APPLICATION
Biomedical

Parkinson dataset

- **Parkinson disease (PD) is thought to affect at least 100 persons in every 100,000. The cardinal symptoms of tremor, bradykinesia, postural instability, and rigor result in substantial disability for patients with PD**

- **During the course of the disease, up to 50% of patients will have symptoms refractory to medication and will experience drug-induced dyskinesias**

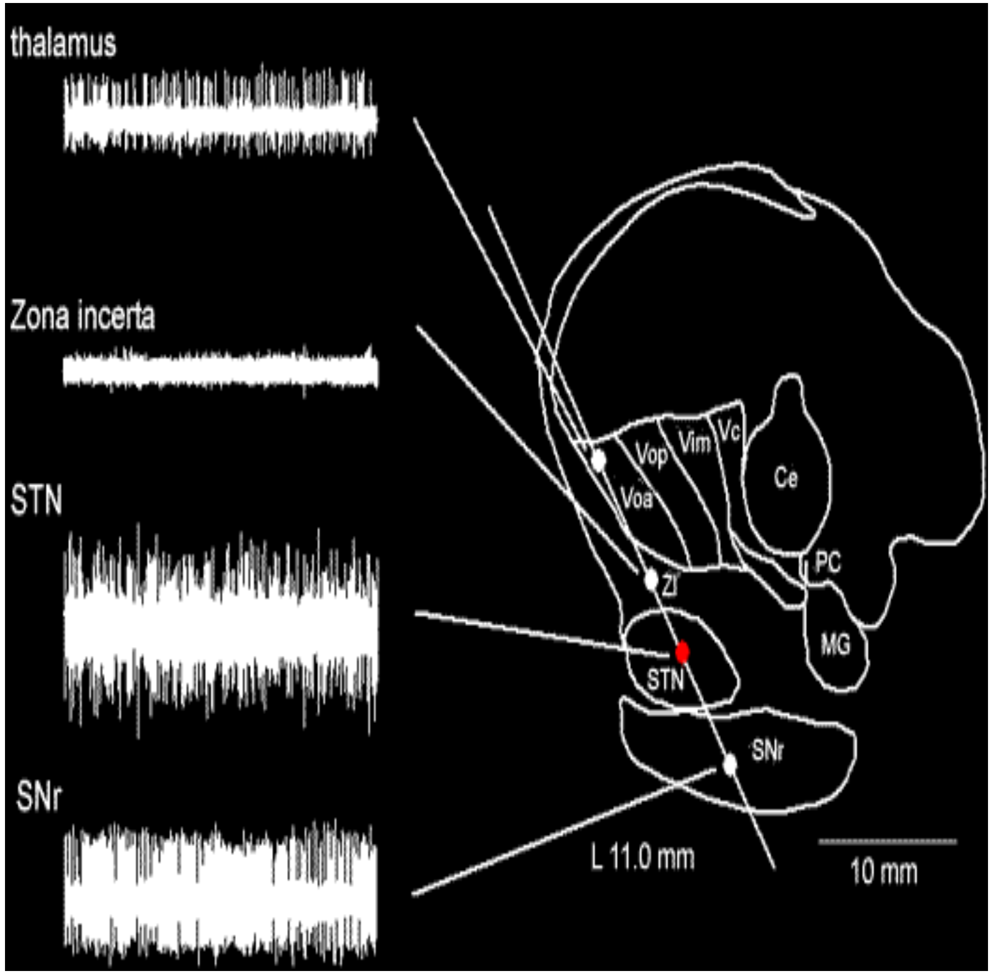
- **Parkinson’s Disease (PD) is primary related to substantia nigra degeneration and, thus, dopamine insufficiency**

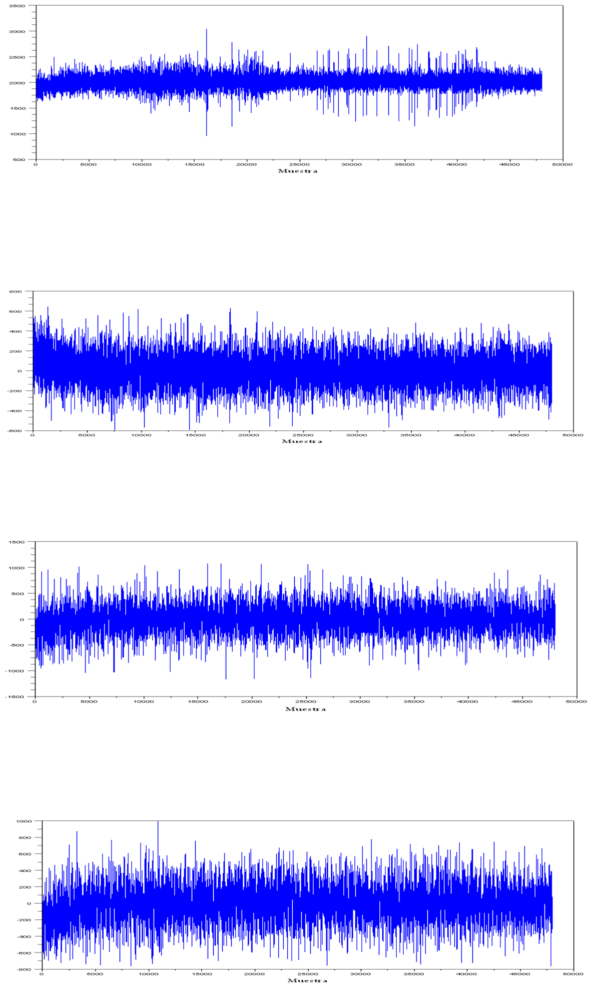
- **Disease progression causes L-DOPA therapy efficiency decay (on-off symptom fluctuation), and neurologists often decide to classify patients for DBS (Deep Brain Stimulation) surgery**

