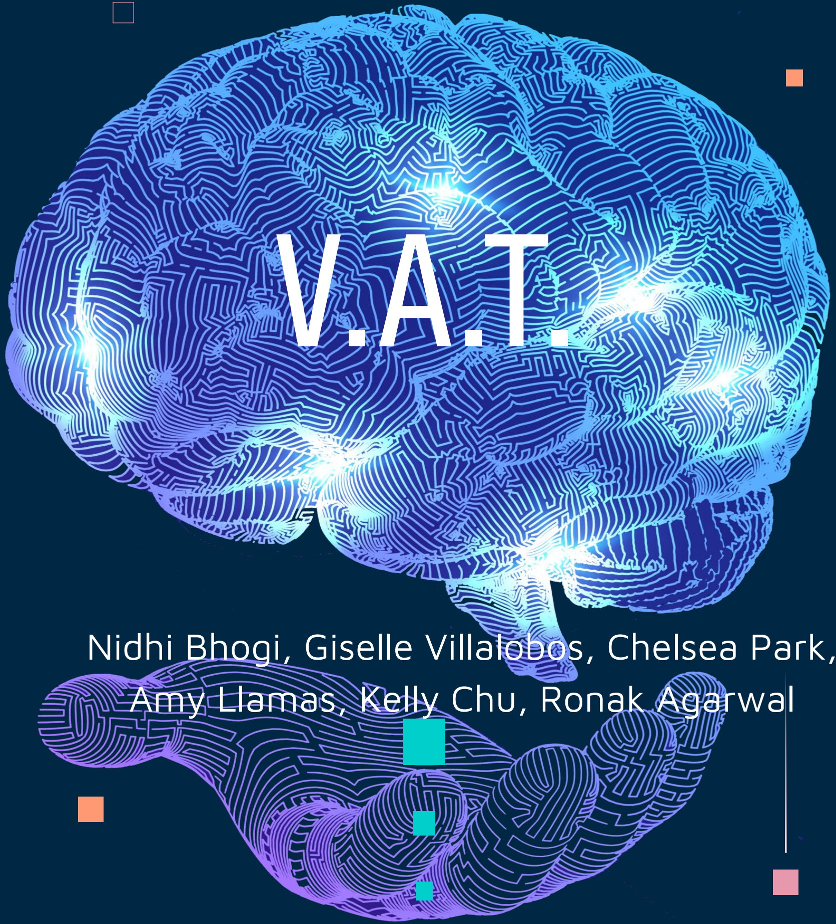
Virtual Reality and AI for Traumatic Brain Injuries

V.A.T.



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OVERVIEW

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Information about traumatic brain injuries, AI, and its applications

02
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Addressing the problem and the need for a solution

