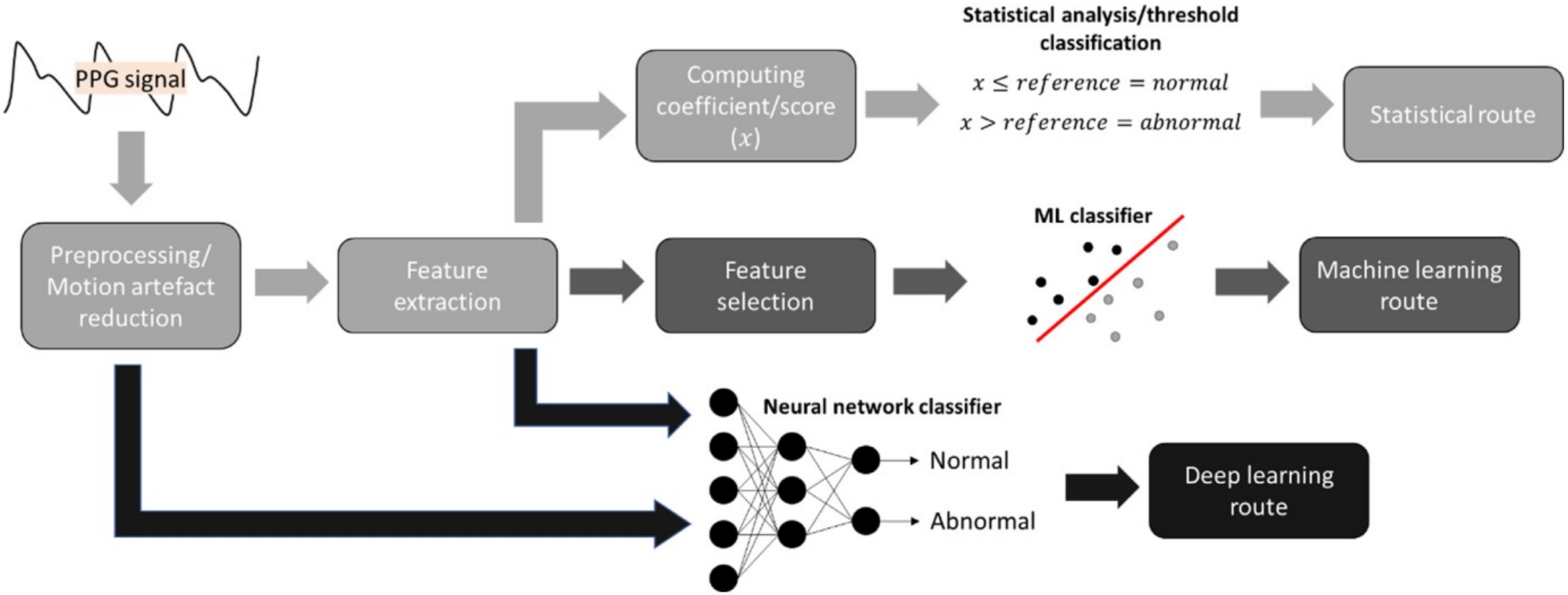


Polikardiograf



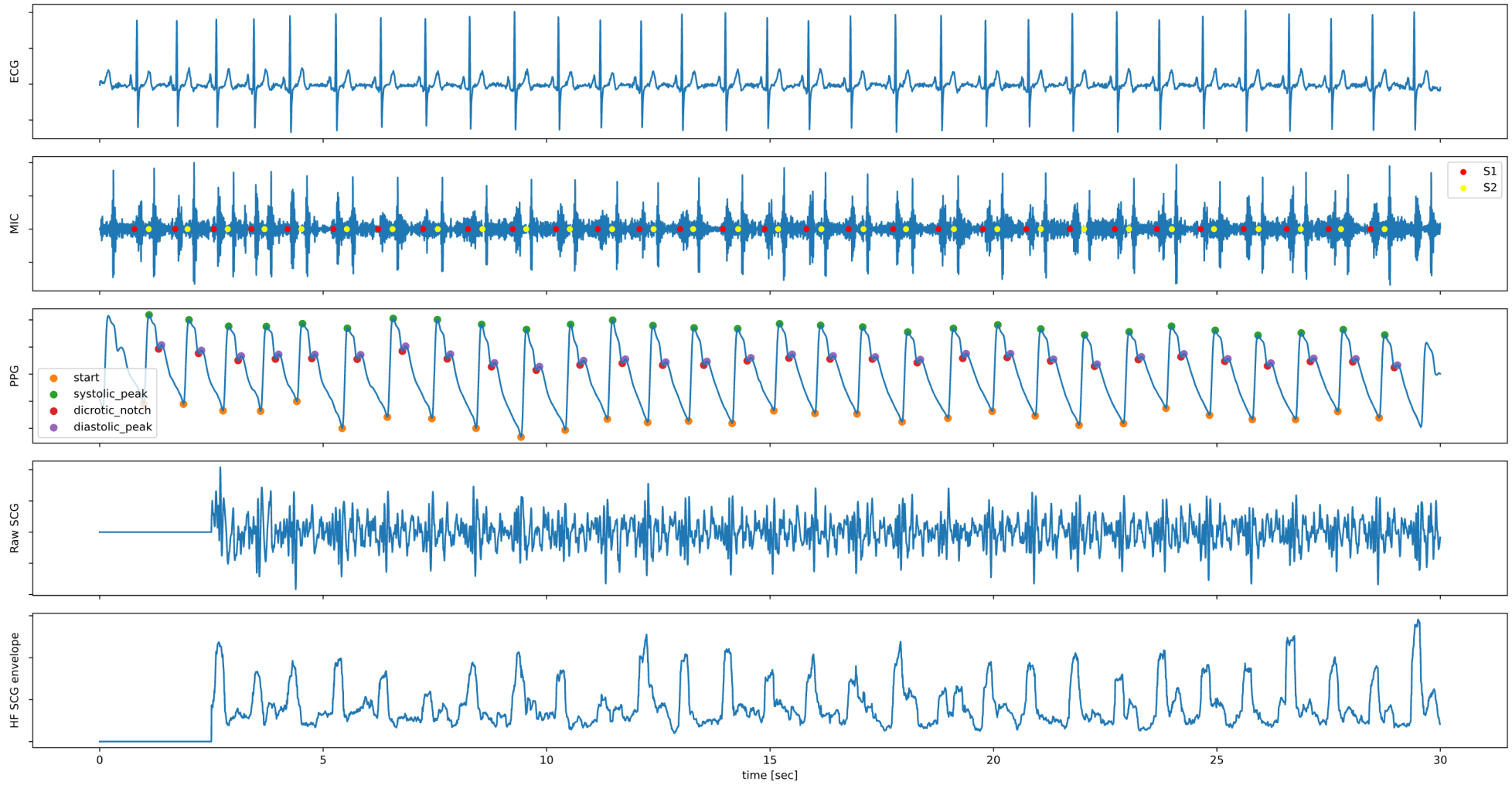
A. Lazović et al. “Multiparameter monitoring of cardiovascular function”, ICCBIKG 2023

