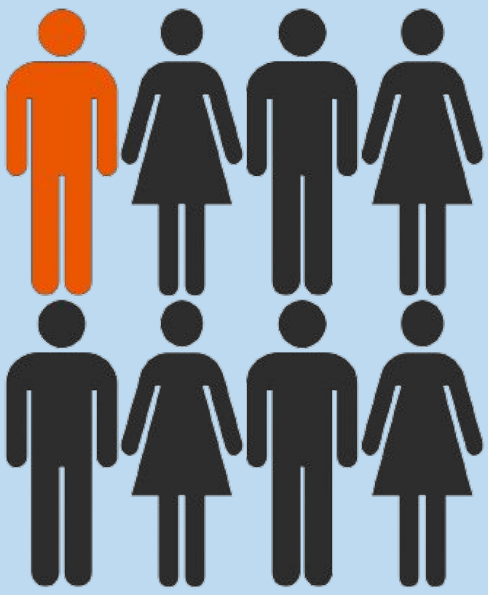
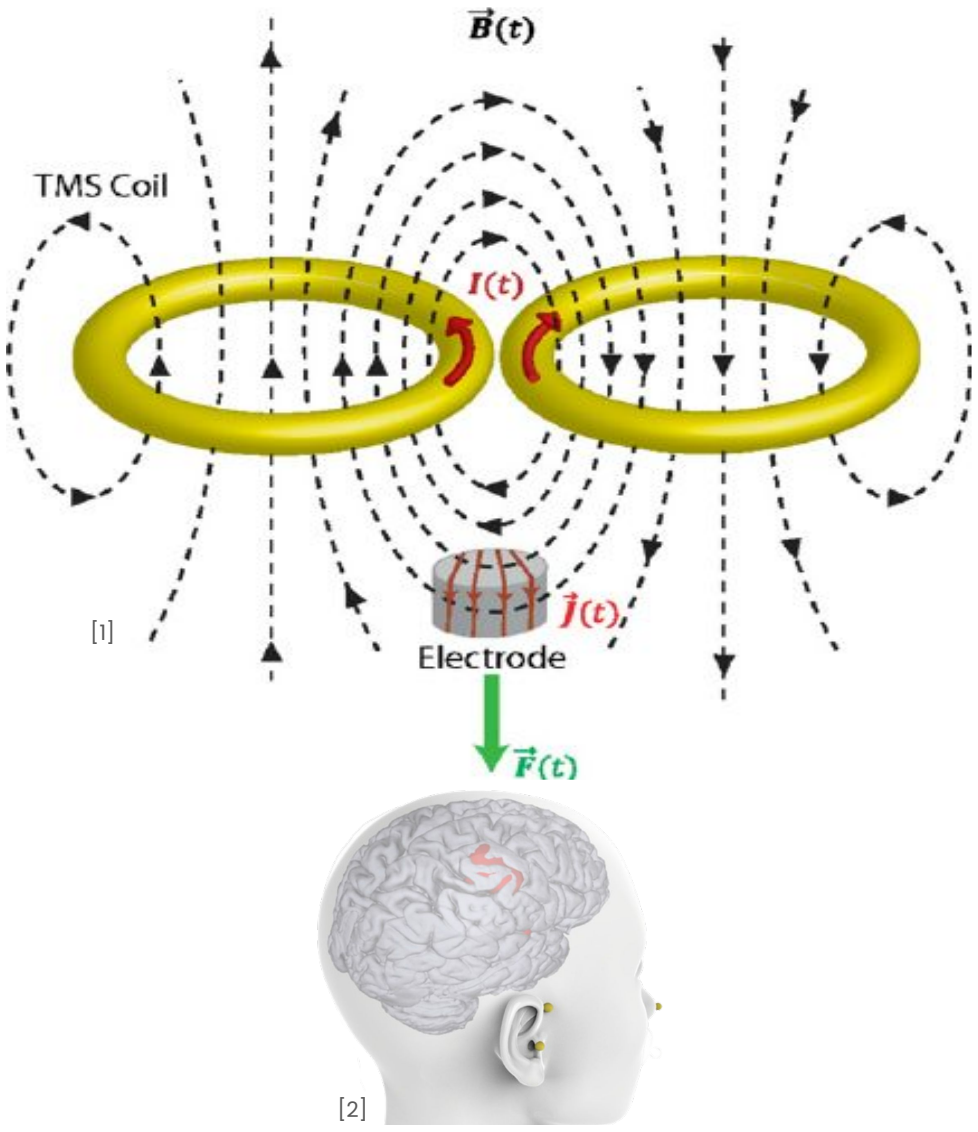
TMS Background and Motivation

