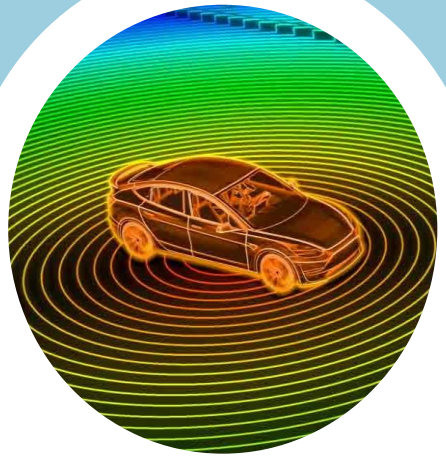
# Detekcija prisutnosti ljudi u Wi-Fi polju pomoću strojnog učenja

Tonka Hrboka

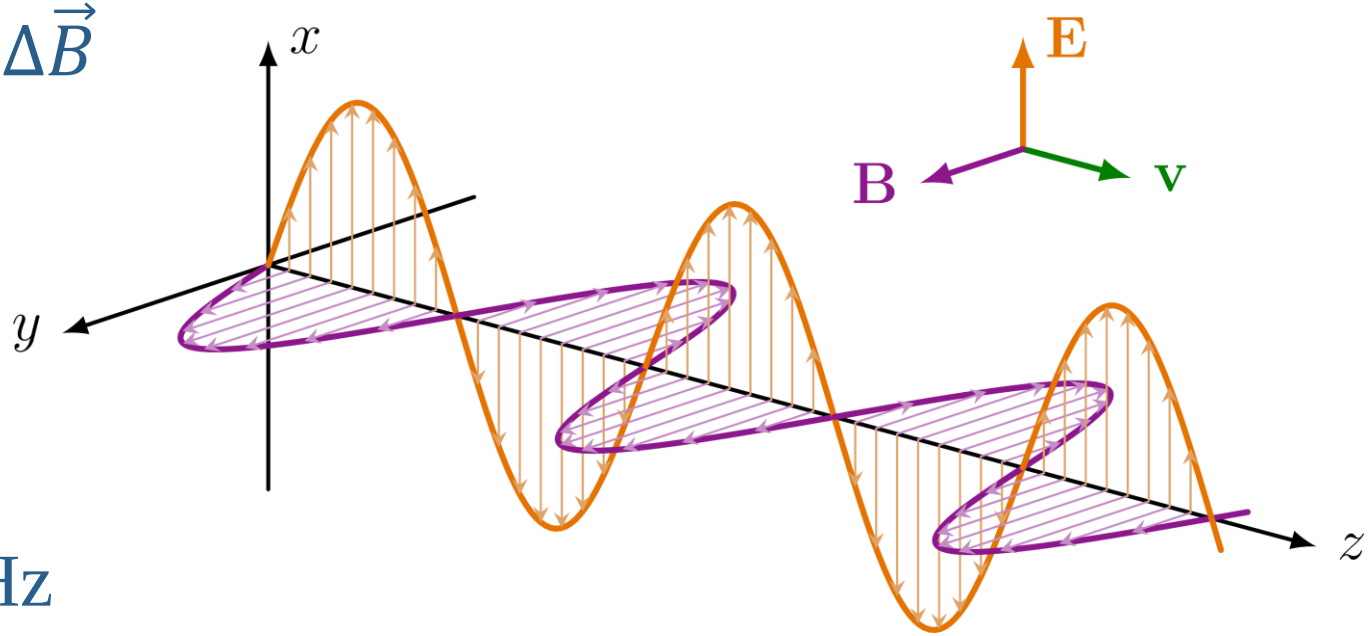
# Detekcija predmeta



# Wi-Fi polje

$$\epsilon\mu\partial_t^2\vec{E} = \Delta\vec{E}$$

