UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

itee PhD information technology electrical engineering

DIETI UNINA

PhD student Alessandro Di Bernardo

Quantum Machine Learning in healthcare field

Tutor: Leopoldo Angrisani

co-Tutor: Egidio De Benedetto

Cycle: XXXVII

Year: 2022/2023

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My background

- MSc degree in Biomedical Engineering
- Research group: Electric and Electronic Measurements
- PhD start date: November 2021
- Scholarship type: without scholarship

Research field of interest

- **Quantum technologies (QTs)** include all those technologies based on quantum mechanics. The fields in which implementations of QT are being tested are as different as: *computing, sensors, measurements, cryptography and imaging*.

- An interesting field is that of **metrology**, in particular the possibility of improving metrological performance of sensors and instrumentation or implementing new perspectives through quantum hardware and software development.

- AI implementation through **Quantum Machine Learning (QML)** technique. Pre-processing e management of dataset for QML applications and comparation with classical machine learning.

Summary of study activities

- Briefly summarize the study activities of the academic year
  - Attended: Courses and Seminars
  - New knowledge: human-machine interface, deep learning, big data architecture and analysis, Quantum Algorithms (QRNG, Grover's algorithm)
  - New tool learning: Azure Quantum, Quantum Development Kit, libraries Q#
  - New programming: python with quantum libraries, Q#

- Ad hoc PhD courses / schools
  - Muscle-based Human-Machine Interfaces
  - Using Deep Learning Properly
  - Big Data Architecture and Analysis

Summary of study activities

	Courses	Seminars	Research	Tuorship	Total
Bimonth1	2.6	1.1	8	0	11.7
Bimonth2	0	1.8	8	0	9.8
Bimonth3	0	0.7	8	0	8.7
Bimonth4	0	1.1	8	0	9.1
Bimonth5	9	0	7	0	16
Bimonth6	0	1.6	6	0	7.6
TOTAL	**11.6**	**6.3**	**45**	**0**	**62.9**
Expected	***10 - 20***	***5 – 10***	***30 – 45***	***0 – 1.6***	

Research activity: Overview

- Problem

The question you want to answer is:

how can QT be applied in the area of metrology and how can it improve current technologies in this area?

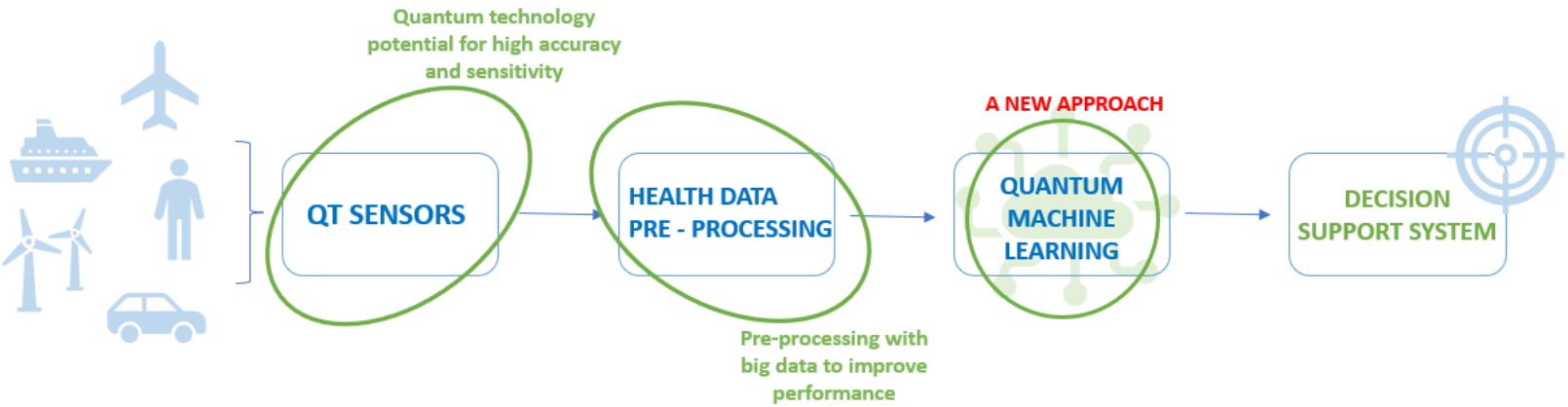
Research activity: Overview

- Objective

Identify the way to fully exploit the potential of quantum technology in metrology, more in detail to integrate any developments in cyber-physical measurement systems (CPMSs) and in particular in healthcare field.

