Classifying Eye-Tracking Scanpaths to make Autism Spectrum Disorder (ASD) Diagnoses More Accessible

... improve People's Lives with Early Diagnosis

Team: Shine with Eyes
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Introduction of the Team

NINA

Product Manager / Project Manager

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Data Engineer / Project Manager

JESSE

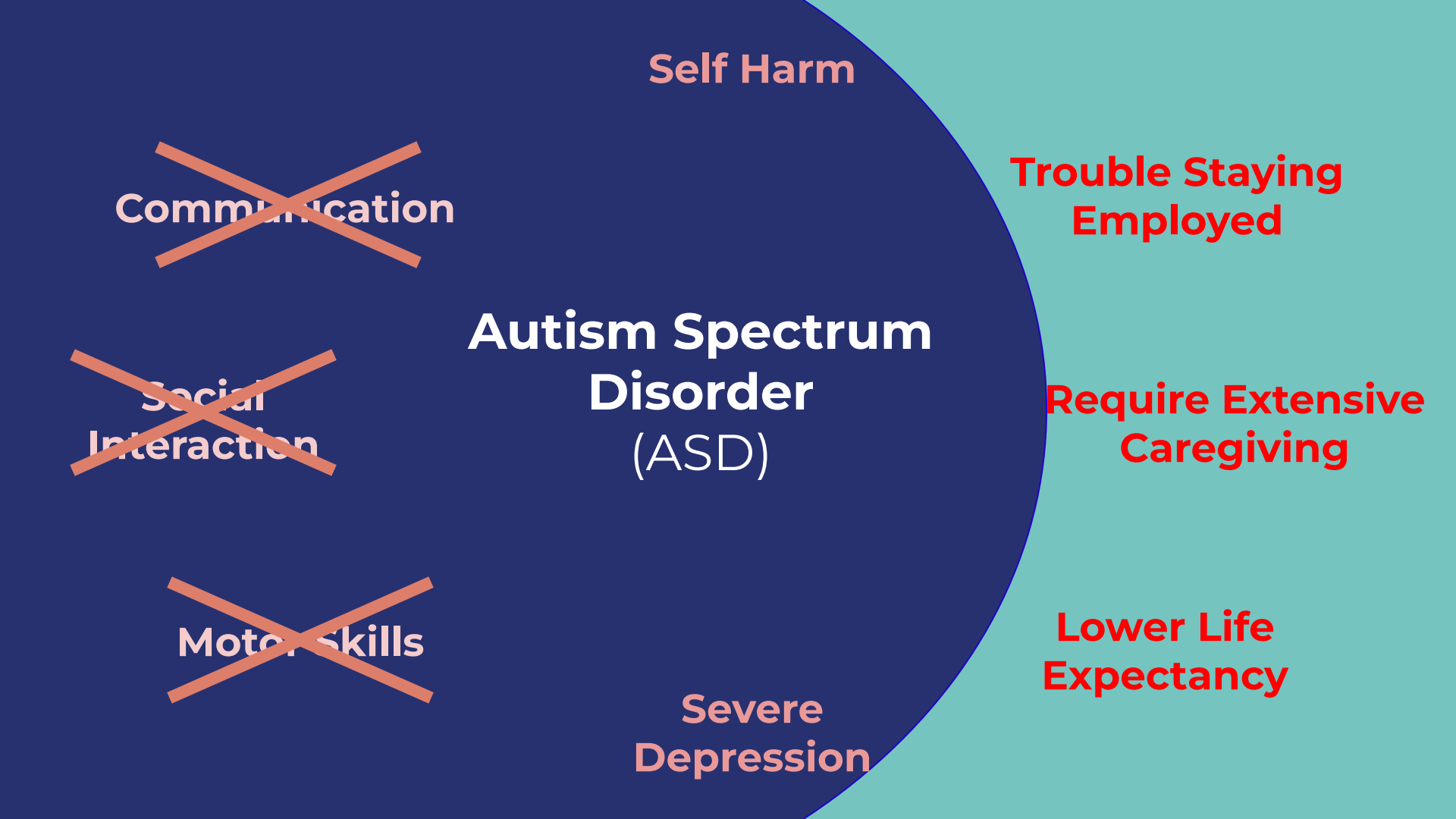
Machine Learning Engineer / Deployment Architect