$$\epsilon\mu\partial_t^2\vec{B} = \Delta\vec{B}$$

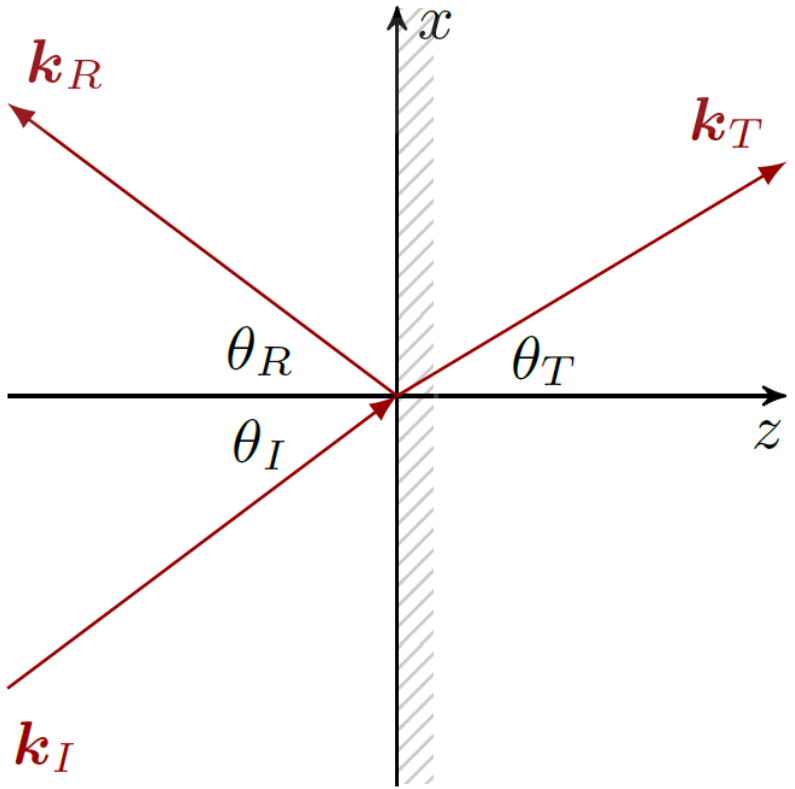



f = 2.4 GHz

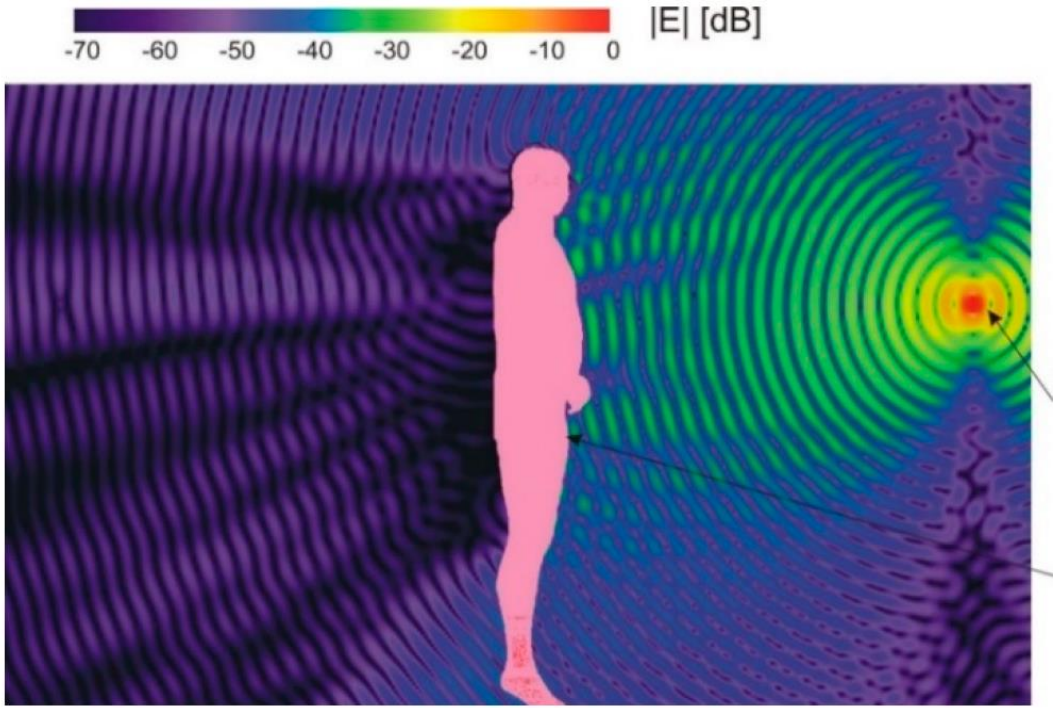
# Snellov zakon

$$\frac{\sin\theta_I}{\sin\theta_T} = \frac{n_T}{n_I}$$

$$n = \sqrt{\epsilon_r \mu_r}$$

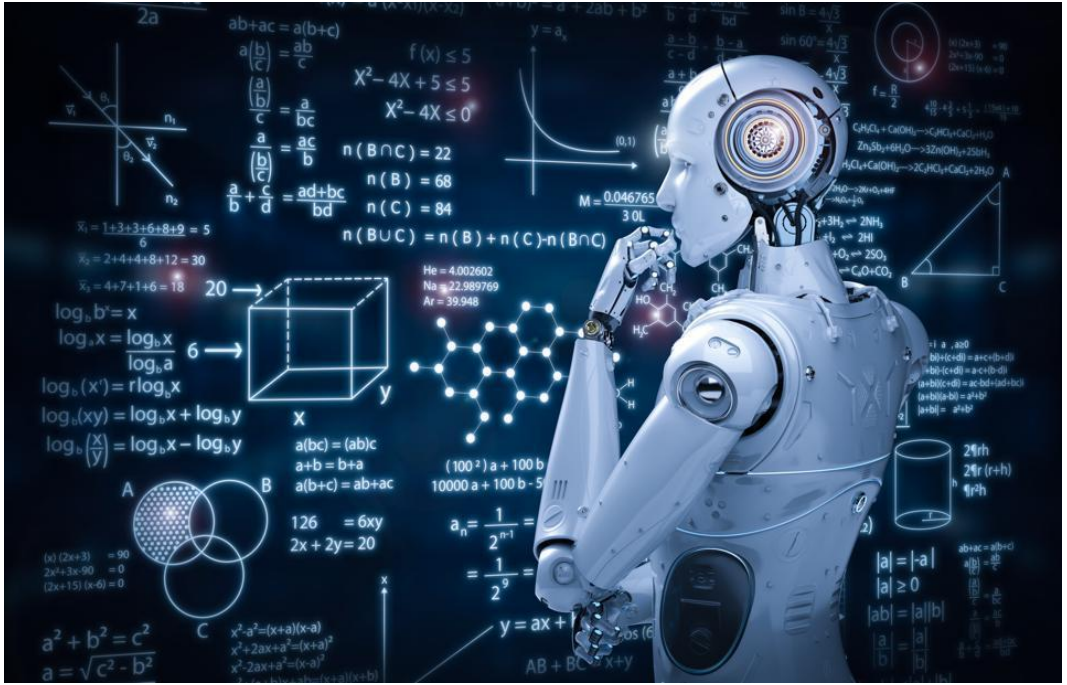


