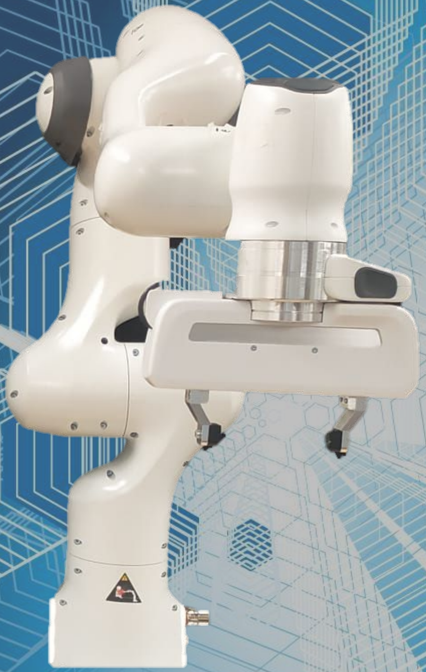


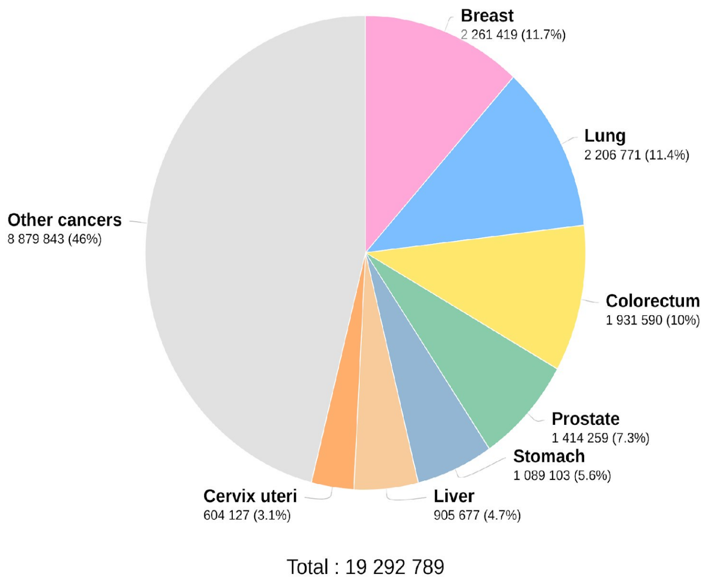
Deep robot path planning from demonstrations for breast cancer examination

TAROS 2021

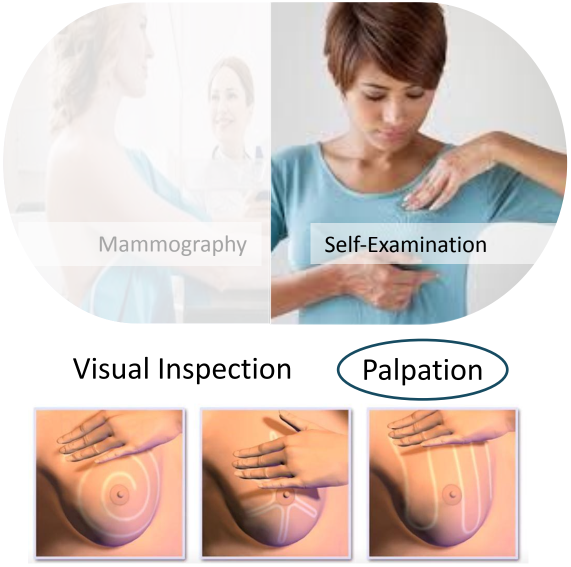
Marta Crivellari, Oluwatoyin Sanni, Andrea Zanchettin and Amir Ghalamzan Esfahani

Introduction

Number of Cases in 2020, Worldwide:



Prevention Methods:



Strengths of the Existing Methods

Self Palpation

Breast Palpation (BP) is the easiest, effective and most widely used early cancer detection.

Clinical Palpation

Experts palpation comes with expert techniques and knowledge that may not be achieved with self palpation.

Mammography

Reduces the risk of dying from breast cancer. Reduces the risk of having to undergo chemotherapy

Weaknesses of the Existing Methods

Self Palpation

Due to lack of patients' expertise in palpation, self-examination has become ineffective across societies.