WAQAS

Machine Learning Engineer / Data Engineer

MAKENZIE

SME Feedback/ Website Development Lead


Self Harm
Communication
Trouble Staying Employed
Autism Spectrum Disorder
(ASD)
Social Interaction
Require Extensive Caregiving
Motor Skills
Lower Life Expectancy
Severe Depression

A Closer Look at Autism Spectrum Disorder (ASD)

NO CURE [13] .. but .. **TREATMENT** can **REDUCE SYMPTOMS** to **UNLEASH POTENTIAL** and **IMPROVE QUALITY OF LIFE** [14]

1.5 yrs old
early ASD detection [12]

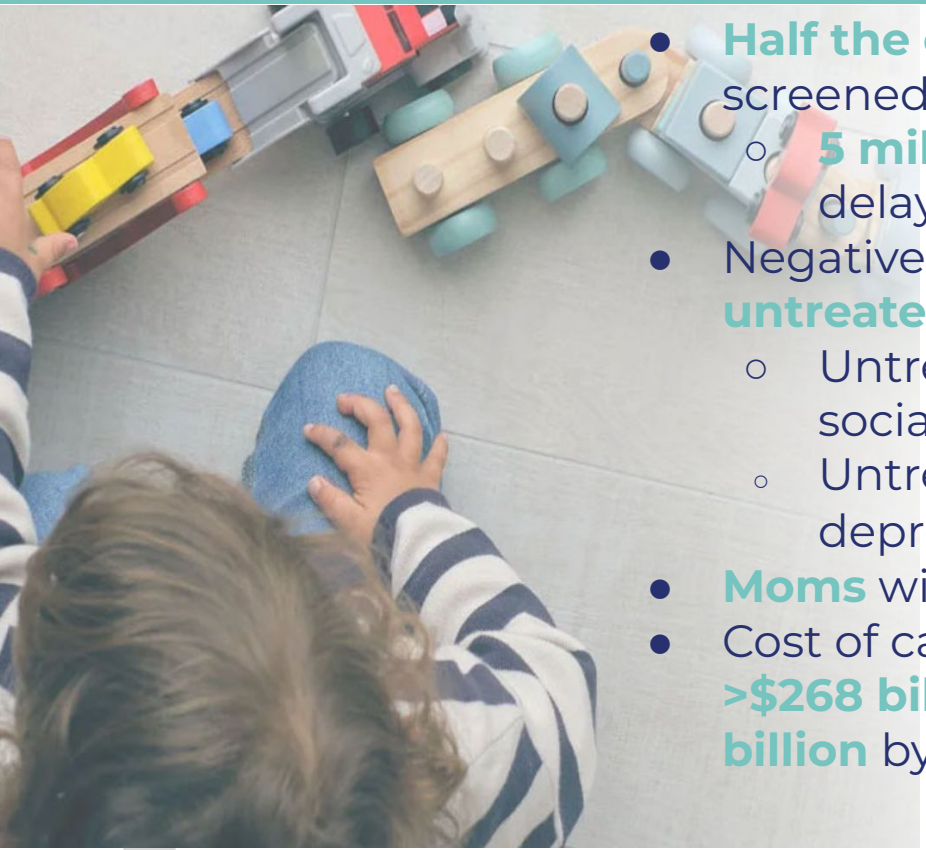
5 yrs old or younger
for effective early intervention (e.g. ABA) [4]

2-year
average ASD diagnostic wait time[1]

Sensitive Time Window for Diagnosis

Nina

ASD - What does it mean?