Mašinsko/duboko učenje

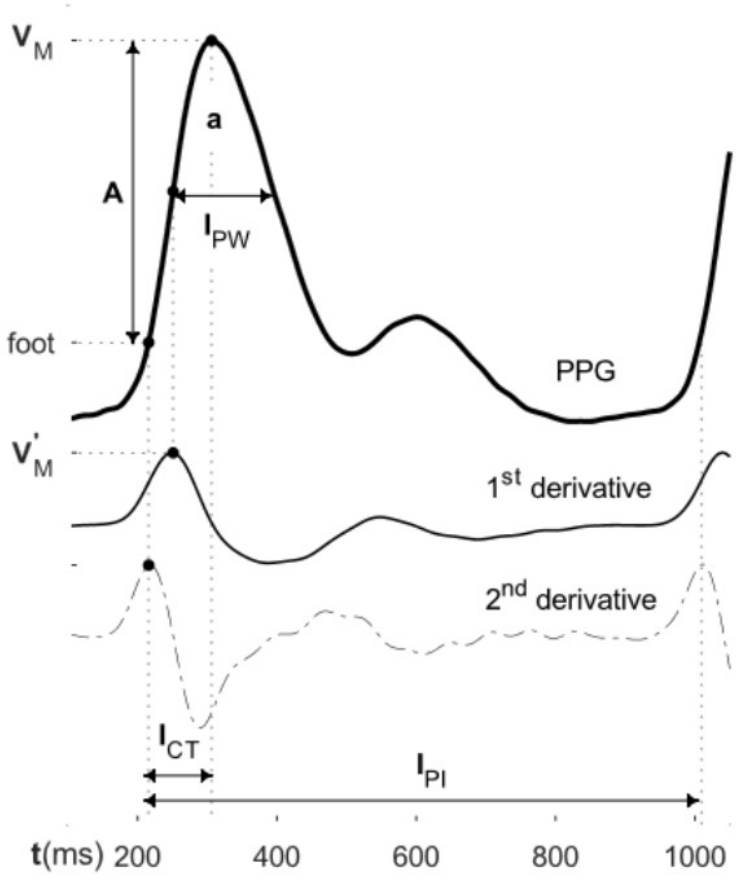


H. W. Loh et al. "Application of photoplethysmography signals for healthcare systems: An in-depth review.", 2022

Stvarna merenja: SensSmartTech studija



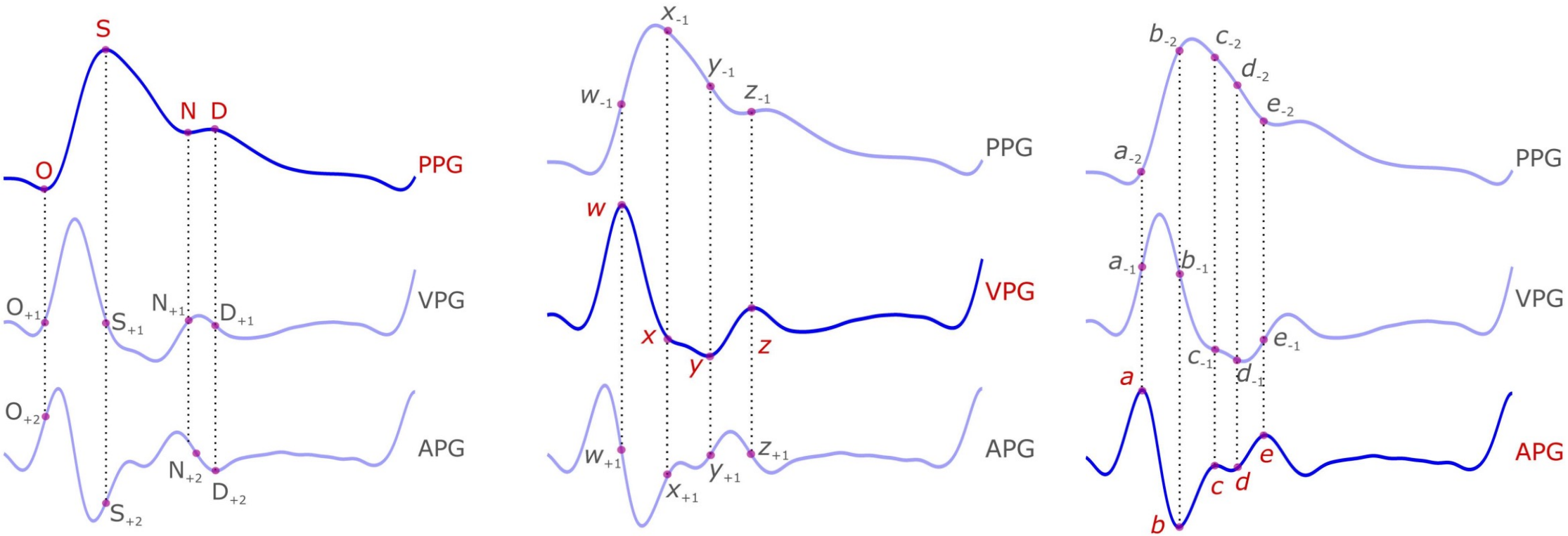
Odlike dobijene iz PPG signala



PPG Pulse Indices – Description	X_n
Pulse peak – absolute maximum value of the PPG pulse.	$V_M = max_{t \in I_{PI}}(PPG(t))$
First derivative peak – the maximum value of the first derivative of the PPG pulse.	$V'_M = max_{t \in I_{PI}}\left(\frac{dPPG(t)}{dt}\right)$
Amplitude – Difference between the PPG pulse peak and foot (foot is the value of the PPG pulse at the second derivative peak)	$A = V_M - PPG(t_{foot})$; t_{foot} is at $max_{t \in I_{PI}}\left(\frac{d^2PPG(t)}{dt^2}\right)$
Area – The sum of the values for which the PPG pulse was greater or equal to the value of maximum slope.	$a = \sum_{I_{PW}} PPG(t)$
Pulse Mean – The mean value of the PPG over the pulse interval.	$\bar{V} = \frac{\left(\sum_{I_{PI}} PPG(t)\right)}{I_{PI}}$
Pulse Interval – Time interval between the maximum of the second derivative of PPG in two consecutive pulses.	$I_{PI} = \left(t_{foot(n)} : t_{foot(n+1)}\right)$; n is the beat number
Pulse Width – Time interval for which the PPG pulse was greater or equal to the value of maximum slope.	$I_{PW} = t\left\{PPG(t) > PPG\left(t_{V'_M}\right)\right\}$
Crest Time – Time interval between the second derivative peak (V''_M) and pulse peak (V_M)	$I_{CT} = \left(t_{foot} : t_{V_M}\right)$