1 in 8 Canadians suffer from depression



20% - 30% of cases are **treatment resistant**

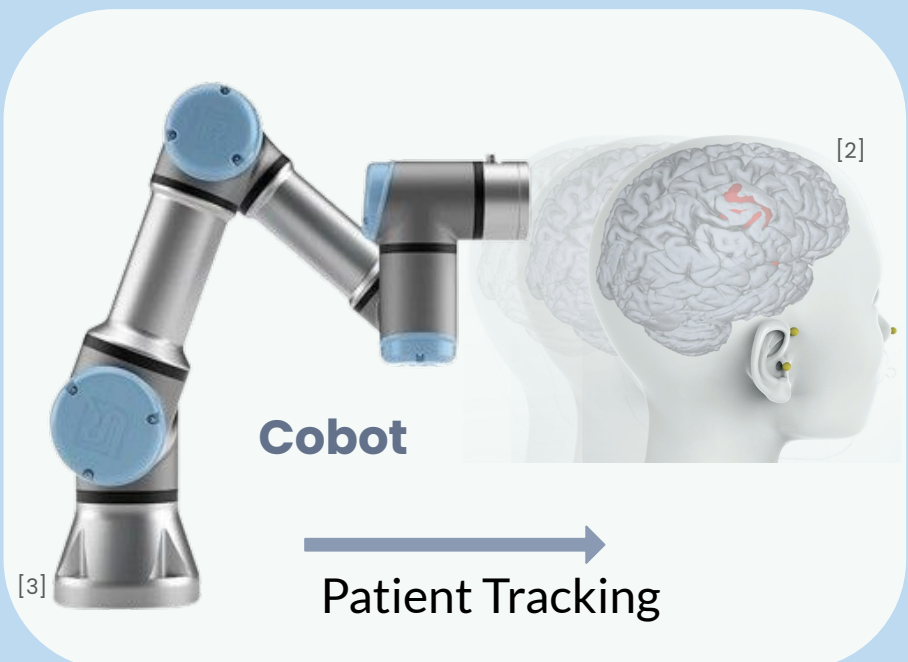
TMS (Transcranial Magnetic Stimulation) is a noninvasive treatment for treatment-resistant depression



How does it work?

- The TMS coil generates a **magnetic field** at a specific hotspot (location of stimulation on the cerebral cortex)
- The magnetic field induces an **emf** which drives **electric signals**
- Signals then modulate **neural activity** and influence **brain function**

However, the current method where the coil is manually moved by a doctor results in a **lack of precision & efficiency**



Our **Solution**

Based on Dr. Takemi's design, we aim to build an autonomous cobot system that can move and maintain its position with **higher precision and efficiency** than a human operator.

[1] www.researchgate.net/figure/The-schematic-of-ECoG-electrode-in-the-presence-of-TMS-coil_fig1_233330682
[2] https://soterixmedical.com/research/hd/neuronavigation
[3] https://www.universal-robots.com/products/ur3-robot/