Clinical Palpation

Subjects are reluctant to be examined by human experts, Detection precision depends on the examiner's expertise.

Mammography

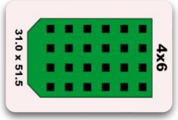
"Dense" breasts, which are at higher risk of cancer, appear opaque on mammograms, making interpretation more difficult. Also expensive.

How to learn a path for a successful breast examination

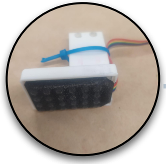
Data Collection Set-up

Franka Emika
Panda Robot

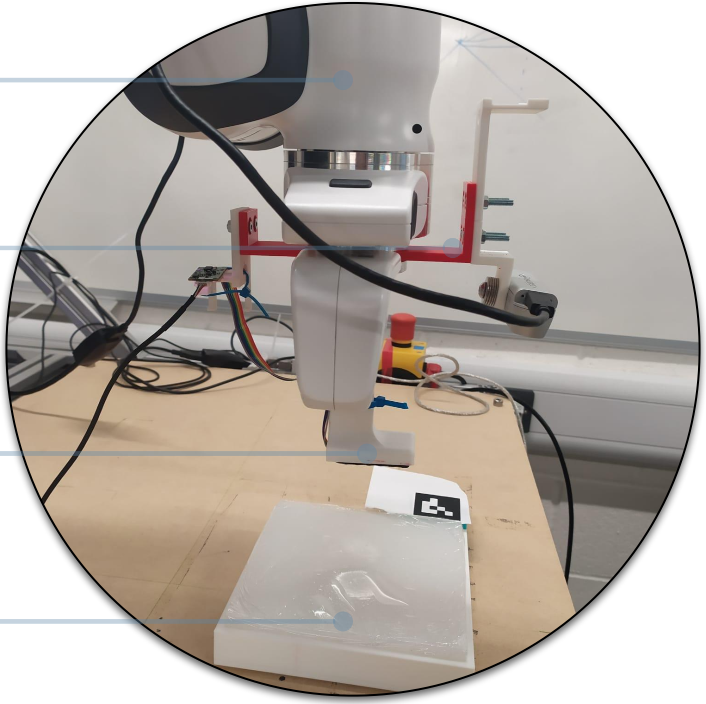
Realsense
Camera



Xela
Sensor

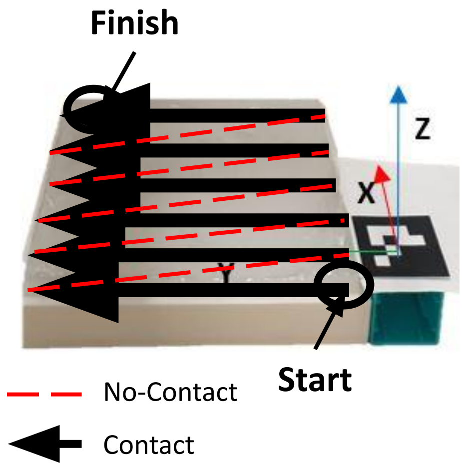


Phantom



Deep Learning from Demonstration

What to learn



- Examine the entire surface.
- Follow a path.

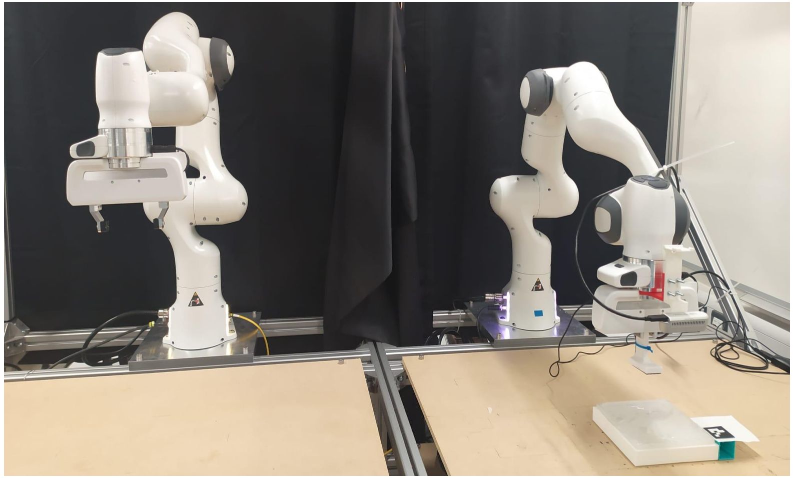
Deep Learning from Demonstration

Data-set Acquisition

Deep Model Implementation

Data-set Acquisition

- Leader-follower impedance control (see the paper for details) to palpate the silicon phantom.
- 31 Demonstrations
- Fixed Phantom
- 1 Operator