- **Half the children** in the US are currently being screened for ASD
  - **5 million** children are at risk of developmental delay [3]
- Negative symptoms can worsen over time **if untreated** [5]
  - Untreated **Children**: Poor motor abilities and social skills; Self harm in children [6, 7]
  - Untreated **Adults**: Employment; Severe depression; Lower life expectancy [6]
- **Moms** with children having ASD earns 33%-56% less [3]
- Cost of caring for Americans with autism costs **>$268 billion** today and projected to reach **$461 billion** by 2025 [8]

Nina

Emerging ASD Diagnostic Solution Landscape

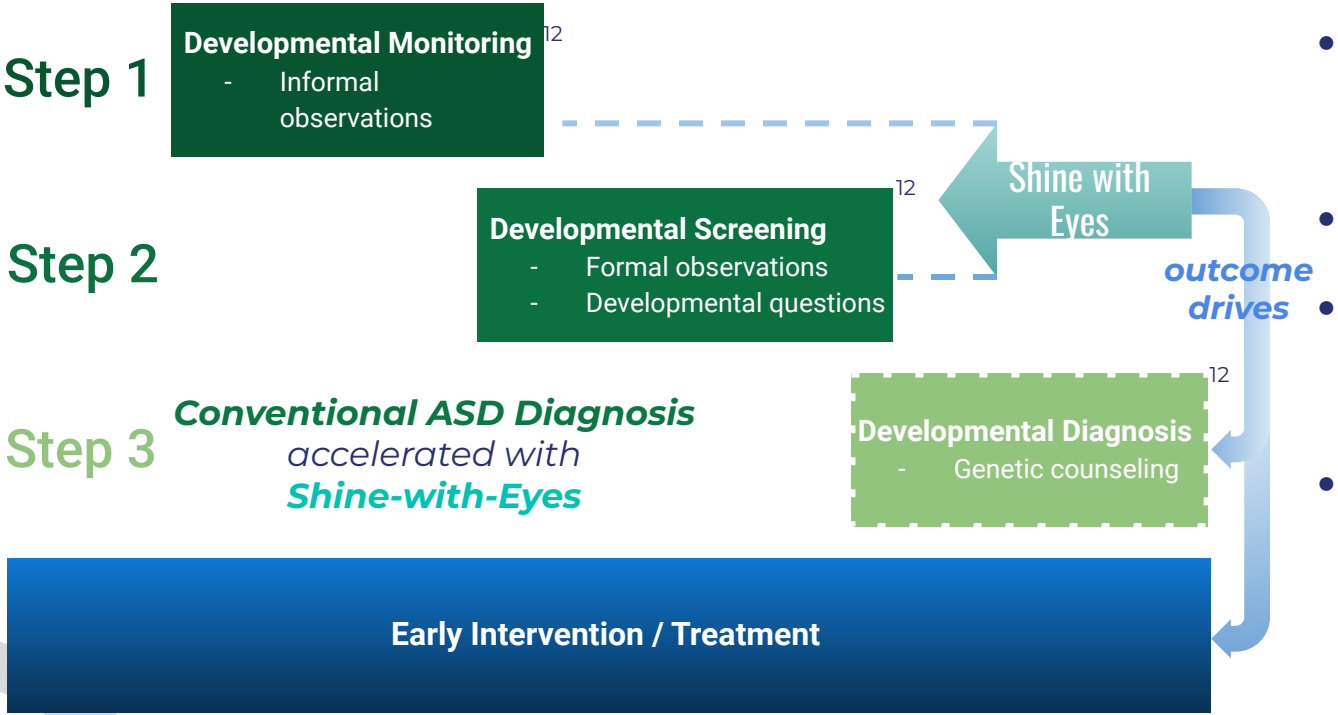
- **An alternative** or supplementary solution to the conventional development monitoring approach focusing on a wide range of drivers:
  - Health history
  - Behavioural data
  - Eye movement
- **Target users:**
  - Healthcare providers [3]
  - Patient & families [3, 9]
- **Leaders:**
  - EarliTec Diagnostics Inc. [9]
  - Cognoa [3]

EarliTec Diagnostics Inc.

cognoa

Our Solution: Shine with Eyes

… improve People's Lives with Early Diagnosis



- A **supplementary** diagnostic solution which is **HIPAA compliant** with no PHI stored [10, 11]
- **AI powered** diagnosis based on eye scanapath
- Introduced in early stages (steps 1-2) of the ASD diagnostic journey to **accelerate** the
- Supports **healthcare providers** who want to have more confidence in their medical diagnostic decisions for **children 2.5-5 years of age**