System Overview

Dynamic connections — Static connections

Patient Tracking Software

Pre-meshed MRI

Hotspot

Image processing

Patient tracking and targeting algorithm

Cobot driver

Cobot

UR3e cobot

TMS coil

Patient Tracking Hardware

Patient

IR reflecting head accesory

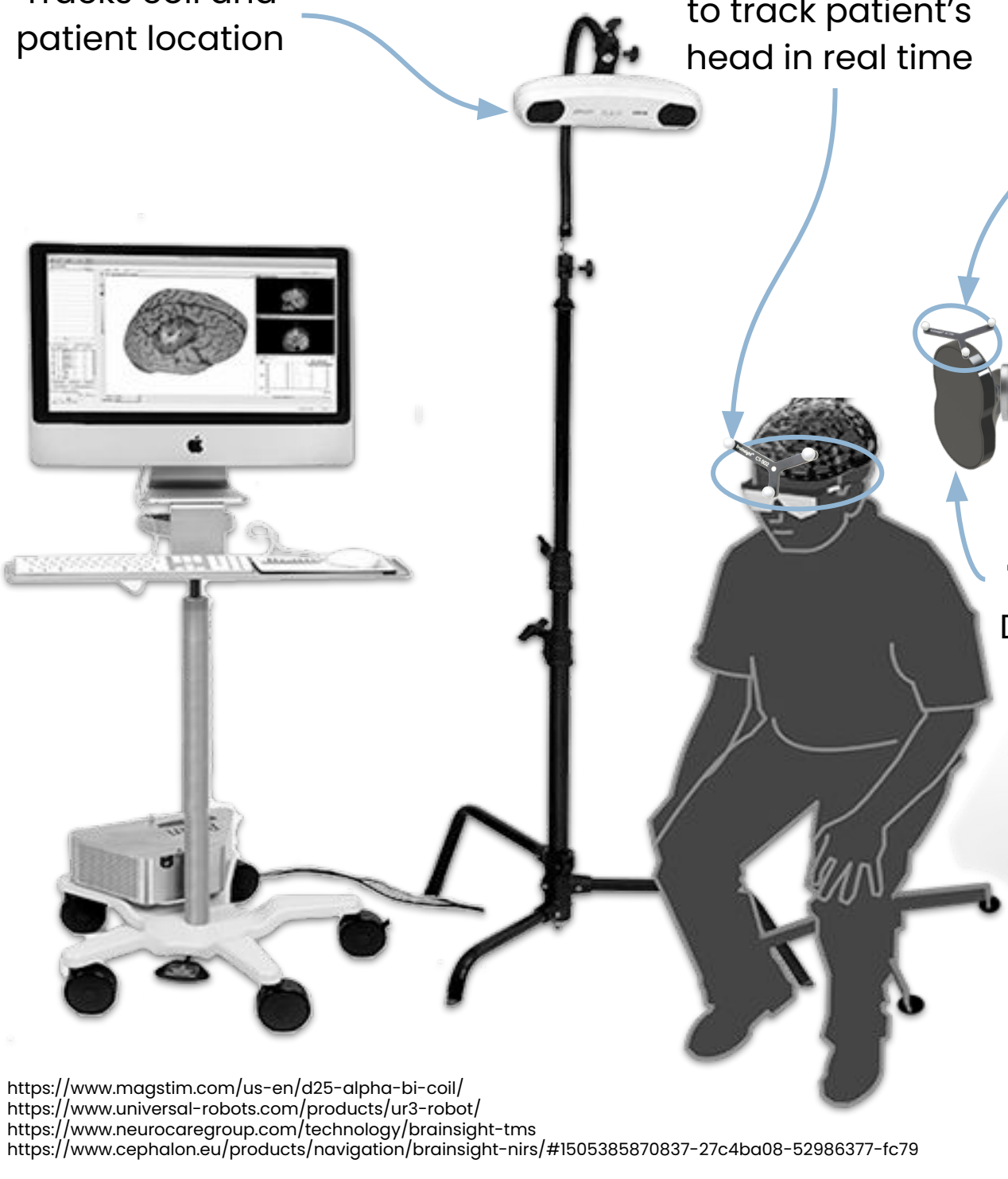
IR camera

IR reflecting orbs

IR Camera
Tracks coil and patient location

IR Reflecting Head Accessory
Allows IR camera to track patient's head in real time