Deep Learning from Demonstration

Data-set Acquisition

Deep Model Implementation

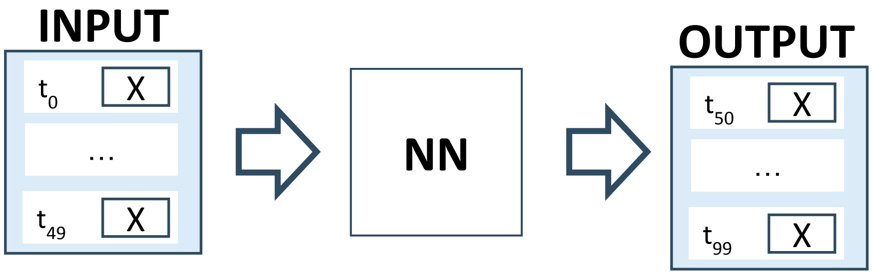
Deep Model Implementation

Deep Model Implementation

Structures

- Variants of RNN
- Sequential Input/Output [samples, time steps, features]
- A NN for each coordinates

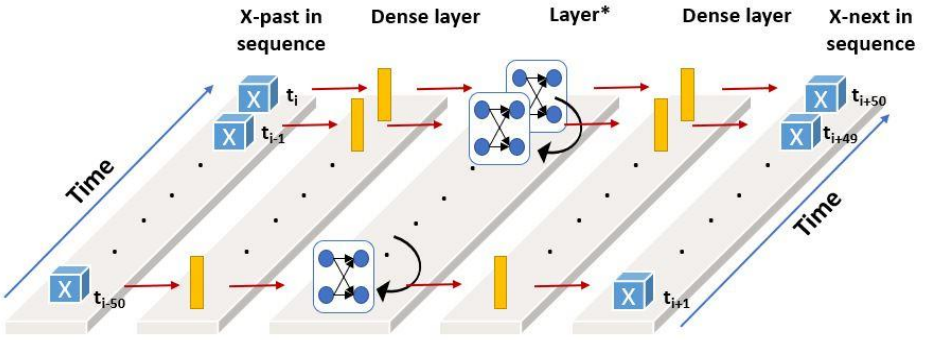
Data Pre-Processing



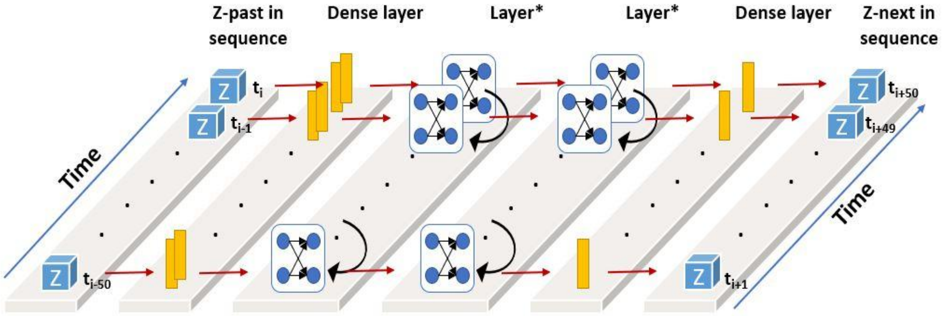
Deep Model Implementation

- Layer* = GRU, TCN, RNN, LSTM
- 15 Epochs
- Mean Absolute Error Loss
- Adam Optimizer