Current State of ASD - Domain Expert Feedback

SME INTERVIEWS

- Pediatric psychiatrist
- PhD Professor in Dept. of Psychiatry & Behavioral Sciences

MAIN CHALLENGES

- Heavily reliant on in-person observations
- Narrow participant window, focus on younger siblings of
- Increasingly high demand for diagnostic screens
- Child may behave differently in different settings
- Lack of standardization across specialists

MVP - Addressing SME Pain Points

Ease of Use

Straightforward interface and easily interpretable results

Explainability

Increased description of results and outcome probability

Reliability

Secure connection to machine learning model and image database storage

Quicker Results

Higher efficiency for part of the diagnostic process

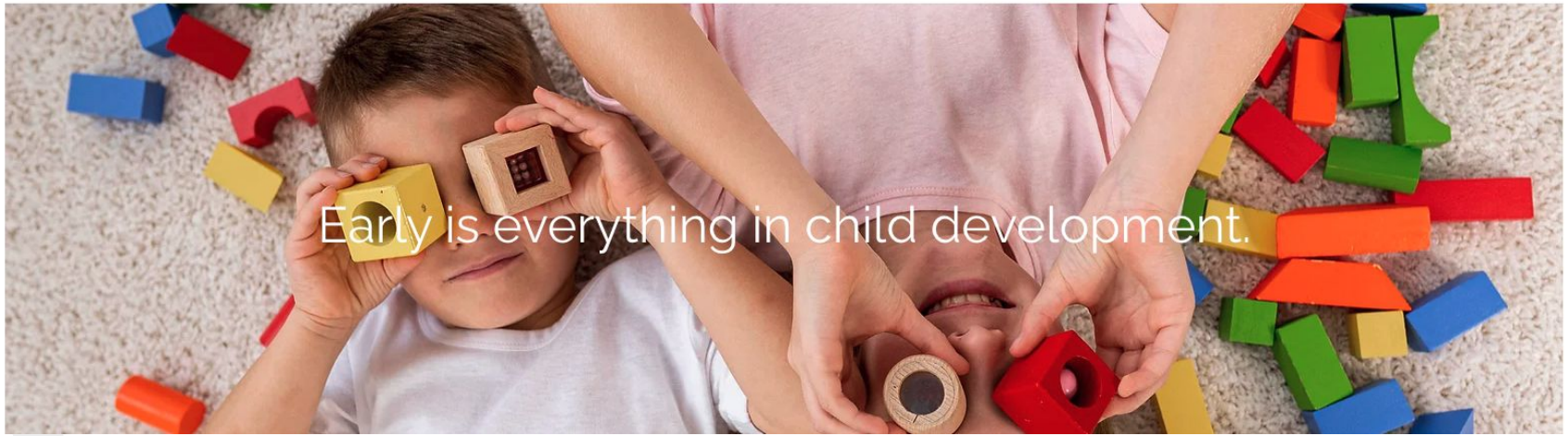