IR Reflecting Orbs
Allows IR camera to track TMS coil in real time



UR3e Cobot
Cobot used in this project

TMS Coil
Delivers TMS to patient

https://www.magstim.com/us-en/d25-alpha-bi-coil/
https://www.universal-robots.com/products/ur3-robot/
https://www.neurocaregroup.com/technology/brainsight-tms
https://www.cephalon.eu/products/navigation/brainsight-nirs/#1505385870837-27c4ba08-52986377-fc79

Calibration and Registration

1) Cobot Calibration & Patient Registration

[1]

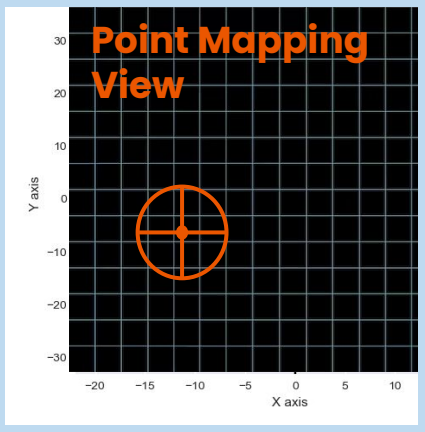
2) TMS Treatment

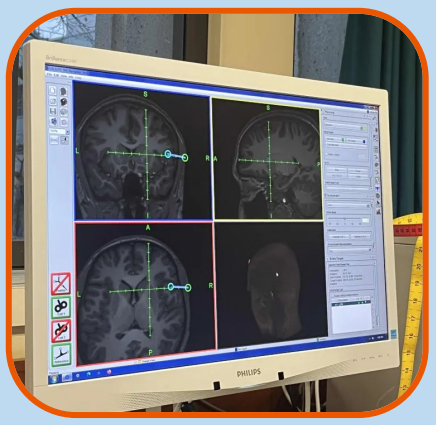
First, we calibrate the cobot by registering points in the patient's **MRI anatomical space** to the **physical space** seen through the IR camera.

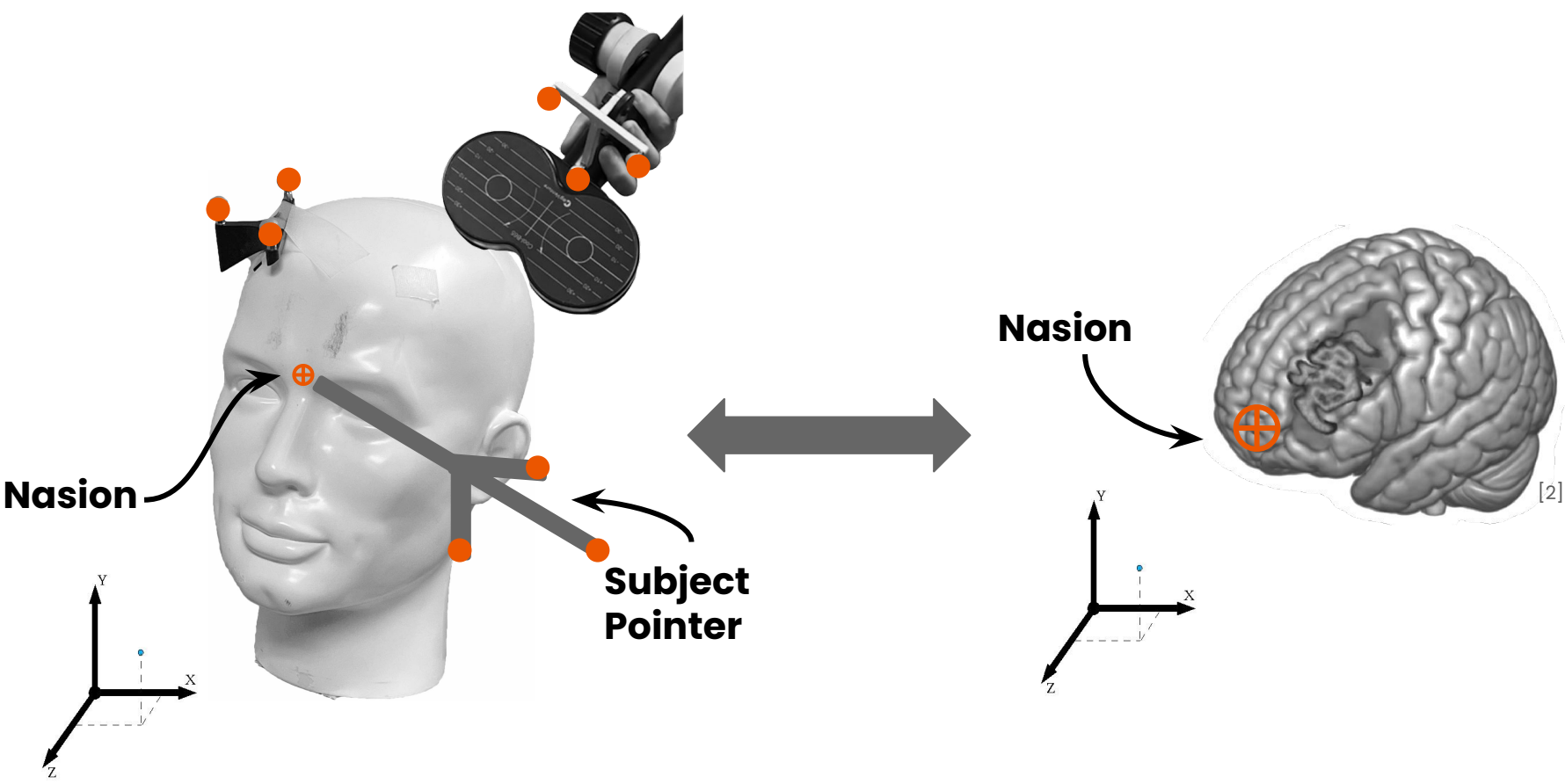
With this, we are able to autonomously position the coil to any point on the MRI using the cobot and real time IR data.