- **DBS involves the surgical implantation of electrodes into deep structures of the brain to modulate brain circuitry in an effort to restore normal physiological function**

- **The risk of errors in the localization of the surgical target for deep brain electrical stimulation (DBS) requires the use of some form of intraoperative neurophysiological monitoring to confirm the correct destination during surgery**

Deep brain stimulation





Signals

- Intra-operative microelectrode records were acquired in Parkinsonian patients, awake and unmedicated, subject to deep brain implantation under electrostimulation. Five Parkinsonian patients (4 males and 1 female) aged between 55□6 years old participated voluntarily assuming previously signed consent

- The acquisition time for each record was 2 seconds with a sampling frequency of 24 KHz (24,000 samples per second). In total, the database comprises 52 micro recordings, 13 for each of the subcortical structures: Thalamus nucleus (TAL), Zona Incerta (Zi), Subthalamic nucleus (STN) and Substantia Nigra (SNR)

- Next, a machine learning algorithm for supervised classification based on deep learning is used with the values of the obtained features, and we show that deep learning can identify and predict with high precision any of the subcortical structures (4 classes): Thalamus (TAL), zona incerta (Zi), subthalamic nucleus (STN) and substantia nigra (SNR)

Features

$$L = \sum_{i=1}^{N-1} |x_{i+1} - x_i| \qquad (6)$$

$$\gamma = \frac{3}{N-1} \sqrt{\sum_{i=1}^{N} (x_i - \bar{X})^2} \qquad (7)$$

$$\kappa = \frac{1}{2} \sum_{i=1}^{N-2} max\{0, |sgn[x_{i+1} - x_i] - sgn[x_{i+2} - x_{i+1}]|\} \qquad (8)$$

$$max(a,b) = \begin{cases} a & si \quad a > b \\ b & si \quad a < b \\ a \text{ o } b & si \quad a = b \end{cases}$$

$$sgn(x) = \begin{cases} 1, & si \quad x > 0 \\ 0, & si \quad x = 0 \\ -1, & si \quad x < 0 \end{cases}$$

$$\delta = \sqrt{\frac{\sum_{i=1}^{N} x_i^2}{N}} \qquad (9)$$

$$\Psi = \frac{1}{N-2} \sum_{i=2}^{N-1} x_i^2 - x_{i-1} x_{i+1} \qquad (10)$$

$$\kappa = \frac{1}{2} \sum_{i=1}^{N-1} | sgn(x_{i+1}) - sgn(x_i)| \qquad (11)$$

Feature Matrix

- As mentioned before when we presented the database, each record was acquired for 2 seconds at a sampling frequency of 24 KHz, which leads to each record having 48,000 samples

- If we consider a trajectory of 13 records for each of the subcortical structures: Thalamus nucleus (TAL), Zona Incerta (Zi), Subthalamic nucleus (STN) and Substantia Nigra (SNR), the final trajectory is made up of 52 records and has a total of 2,496,000 samples

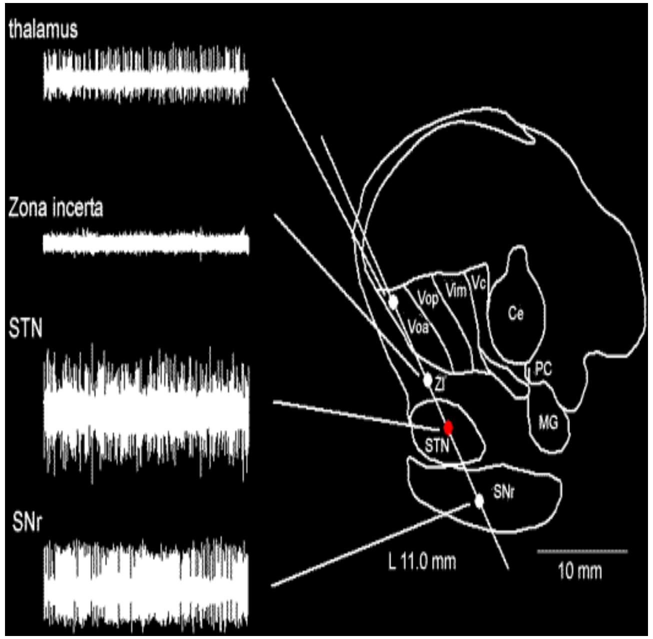
- Next, the final trajectory is divided into windows 4992 consecutive samples and for each of these windows the six features are determined, yielding a total of 500 instances (patterns) by feature. The decomposition described above is presented in matrix form as follows:

$$X = \begin{array}{c} \\ X_1 \\ X_2 \\ \vdots \\ \vdots \\ X_n \end{array} \begin{array}{c} \begin{array}{ccccc} V_1 & V_2 & \cdots & \cdots & V_p \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & \cdots & x_{2p} \\ \vdots & \vdots & \ddots & \cdots & \vdots \\ \vdots & \vdots & \cdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & \cdots & x_{np} \end{bmatrix} \end{array}$$

Deep brain stimulation for Parkinson’s disease

Learning to classify subcorticals structures for DBS

- Features



Machine learning