Demo - Provider Portal & Results

Log In

Shine with Eyes

An Autism Spectrum Disorder (ASD) Early Diagnostic Support Tool

Home Project Overview Product Demo image test



Deployment Architecture

Highly Available

Access anywhere, anytime

Highly Reliable

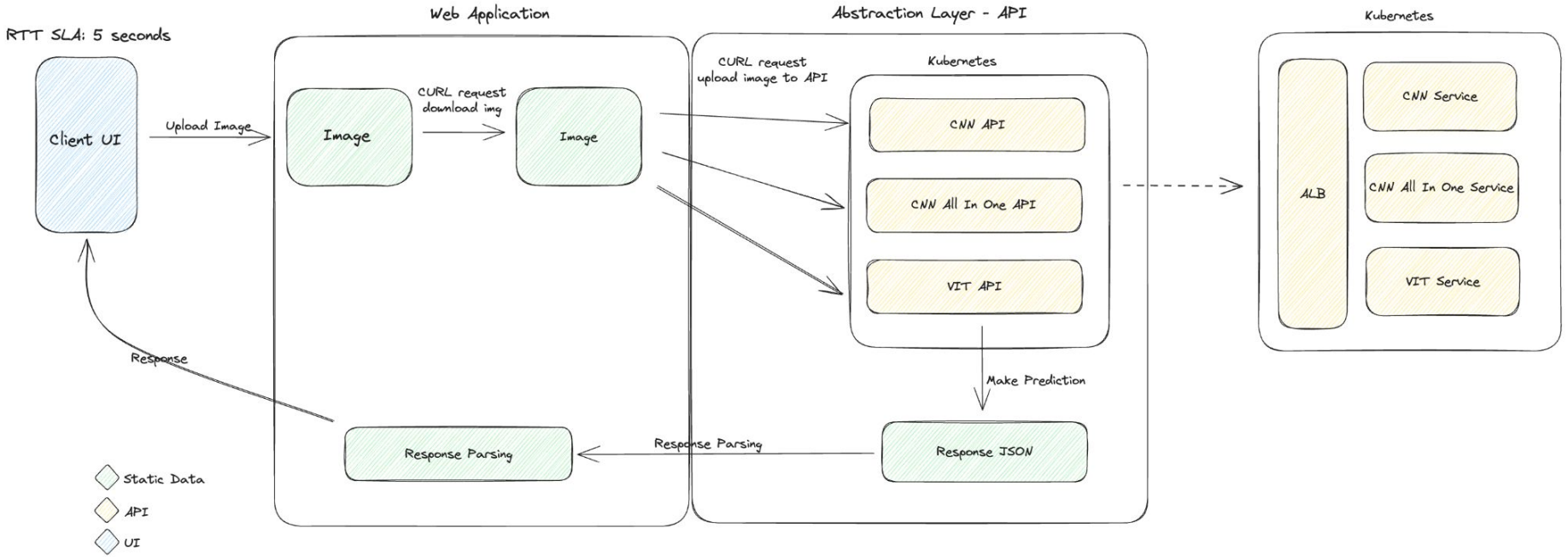
No interruptions. Ever

Highly Scalable

No throttling no matter the traffic

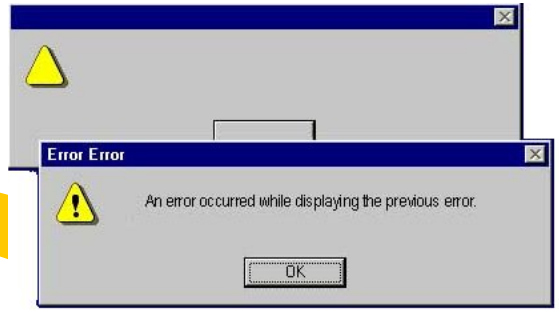
Jesse

Deployment Architecture



Deployment Architecture

Key Learnings



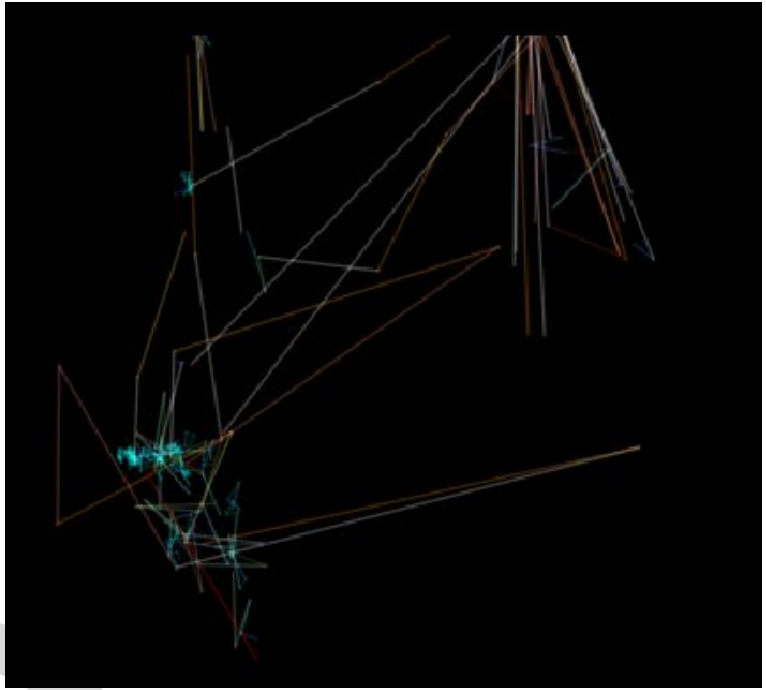
Lots of logging for deployment

Packages are identical between development and deployment

Unblock yourself

Data & Features

Images - Eye Scanpath



Features

Cyan	Fixation
White	Saccade
Green	Acceleration
Blue	Jerk