03
SOLUTION
Proposing a potential solution

04
ROLE OF AI
How AI plays a role in our solution

05
IMPLICATIONS
Limitations generated by our solution, as well as future applications

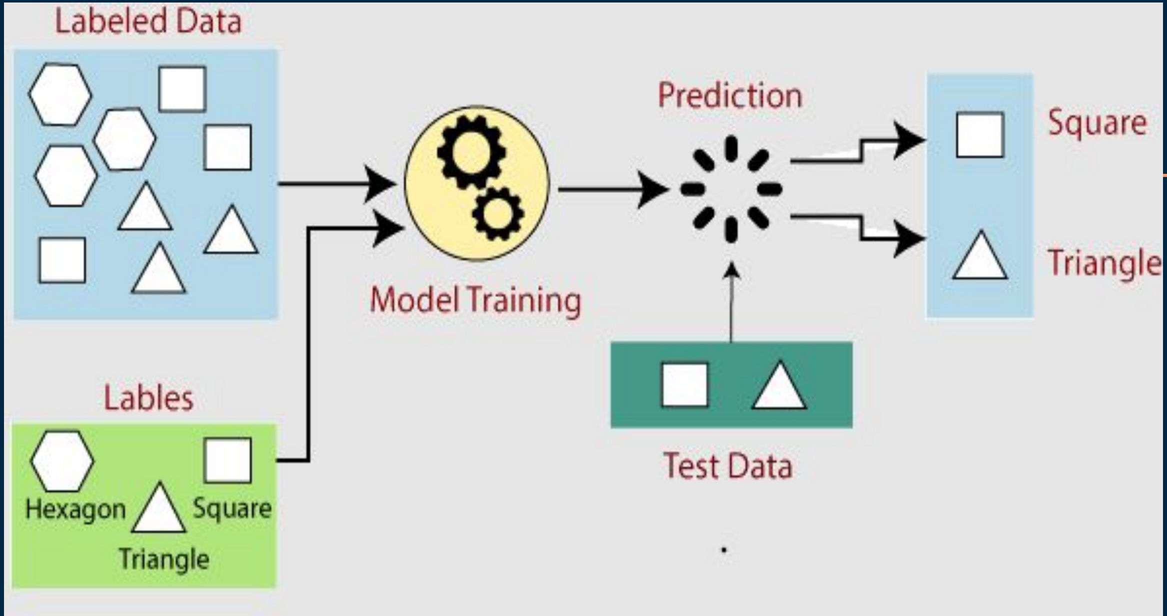
Background

Background- TBI

- Caused by a violent bump, blow, or jolt to the head, resulting in a brain dysfunction
- Symptoms: confusion, blurry vision, concentration difficulty, and **motor dysfunctions**
- ~**25%** of people achieve **long-term functional independence** following TBI
- Moderate and severe brain injuries → **long-term** challenges, such as **permanent physical and mental limitations**

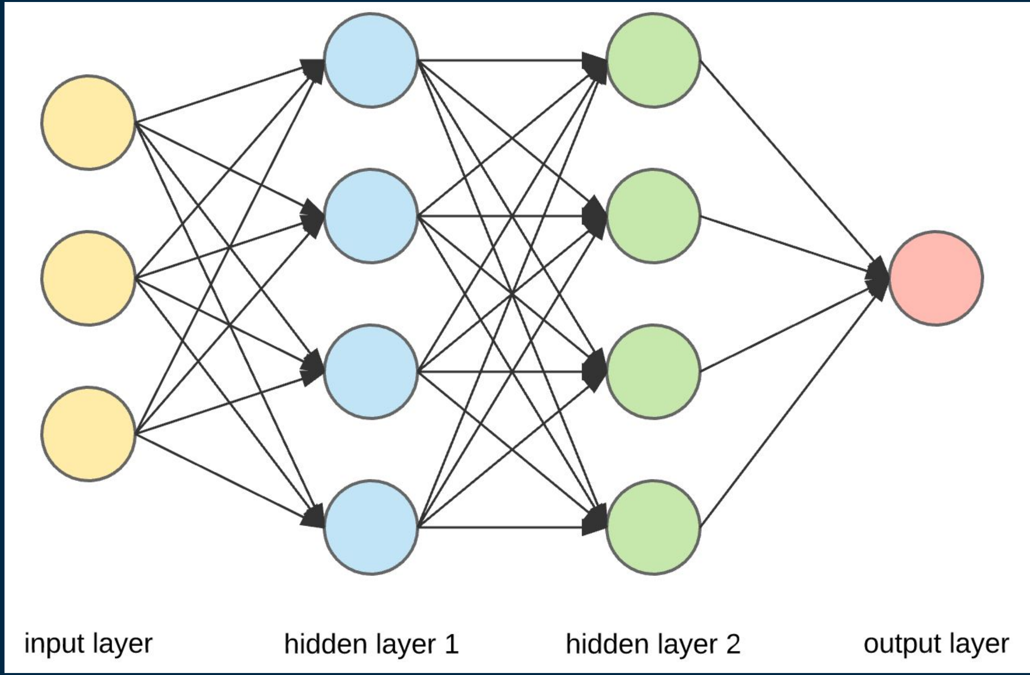
Background- Artificial Intelligence (AI)

- Machine programmed to imitate human cognition
  - Input vector → (function) → output vector
  - Training data: has both input and output, shows model what output vector *should* be
  - Use math to find function that best fits training data
  - This function is the trained model