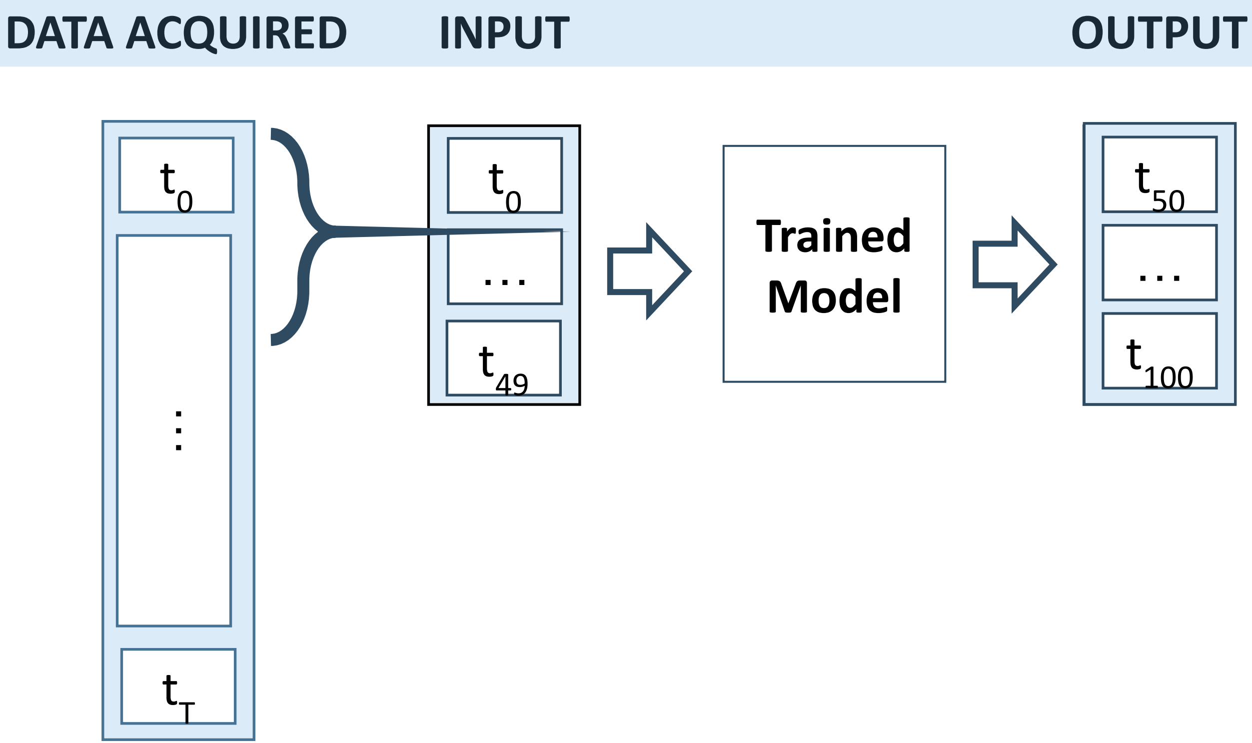
X and Y Model

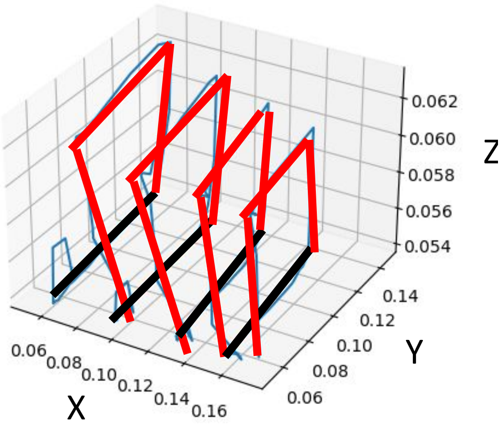


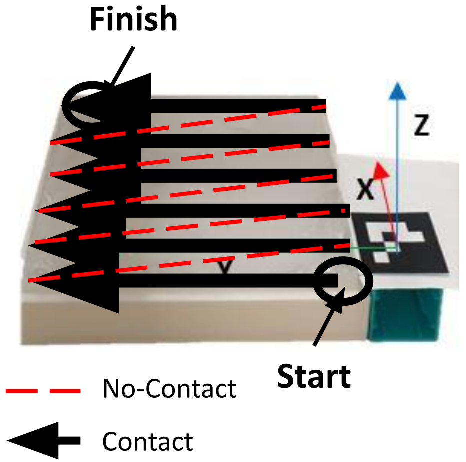
Z Model

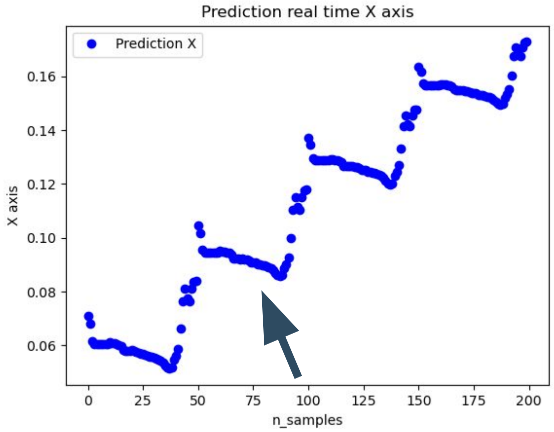


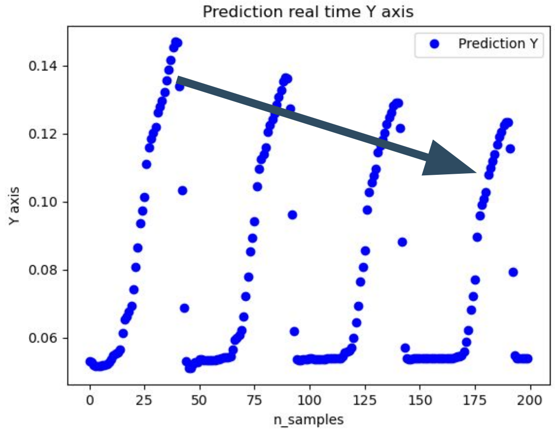
Results


DATA ACQUIRED
INPUT
OUTPUT
t_0
⋮
t_T
t_0
...
t_{49}
Trained Model
t_{50}
...
t_{100}