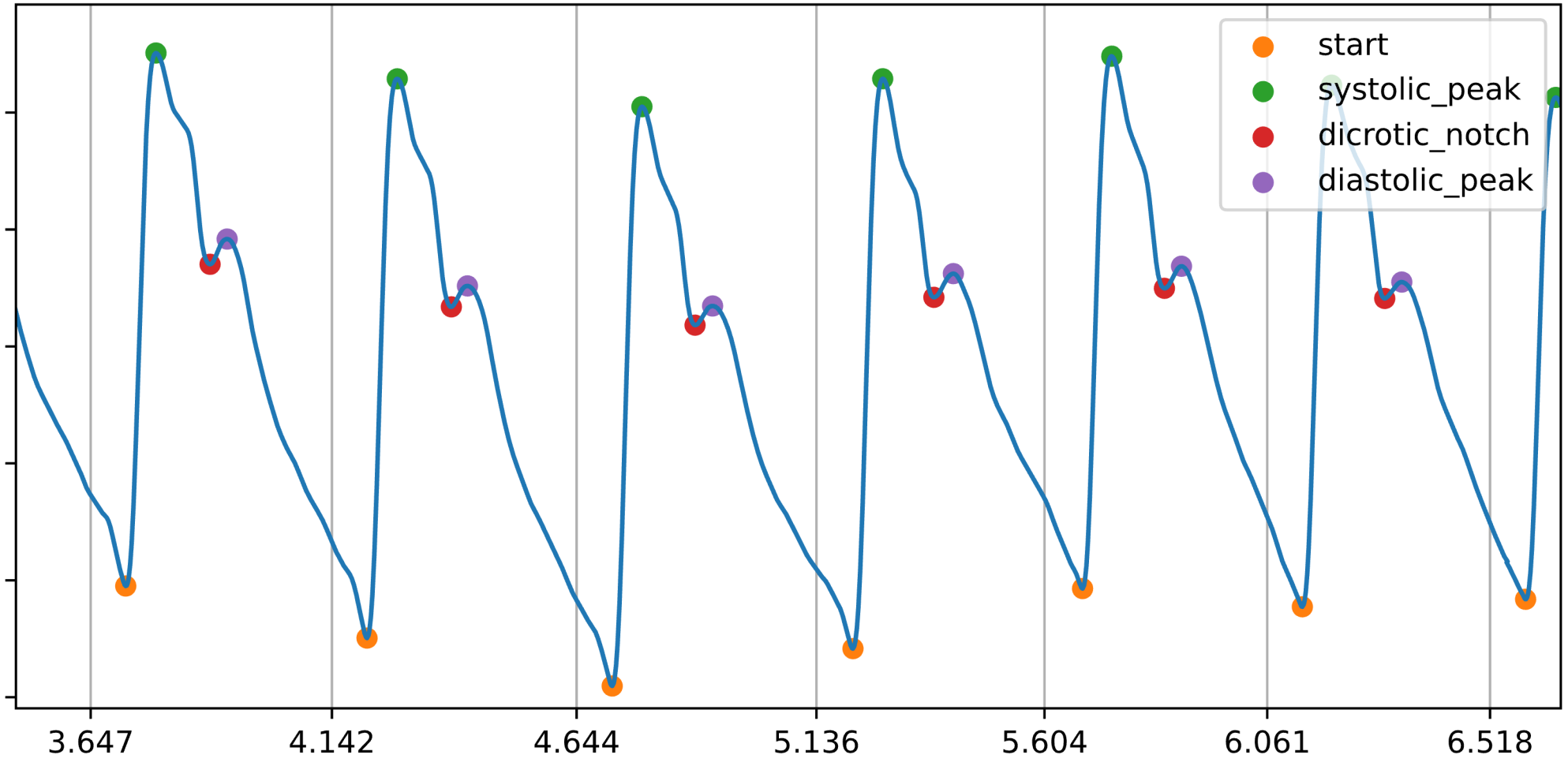
T. Besleaga et al. "Non-invasive detection of mechanical alternans utilizing photoplethysmography", 2018