Research activity: overview

- Implementation a CPMS application with QT instruments



Research activity: overview

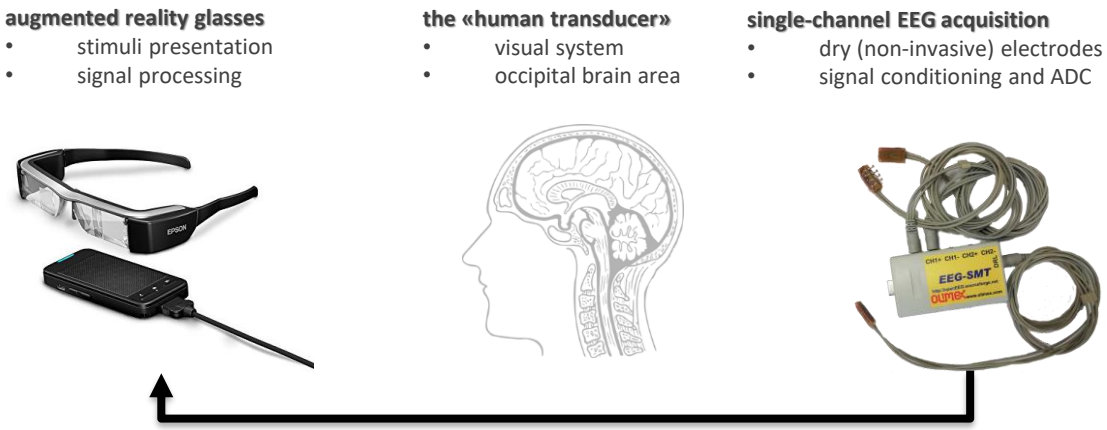
Two principal element of QT for this application:

- QT sensors
- Quantum Machine Learning
  - Pre-processing of dataset
  - AI technique with Q# libraries

Research activity: Overview

- Methodology: Dataset

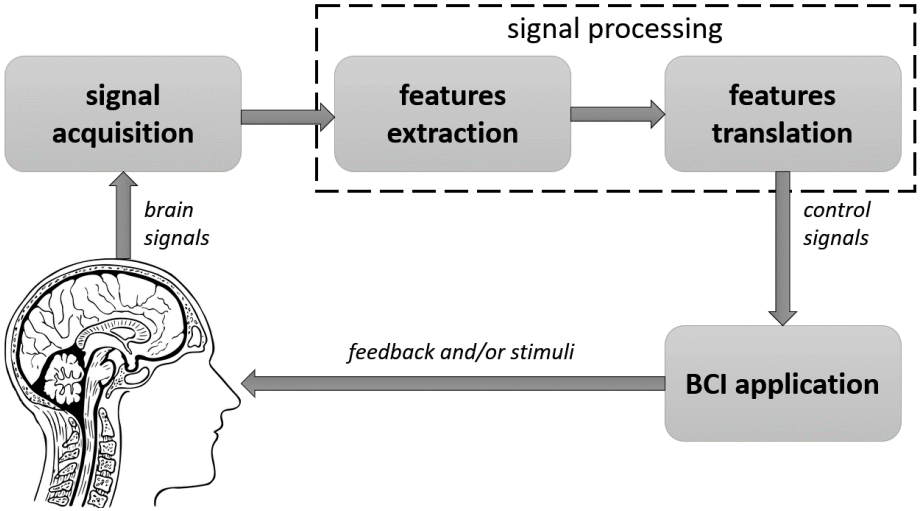
The first step for a QML application, is to analyze an EEG dataset. In particular, the EEG signals are obtained from Brain Computer Interface (BCI) system as reported in this rappresentation:



Research activity: Overview

- Methodology: Dataset

The acquisition of signal is reported:



Relationship between class and acquired signal: a class is assigned for each signal processed and the intention to react to the user's input is correlated to each one. In the details the value of class is 1 if the subject looks the input at 12/24 Hz or 0 for 10/20 Hz.