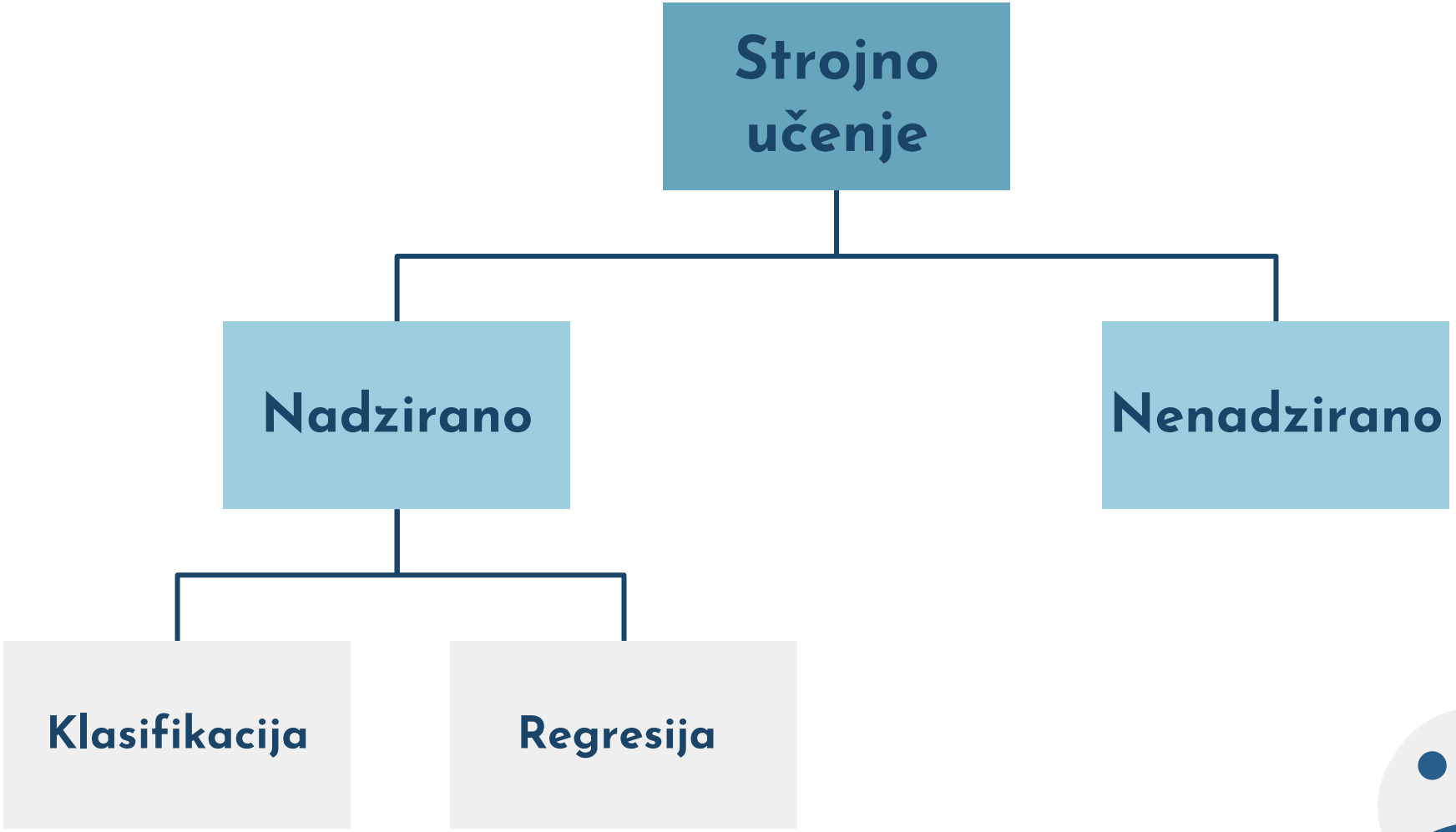
# Wi-Fi polje i ljudsko tijelo



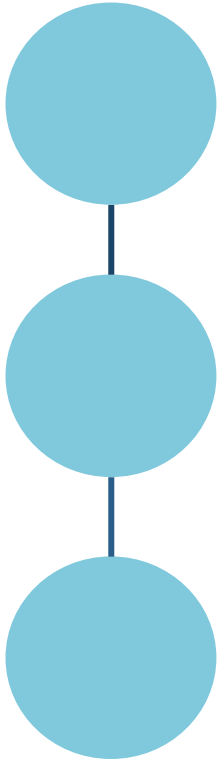
# Strojno učenje

- automatska detekcija značajnih uzoraka u podatcima




Strojno učenje
Nadzirano
Nenadzirano
Klasifikacija
Regresija