Odlike dobijene iz PPG signala

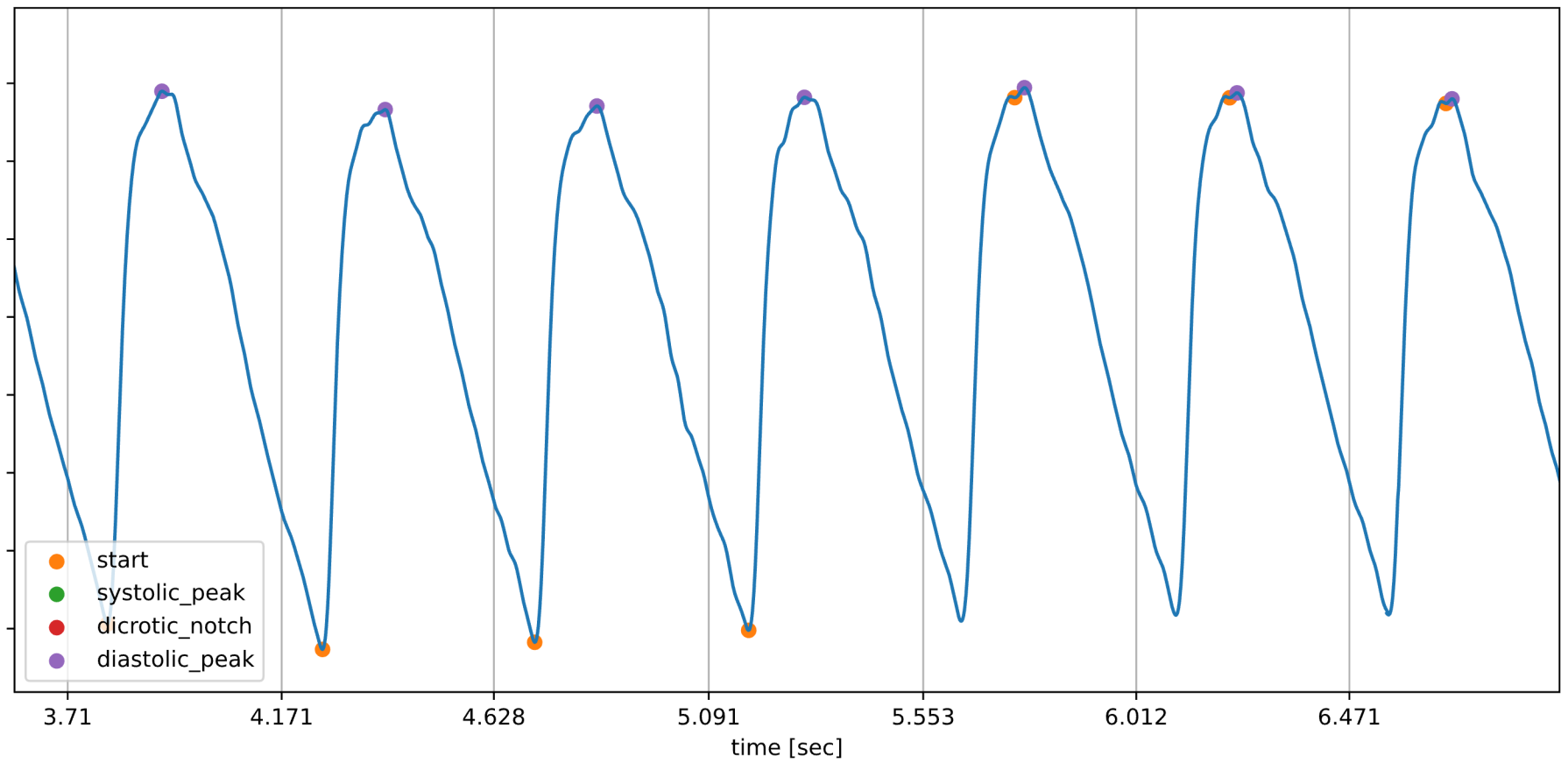


M. Elgendi et al. "Toward generating more diagnostic features from photoplethysmogram waveforms.“, 2018

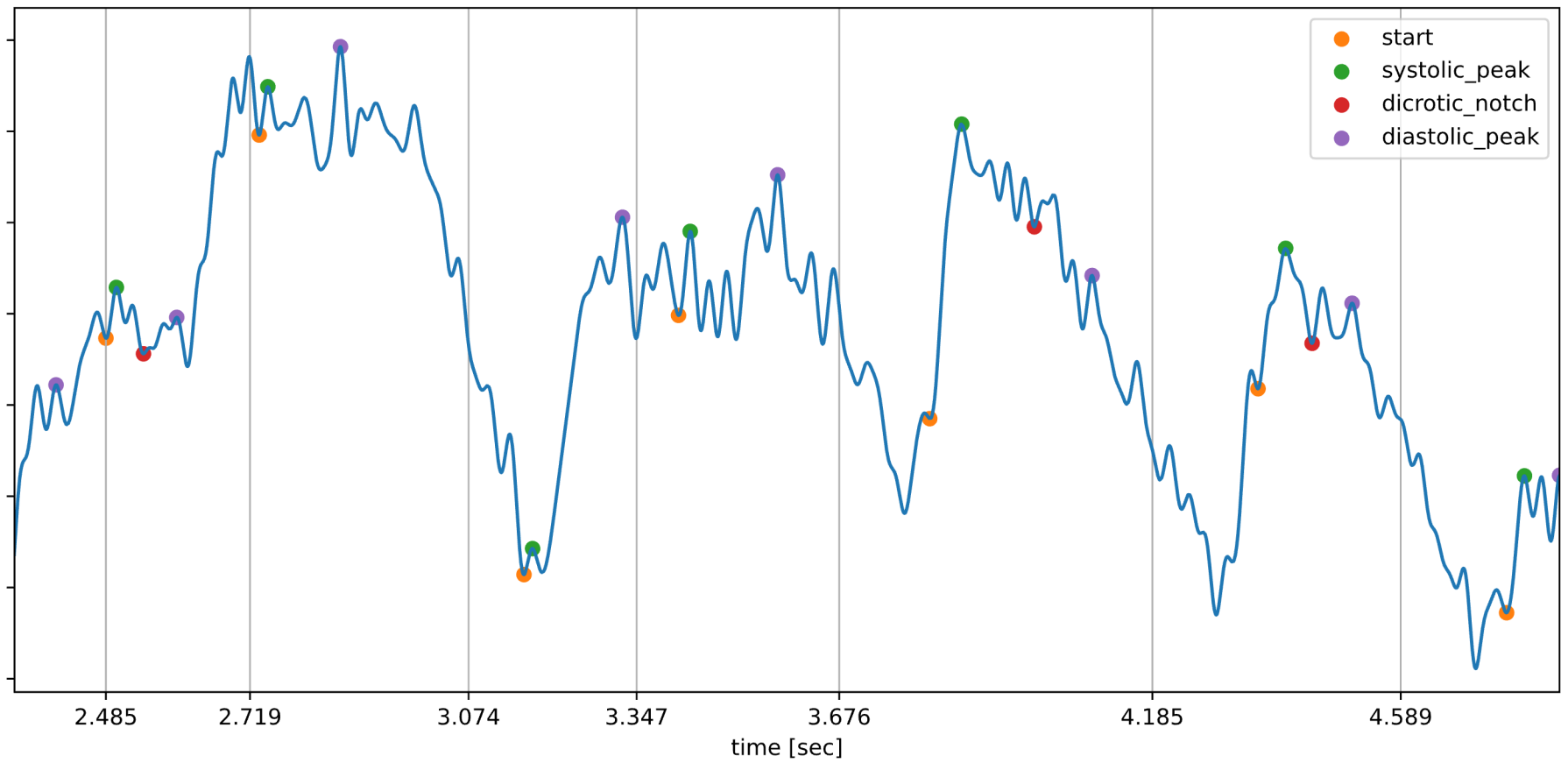