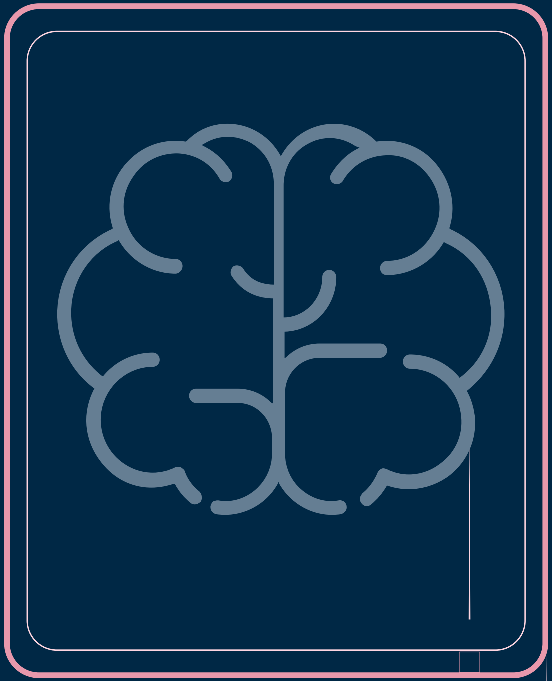
Background- Artificial Intelligence (AI)

- Neural nets
  - Takes input vector, runs it through neural net to get output
  - **Takeaway: less noise in the input vector = better training**



AI is applicable in every corner:

- AI therapist
- Diagnosis
  - Detecting autism from video
  - Predicting depression from facebook posts
  - Finding brain abnormalities from scans
- Reading brain signals
  - Recreating video from brain waves
  - Seizure prediction
- Efficient/reproducible quantification of subjective measures
  - NLP’s to compare phases
  - Quantifying aspects of therapy, allowing implementation of scientific method in evaluating therapeutic methods



Problem

Problem & Need Statement

PROBLEM

- TBI affects people in vastly different ways
- patients face **incomplete recovery** of motor deficits due to lack of **personalized rehabilitation resources**

NEED

- Patients diagnosed with TBI need to find **personalized motor rehabilitation** programs in order to improve their **motor** skills.

Demographics

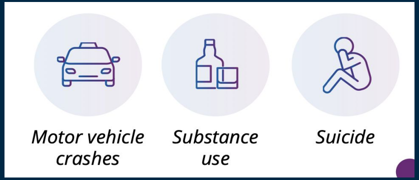
Region

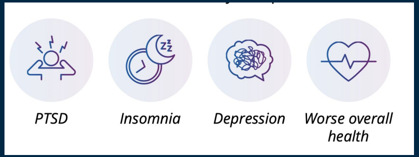
Each year in the United States:

- **two million people** suffer a traumatic brain injury
- 500,000 people are **hospitalized** for TBI
- 270,000 people experience a **moderate or severe TBI**
- 50,000 people **die from head injury**

Groups affected by TBI

- **Homeless**
- **Domestic Violence Survivors**
- **Military Service Members & Veterans**
- **Racial** and **Ethnic Minorities**
- People in **Correctional** or **Detention Facilities**