# Komponente algoritma strojnog učenja

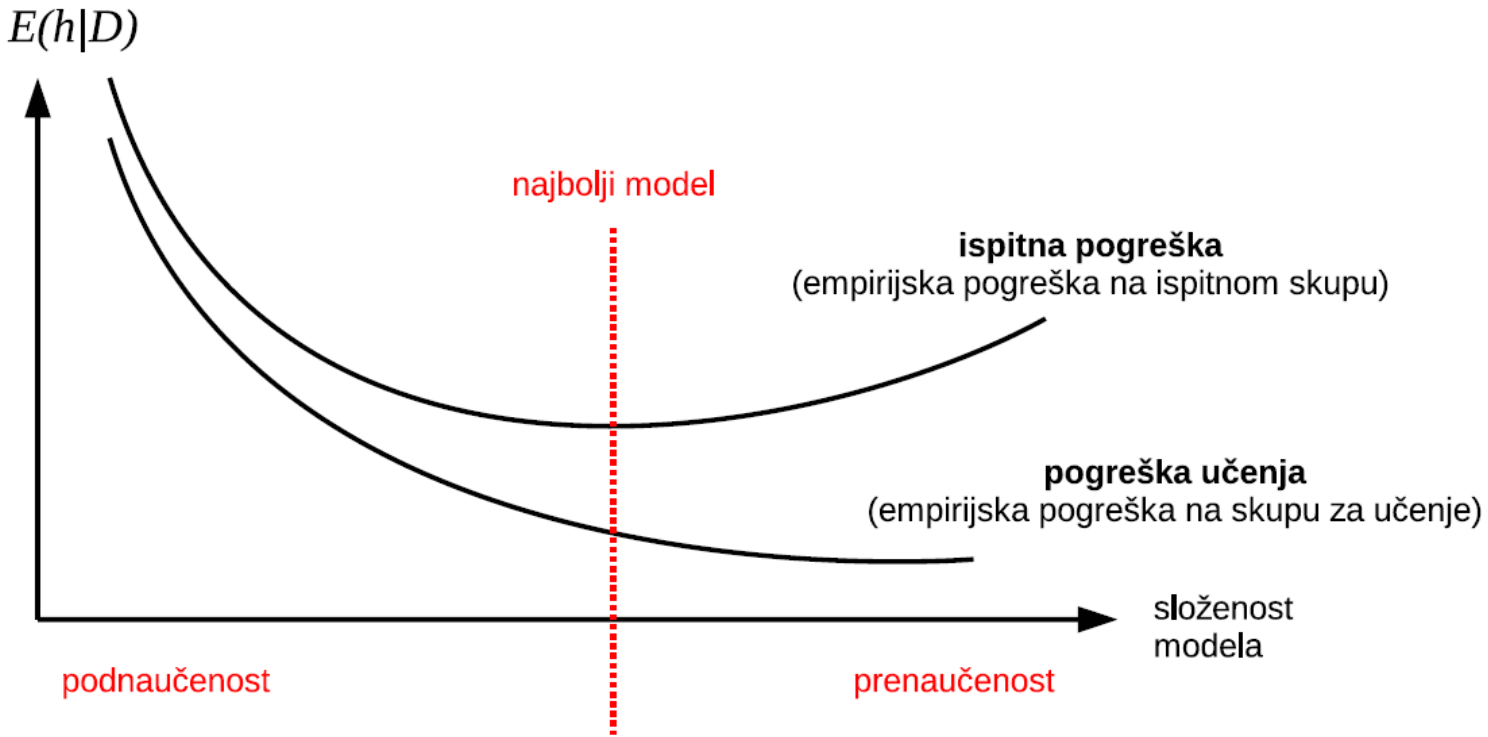


Model

Funkcija pogreške

Optimizacija

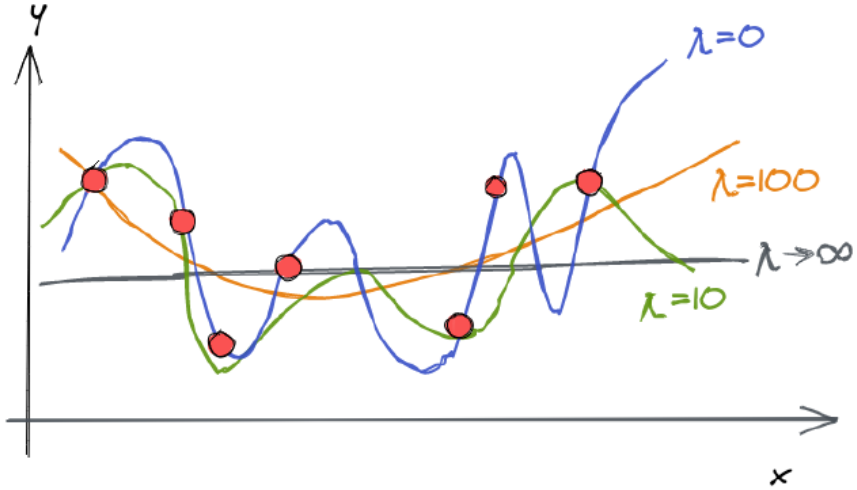
# Optimalni model




Unakrsna provjera

# Regularizacija

$$\|\overrightarrow{w}\|_p = \left( \sum_{j=1}^{m} |w_j|^p \right)^{\frac{1}{p}}$$