During this process, users will be able to monitor the cobot's progress through a Graphical User Interface (**GUI**).

This will display real time **IR coordinates** of the Cobot, Coil, and Patient, overlaid upon the existing MRI.







We can calibrate the cobot by mapping points between anatomical space and image space

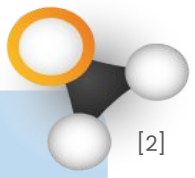
[1] https://www.fieldtriptoolbox.org/faq/coordsys/
[2] https://pharmrev.aspetjournals.org/content/pharmrev/74/4/918.full.pdf

Implementation

[1]

Stereo IR Camera

Stereo IR Camera: collects then feeds IR image input to the PC running Motive



[2]

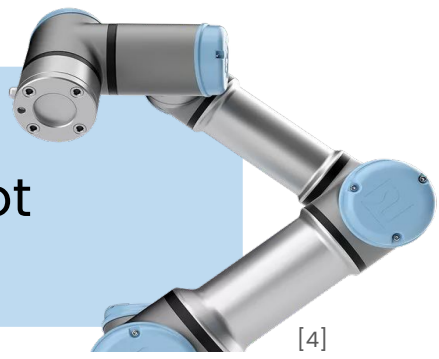
Camera PC (Motive)

Camera PC (Motive): runs Motive software to extract position coordinates and angular orientation from image feed and stream data to the Cobot PC

ROS [3]

Cobot PC

Cobot PC: runs custom GUI which operates the controller that controls cobot position using UR ROS drivers and calculates positional errors from IR coordinate inputs and force-torque readings



[4]

Cobot

Cobot: collects force-torque input data which can be accessed by the Cobot PC

Next Steps:

- Iterate on Dr. Takemi's system with a combined force and IR camera cobot controller
- Manufacture 3D printed TMS coil holder, robot fixing stand, and subject pointer
- Refine and improve cobot force control loop
- Integrate all system components to create a useable platform for psychiatric researchers in the NINET Lab

[1] https://optitrack.com/cameras/v120-duo/
[2] https://optitrack.com/software/motive/
[3] https://medium.com/analytics-vidhya/getting-started-with-ros-overview-installation-and-ros-computational-graph-model-e94d7a16187f
[4] https://www.universal-robots.com/products/ur3-robot/