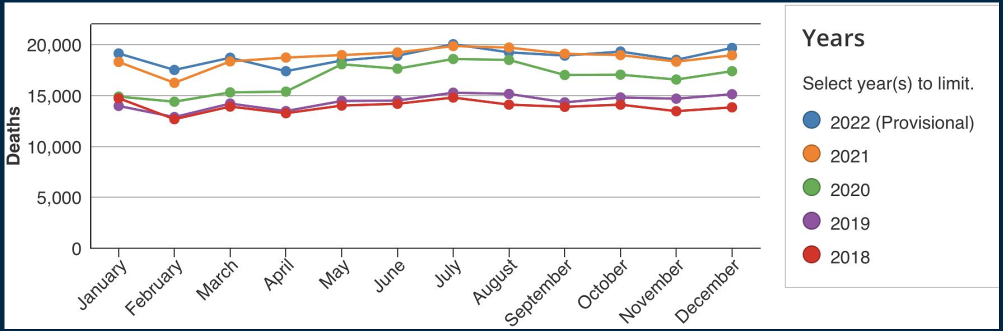
Males

The rate of TBI-related hospitalizations in males is

2 times as high as in females

The rate of TBI-related deaths in males is

3 times as high as in females

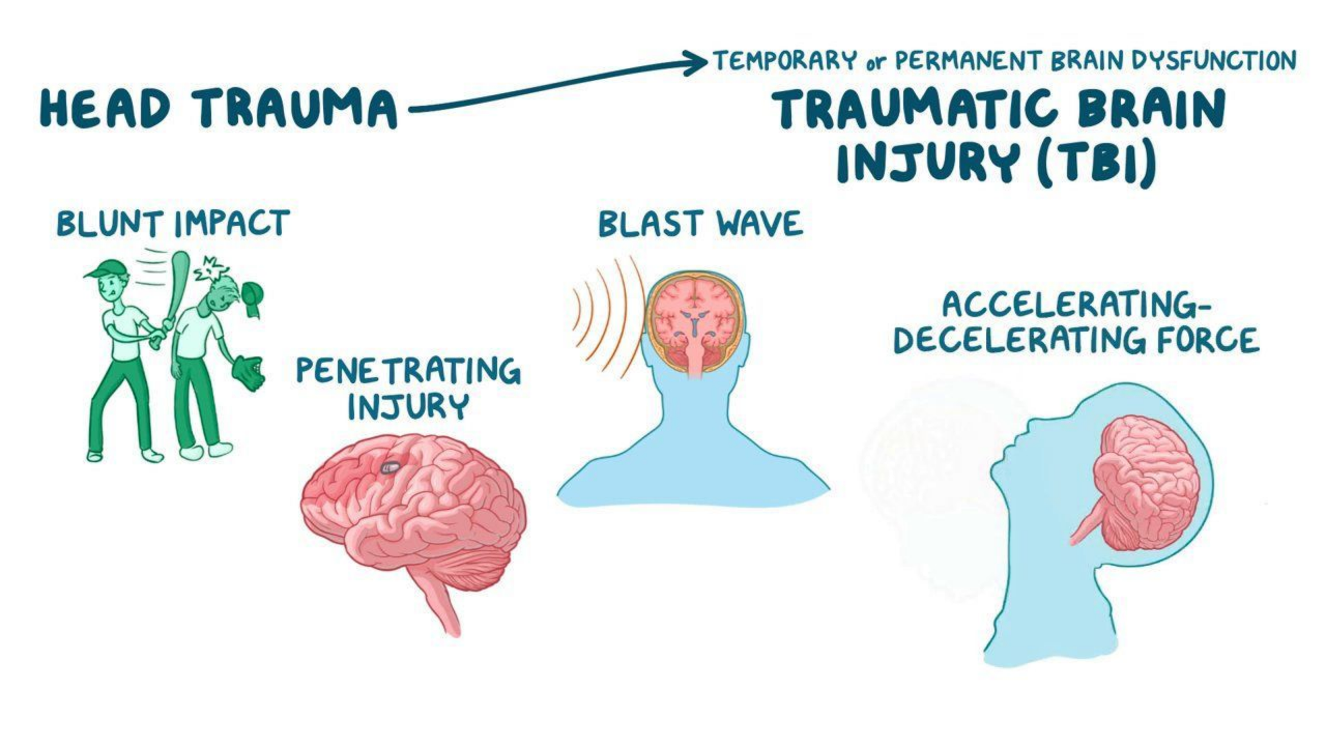


Solution

Solution

- Our solution is **VAT**, a virtual reality technology that helps TBI patients improve motor skills
- VAT incorporates the use of artificial intelligence to better collect data on people's existing motor skills
  - Allows for better training of AI-diagnosis models and better diagnosis using these models
  - Allows for more adaptive and personalized treatment adheres to each patient's needs,

TARGET AUDIENCE



Process

1. Patients enter a Neurology Clinic
2. Patients take a Diagnostic Test
    a. Brain scan
    b. Healthcare history
    c. Motor skills test
3. Receive VR to take home and do activities, complete activities at home
4. Schedule follow up appointments (frequency of follow up on case by case basis, depending on severity of TBI

Activities

The activities that the VR would implement include gross motor coordination skills, which have proven to help patients struggling with motor issues post TBI*.

- AI would identity motor deficits
  - Could tailor courses to patient to best map out motor function
- VR headset could use output from AI model to present personalized course for patient
- It is important to consider personal patient progress and severity of TBI when listing activities

Table II. *Bruininks-Oseretsky Test of Motor Proficiency results: the 4 subtests of gross-motor function and upper-limb co-ordination and the 3 subtests of fine-motor function*

	MTBI group $n=27$			Control group $n=79$			
	Mean (SD)	Median	Range	Mean (SD)	Median	Range	p-value
Gross-motor function							
Running speed and agility[a]	9.1 (4.9)	9	1–17	9.9 (3.9)	11	1–17	Ns
Balance	15.4 (4.4)	15	1–20	17.4 (4.7)	18	1–26	0.03
Bilateral co-ordination	17 (5.1)	17	1–19	18.4 (3.7)	19	1–19	Ns
Strength	16.3 (6.1)	17	1–28	17.1 (4.8)	17	1–21	Ns
Upper-limb co-ordination	16.2 (4)	17	1–17	17 (4.5)	17	1–24	Ns
Fine-motor function							
Response speed	16.9 (6.2)	16	1–22	19.1 (5.6)	19	1–24	Ns
Visio-motor control	17.2 (5)	18	1–22	18.3 (4.5)	19	1–25	Ns
Dexterity	11.9 (7)	10	1–25	13.7 (4.7)	14	1–23	Ns

[a] $n=78$.