- p = 1 ⟶ L1 - Lasso
- p = 2 ⟶ L2 - Ridge

# Logistička regresija

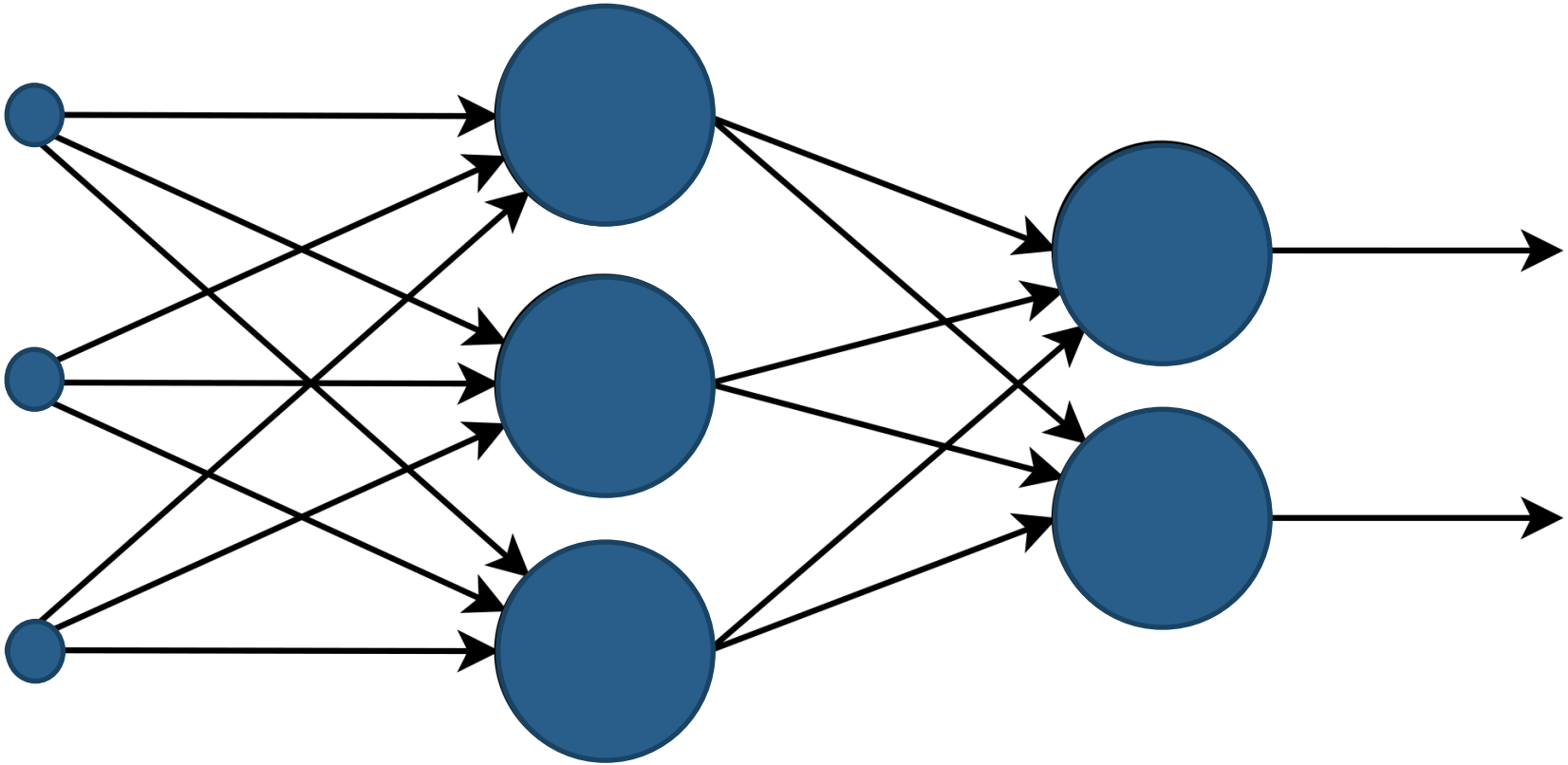
$$h(\vec{x};\vec{w}) = \sigma(\vec{x}\cdot\vec{w}) = \frac{1}{1+e^{-\vec{x}\cdot\vec{w}}}$$

$$L(y, h(\vec{x})) = -yln(h(\vec{x})) - (1-y)ln(1-h(\vec{x}))$$

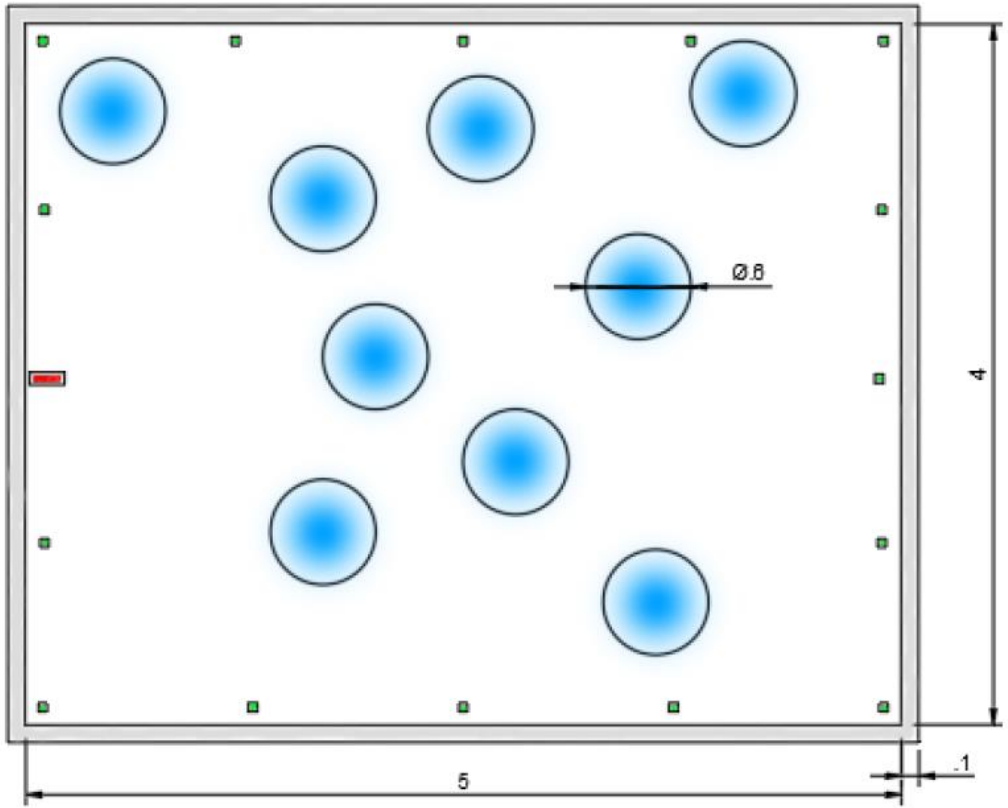
$$h_k(\vec{x};\vec{w_1},...,\vec{w_K}) = \frac{exp(\vec{w}_k\cdot\vec{x})}{\sum_{j=1}^{K} exp(\vec{w}_j\cdot\vec{x})} = P(y=k;\vec{w_1},...,\vec{w_K})$$