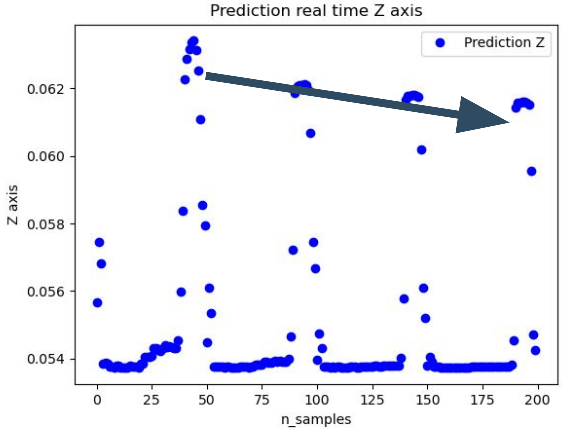

0.062
0.060
0.058
0.056
0.054
Z
0.14
0.12
0.10
0.08
0.06
Y
0.06
0.08
0.10
0.12
0.14
0.16
X

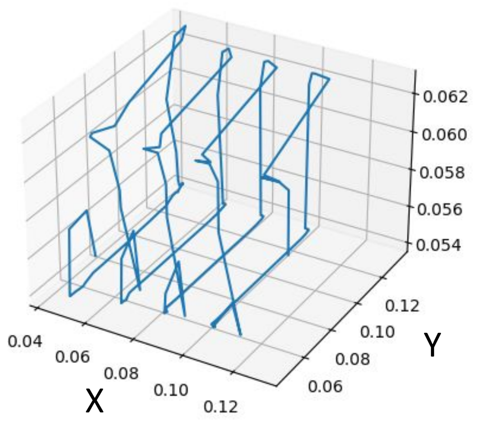

Finish
Z
X
Start
No-Contact
Contact


Prediction real time X axis
Prediction X
X axis
n_samples


Prediction real time Y axis
Prediction Y
Y axis
n_samples

GRU


Prediction real time Z axis
Prediction Z
Z axis
n_samples


0.062
0.060
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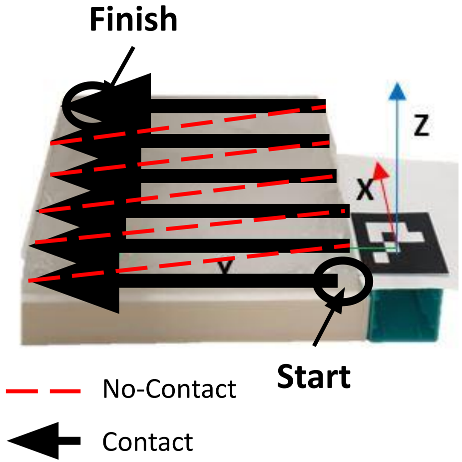
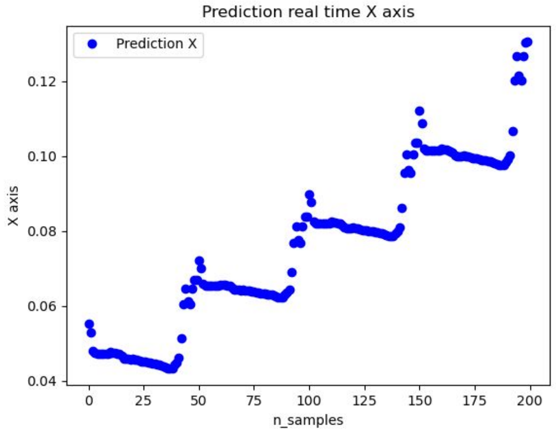
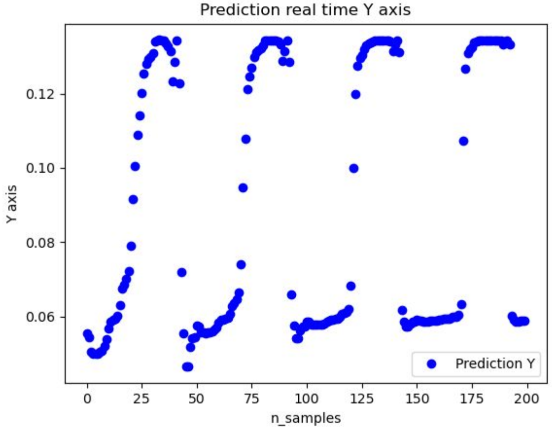
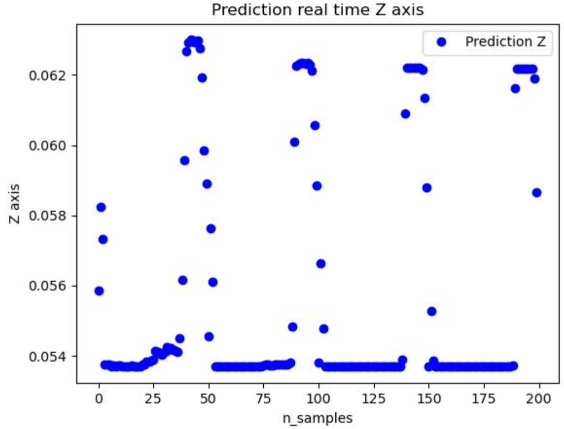
0.054
0.04
0.06
0.08
0.10
0.12
X
0.06
0.08
0.10
0.12
Y


Finish
Z
X
Y
Start
No-Contact
Contact


Prediction real time X axis
Prediction X
X axis
n_samples
0.12
0.10
0.08
0.06
0.04
0
25
50
75
100
125
150
175
200


Prediction real time Y axis
Prediction Y
Y axis
n_samples
0.12
0.10
0.08
0.06
0
25
50
75
100
125
150
175
200

TCN


Prediction real time Z axis
Prediction Z
Z axis
n_samples
0.062
0.060
0.058
0.056
0.054
0
25
50
75
100
125
150
175
200

Done

Implementation of a **teleoperation control** with **force feedback** for palpation.

First **TCN network** implementation for a **full path prediction** starting from few initial points (We observed TCN could outperforms other network architecture).

Limitation

- The dimensions predicted differ from the real ones.
- Lack of Generalization and possibility of models overfitting.

Current/Future Work

Model prediction improvements:

- Using a Silicon Breast Phantom for Data Collection.
- Using Deep ProMP for end-to-end path planning for generalization.

Reproducibility

https://github.com/imanlab/artemis_dpd

Thank you for your attention!