Standard score [15±5 points].

Ns: not significant; SD: standard deviation; MTBI: mild traumatic brain injury.

In the present study the BOTMp test in 27 children with acquired MTBI and 79 controls indicated that the MTBI group performed less well in sub-tests of fine-motor control and dexterity (p= 0.07)

Role of AI

Training Data

- First users of the V.A.T. take different motor tests
  - Example: Graded Wolf Motor Test

- Live brain scans through fMRI

Table 1: WMFT Task Items

1. Forearm to table (side)
2. Forearm from table to 25.4-cm box (side)
3. Extend elbow 28cm on table top (side)
4. Extend elbow 28cm on table top (1-lb weight)
5. Hand to table (front)
6. Hand to box (front)
7. Retrieve .45-kg weight from 28-cm line on table top by elbow flexion
8. Lift can to mouth
9. Lift pencil from table
10. Lift paper clip from table
11. Stack 3 checkers
12. Flip 3 cards
13. Turn key in lock: clockwise to 180°, counterclockwise to 180°, and back to the starting position
14. Fold face towel
15. Lift basket with 1.35-kg weight from chair to fully raised bedside table

Application

Input:

- Movement data collected from devices on patient joints as they move through VR experiences

- Motion sensors on the VR can capture real time movements of patients such as accuracy, speed, or range of motion

Output:

- Quantification of motor skills

- Performance Tracking
- Scores on a variety of subtypes of skills

- Adaptive Levels of Difficulty

Why VR?

- Greater real-time malleability for patient experience
    - E.g. if algorithm wants to further test a certain motor skill, it can present a course that uses that skill
- Standard obstacle courses → consistent training data → better ML models

*AI algorithms can lead to the better quantification of motor skills, for better training data and better medium for diagnosis

Implications

Prediction

- VR = better medium to collect motor-skill data, ML algorithms will be **easier to train** and have better data upon which **to make predictions**
- VR also provides **more time** in motor-control therapy, **improving patient outcomes**
- VAT = access to **personalized treatment** for TBI patients
- Further research:
    - Use VR therapy for other medical conditions, such as anxiety, post traumatic stress disorder, depression, etc.

Obstacles to V.A.T.

- **Cost** of a Virtual Reality set
  - Virtual Reality therapy costs an average of **$49.45 - $77.50 per week**
  - Movement-intensive VR **needs additional apparatuses** to keep patients from running into obstacles (e.g. treadmill-type device)
- Locomotion **sickness**
- Long-term **eye damage**
- Exploitation of and **addiction** to VR world
- **Lack of quality training data** for AI model

We hope you enjoyed our presentation!

Thank you!

Works Cited

CDC. (2020, August 19). *Health Disparities and TBI | Concussion | Traumatic Brain Injury | CDC Injury Center*. Www.cdc.gov. https://www.cdc.gov/traumaticbraininjury/health-disparities-tbi.html

Get the Facts About TBI | Concussion | Traumatic Brain Injury | CDC Injury Center. (2023, April 20). Www.cdc.gov. https://www.cdc.gov/traumaticbraininjury/get_the_facts.html#:~:text=Anyone%20can%20experience%20a%20TBI

Mayo Clinic . (2019). *Traumatic brain injury - symptoms and causes*. Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/traumatic-brain-injury/symptoms-causes/syc-20378557

National Institute of Neurological Disorders and Stroke. (2023). *Traumatic Brain Injury (TBI)*. Www.ninds.nih.gov. https://www.ninds.nih.gov/health-information/disorders/traumatic-brain-injury-tbi

Traumatic brain injury epidemiology and demographics - wikidoc. (n.d.). Www.wikidoc.org. Retrieved July 20, 2023, from https://www.wikidoc.org/index.php/Traumatic_brain_injury_epidemiology_and_demographics#:~:text=The%20age%20groups%20most%20at

Wolf Motor Function Test (WMFT). (n.d.). Strokengine. https://strokengine.ca/en/assessments/wmft/