$$L(y, h_k(\vec{x})) = -\sum_{k=1}^{K} y_k ln(h_k(\vec{x}))$$

# Neuralna mreža



# Simulacija




- Izvedena u programu Comsol

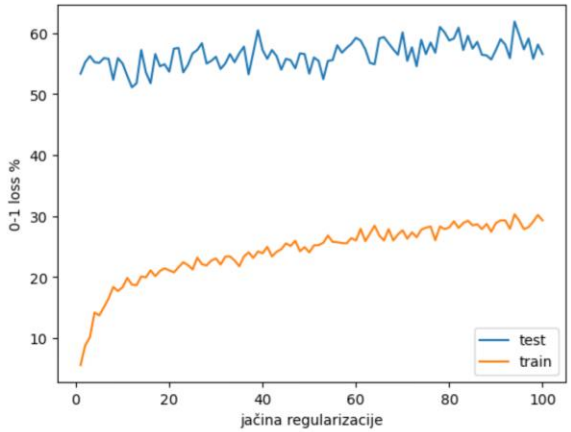
# Podatci

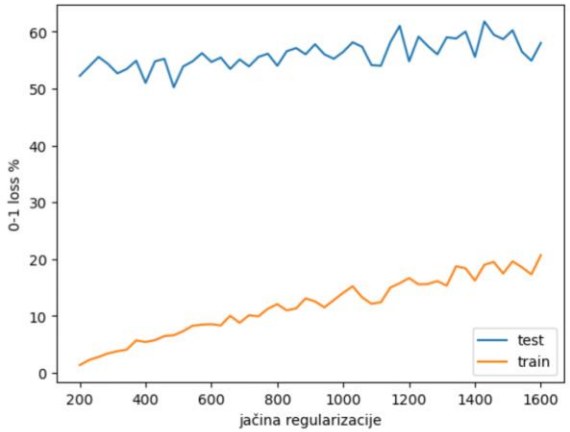
| | % x_cyl1 (m) | y_cyl1 (m) | freq (GHz) | Electric field, z component (V/m), Point Probe 1 | Electric field, z component (V/m), Point Probe 2 |
|---|---|---|---|---|---|
| **0** | 2.531433 | 1.876546 | 2.4 | 129.71268991231247+89.88570310539056i | 312.53412424485856-259.25192202306556i |
| **1** | 0.842063 | 3.389266 | 2.4 | 207.43611006017025-28.31932299402317i | 577.4981325573726+56.30056324345263i |
| **2** | 1.549929 | 2.140417 | 2.4 | -32.24836906129431+323.6849120619208i | 255.03846513476083+200.8633338170793i |
| **3** | 3.704058 | 2.063407 | 2.4 | 311.8766364728494+4.1532356831568755i | 423.33511705994096-348.572860545794i |
| **4** | 0.616881 | 1.194783 | 2.4 | 526.5747988019667+553.7652696016759i | 480.34718757566003+173.2734721374108i |
| **5** | 4.215417 | 1.966693 | 2.4 | 215.78702270414217+314.7807370708401i | 486.3321605178132-193.25024265914593i |
| **6** | 3.421323 | 2.372180 | 2.4 | 76.13026080300682+13.978200041080445i | 539.5994017635433-27.736729403505684i |
| **7** | 2.454436 | 2.537407 | 2.4 | 252.20872762723383-14.73899911119828i | 717.7104917722033-252.5746971676793i |
| **8** | 2.814100 | 1.686546 | 2.4 | -25.39063724550902+371.54477648874314i | 340.25626413356486-89.44927473082052i |
| **9** | 1.449134 | 1.602310 | 2.4 | -210.8360943507636+96.46443183310589i | 342.96566224691264-243.92345005242785i |

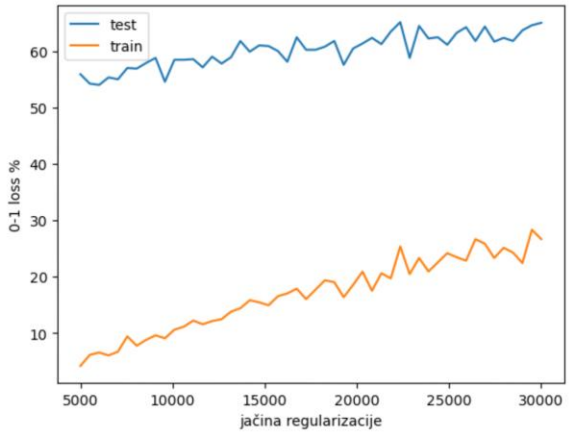
# Rezultati

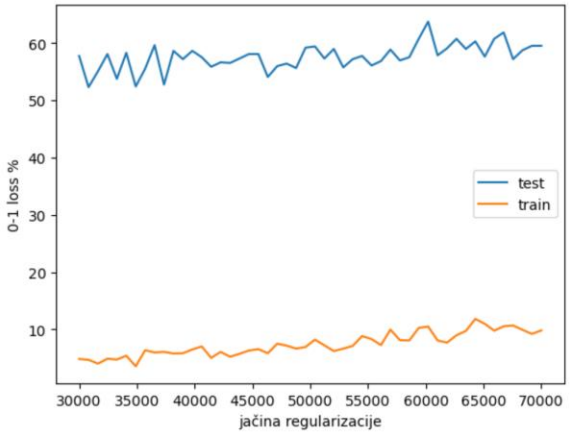
# Logistička regresija

Ovisnost gubitka logističke regresije o jačini regularizacije bez preslikavanja te s preslikavanjem u polinom drugog, trećeg i četvrtog stupnja