Research activity: Overview

- Methodology: Feature Extraction

There are two representations of features:

I. PSD at 10 Hz and 12 Hz (where these frequencies are linked to the visual stimuli given in input, and the signal is acquired for a duration of 10 seconds)

II. Second harmonic then 20 Hz and 24 Hz

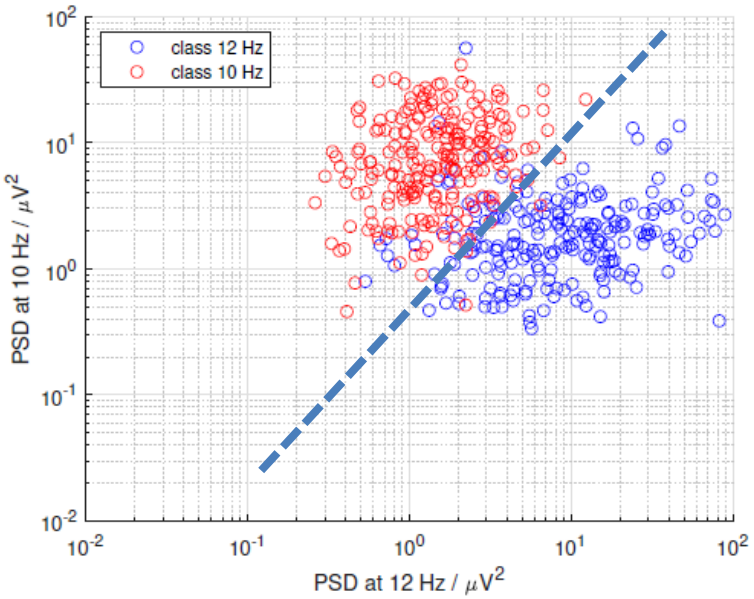
→ **4D SPACE**: hyperplane to classify classes

*simplified to a **linear SVM (2D)***

Research activity: Overview

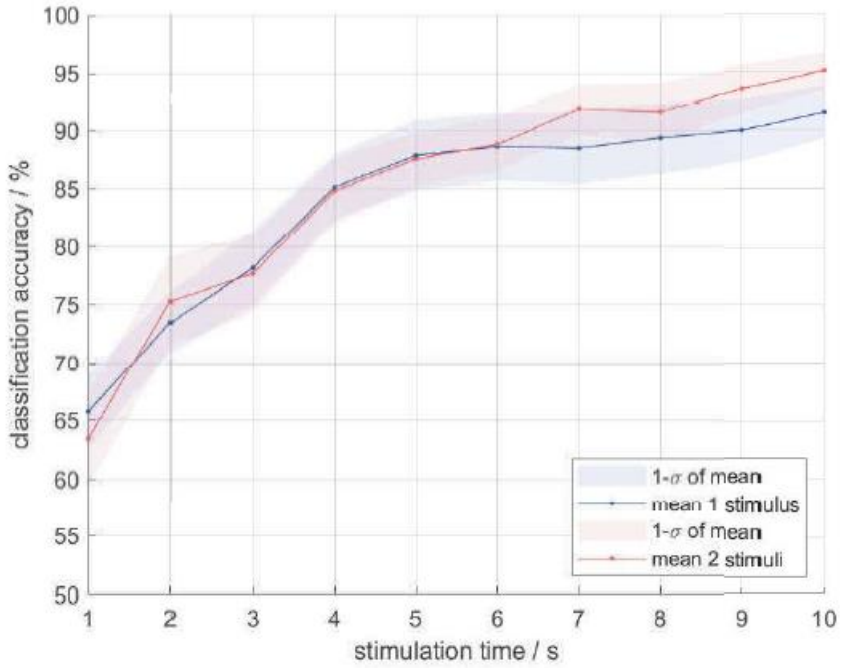
- Methodology: Feature Extraction

SVM with linear kernel



Research activity: Overview

- Methodology: Machine Learning results



In this rappresentation is reported mean classification versus SSVEP stimulation time.

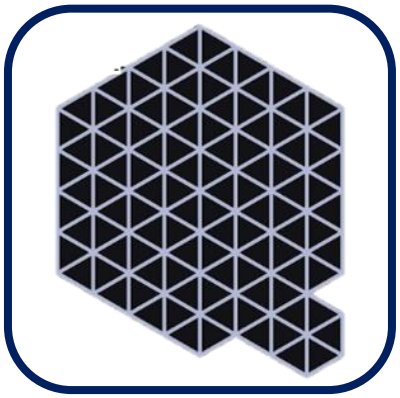
Research activity: Overview

- Methodology: Quantum Machine Learning

PLATFORM FOR THE DEVELOPMENT OF QML

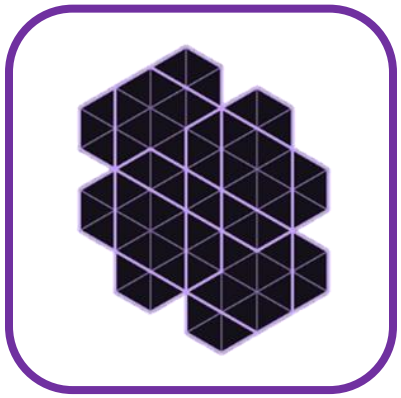
Q# Microsoft

Q# is a high-level programming language, through special libraries and a cloud platform where it can develop. Microsoft makes avaible:



Azure Quantum

+



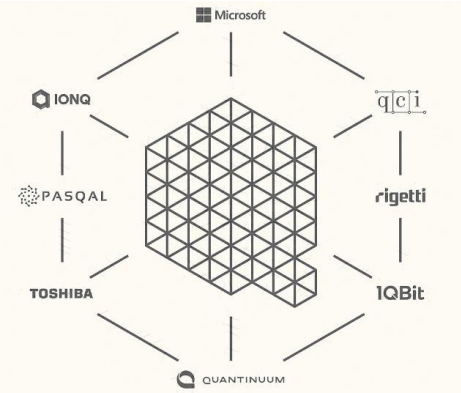
Quantum Development Kit

Research activity: Overview

- Methodology: Quantum Machine Learning

Azure Quantum

- Cloud service that allows you to write code and run it on quantum hardware.
- Azure Quantum uses quantum resources like



Quantum Development Kit

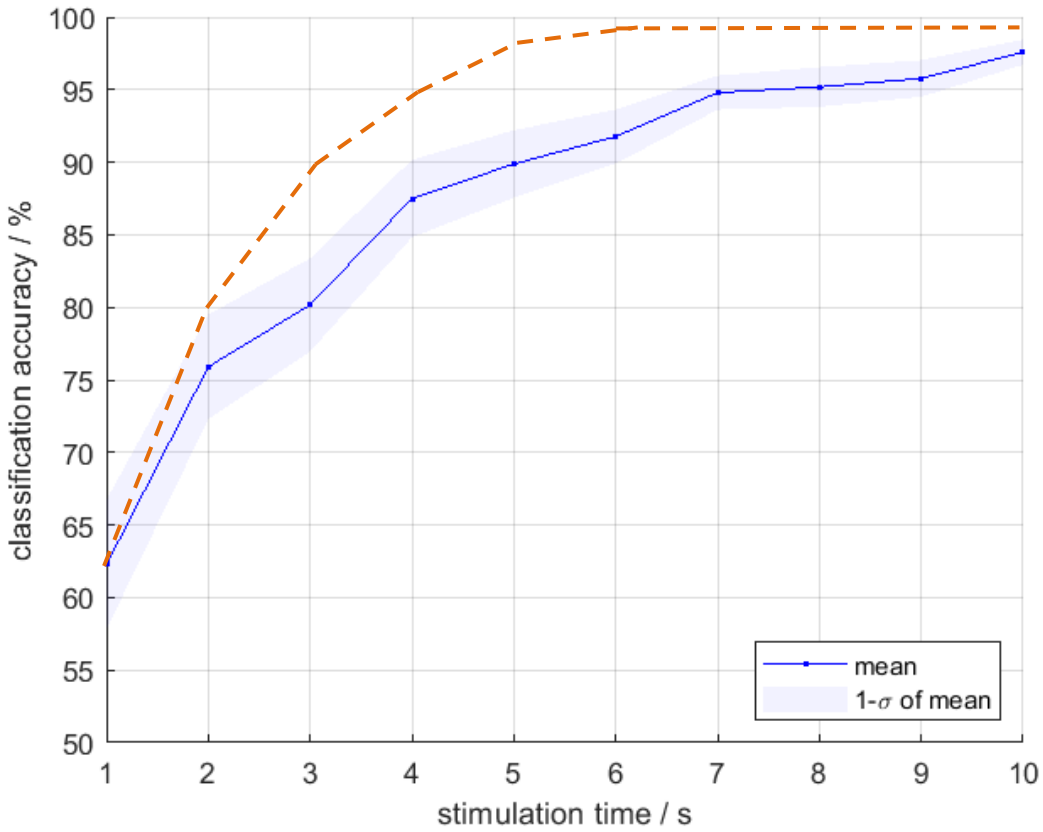
- QDK allows you to run quantum applications that use Q#, Qiskit or Cirq.
- Q# Language and Quantum Libraries
- Quantum simulators that simulate quantum computers
- Extensions for visual studio code and integration with Jupyter Notebook.

Research activity: next step

How can QML improve compared to classical ML ?

QSVM vs SVM?

DECISION SUPPORT SYSTEM



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Thanks for attention