Stvarni PPG signali



Stvarni PPG signali

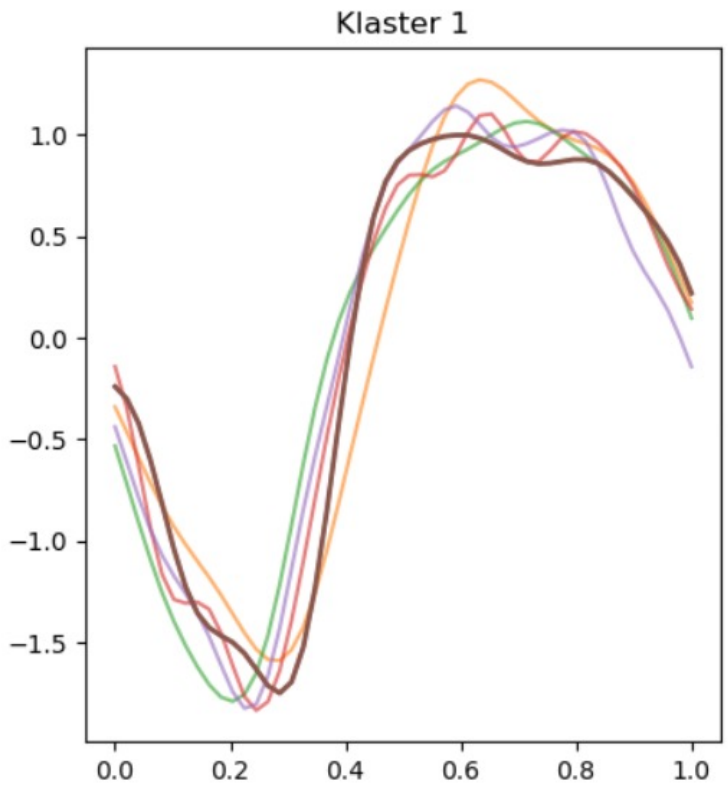


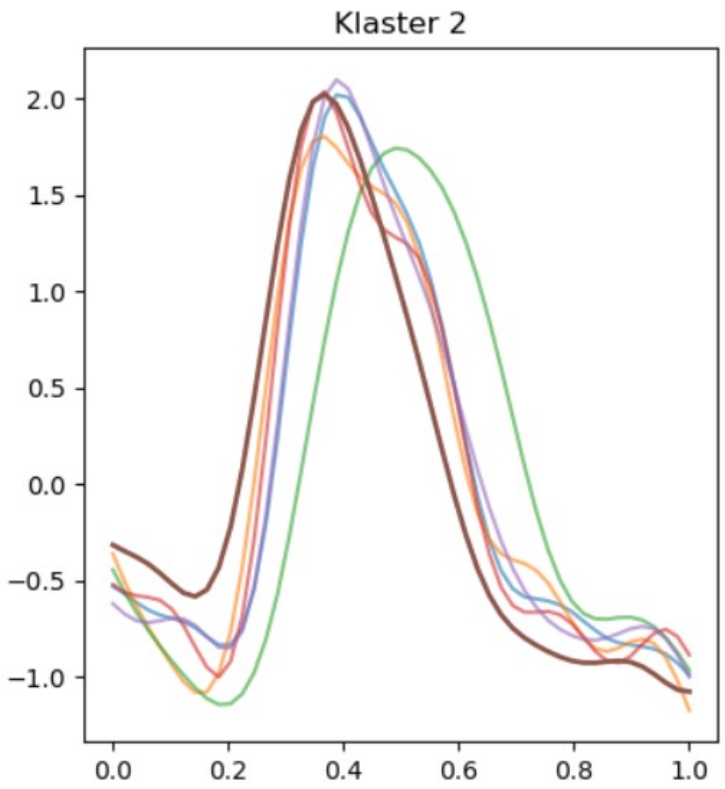
Stvarni PPG signali

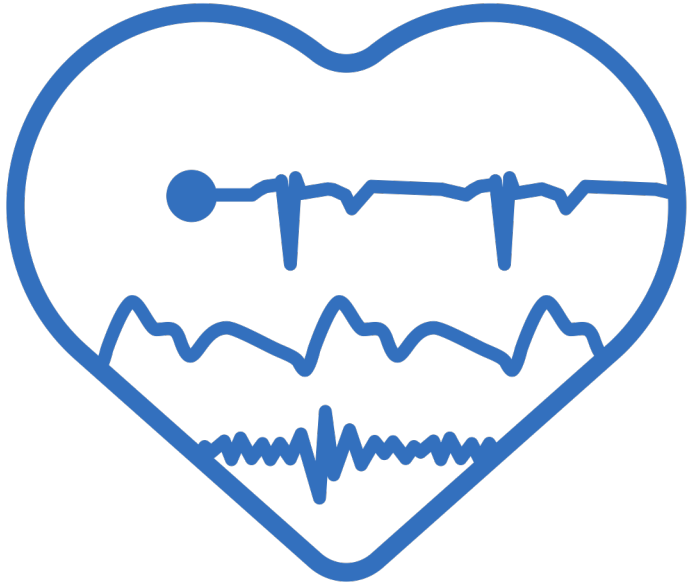


Klasterizacija oblika PPG signala

- Podela u klastere
- Anotacija centroida
- k-means + DTW
- RR-intervali







SENSSMART

IDEAS, Science Fund

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