# Logistička regresija

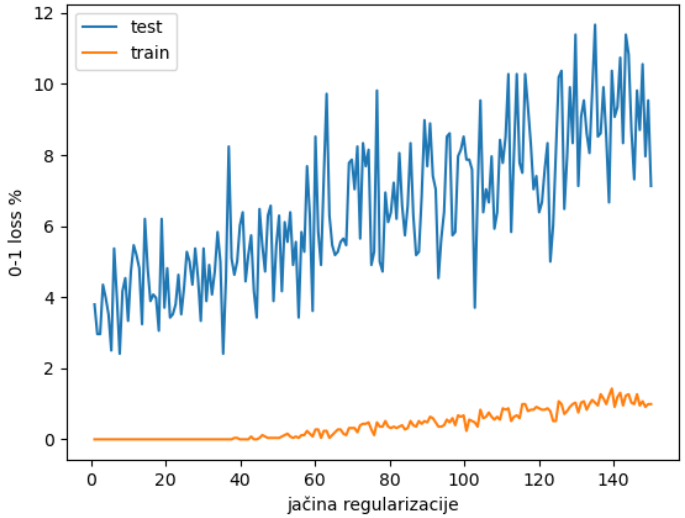
Najveća postignuta točnost modela logističke regresije za različite stupnjeve preslikavanja u prostor viših dimenzija

| Stupanj preslikavanja | Najveća točnost [%] |
|---|---|
| 1 | 48.89 |
| 2 | 49.78 |
| 3 | 46.00 |
| 4 | 47.67 |

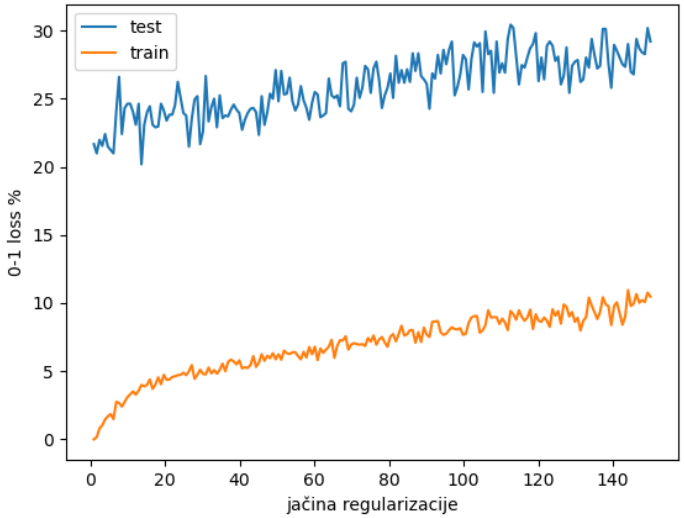
# Logistička regresija

Ovisnost greške logističke regresije o jačini regularizacije na podskupovima podataka: klase 1 i 9 te klase 1, 5 i 9

Najveća točnost 97.59%

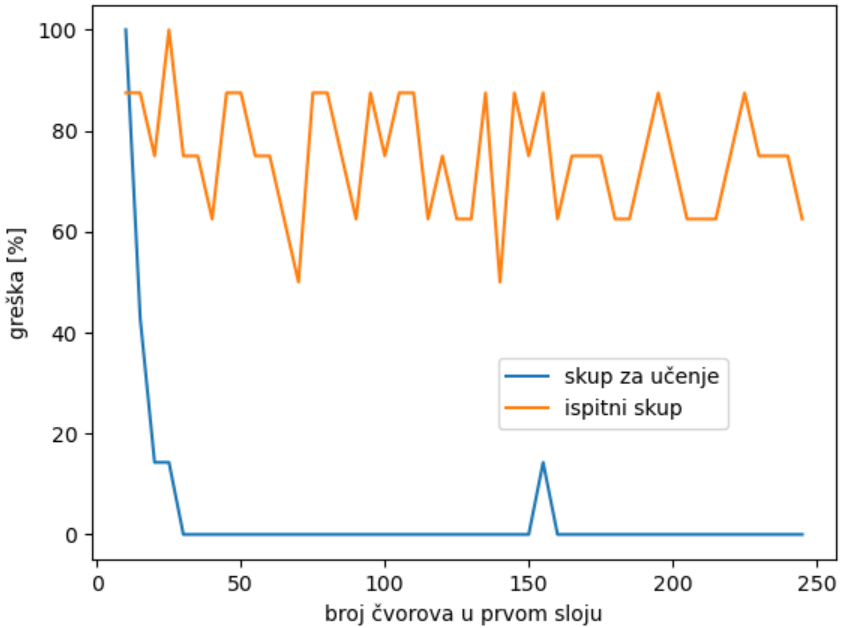



Najveća točnost 79.81%

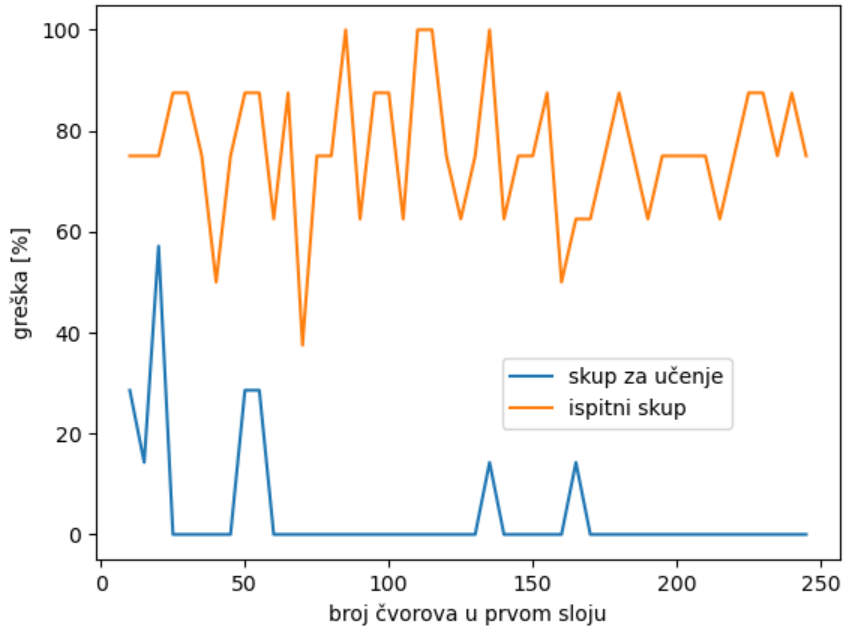


# Neuralna mreža

Najveća točnost 50%



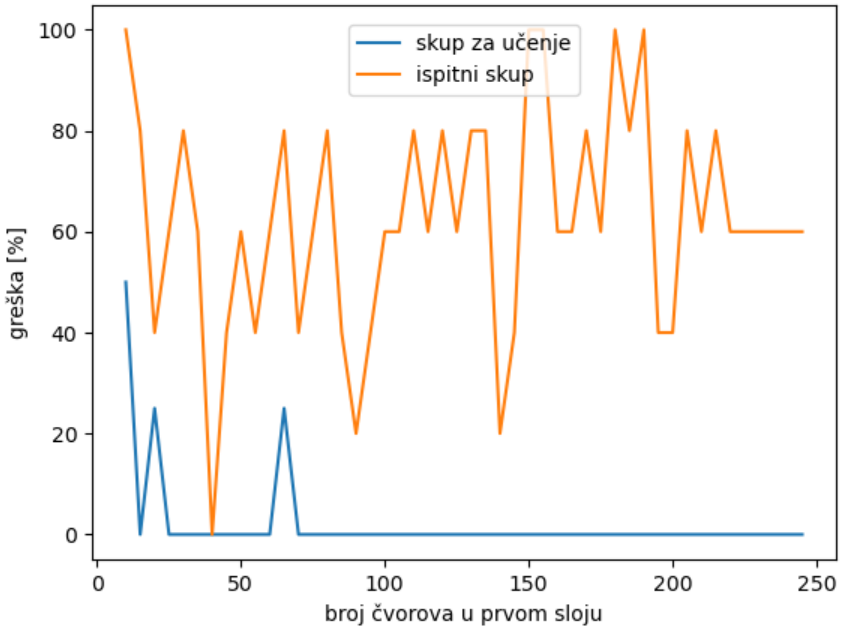

Najveća točnost 62.5%



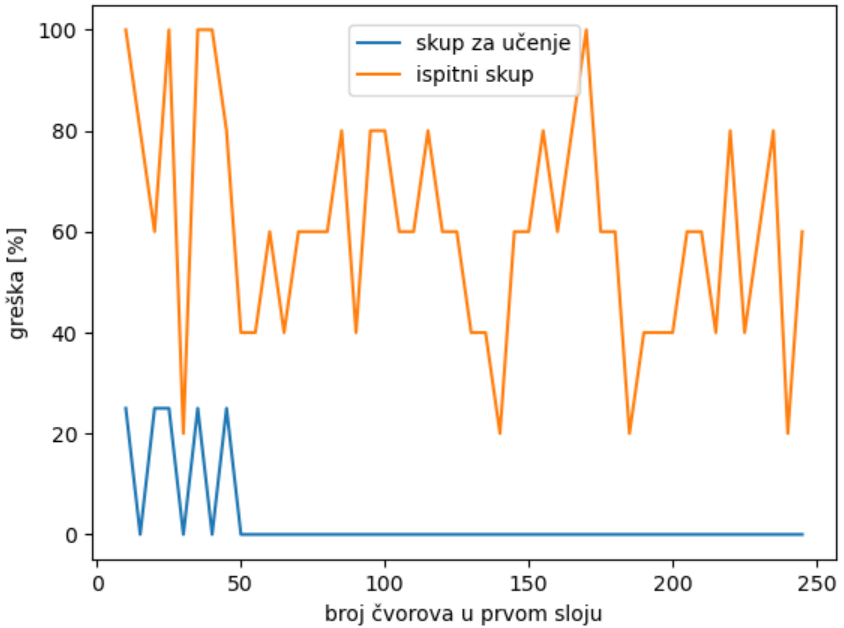

Ovisnost greške o broju čvorova u prvom sloju neuralne mreže, za mrežu s ukupno tri sloja te mrežu s ukupno četiri sloja na cijelom skupu podataka

# Neuralna mreža

Najveća točnost 100%




Najveća točnost 80%




Ovisnost greške o broju čvorova u prvom sloju neuralne mreže, za mrežu s ukupno tri sloja te mrežu s ukupno četiri sloja na podskupu podataka - klase 1, 5 i 9 ljudi u prostoriji

# Zaključak

Najveća dobivena točnost na cijelom skupu podataka iznosi 62.5% i  dobivena je četveroslojnom neuralnom mrežom

# Hvala na pažnji