Red	Velocity

Challenges

1. Small Datasize
2. Lack of Features
3. Unknown Start/End-point

Classifying these images is a DIFFICULT problem to solve.

Waqas

Data Split - Test/Train/Validation

DataSize

- Image Count: 547
- Positive Class (ASD): 219
- Negative Class (Non-ASD): 328

Train-Test Split

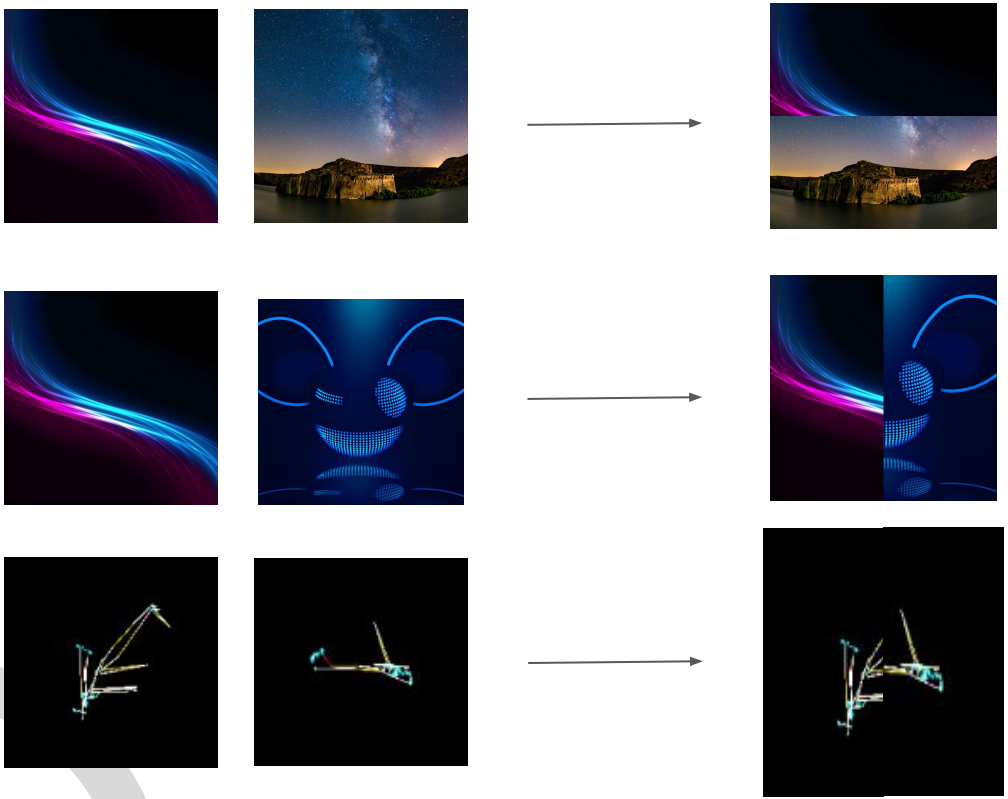
- Train: 90% - 492 images
- Test: 10% - 55 images

Train-Val. Split

- Train: 70% - 344 images
- Validation: 30% - 148 images

Data augmentation increased training data size by 10x.

Data Augmentation - Mix & Match Strategy



Horizontal & vertical concatenation of all image combinations (within each participant) increased training data size **10x**.

Pros: Huge multiplier of data & mitigated overfitting issue.
Cons: Caveat as synthetic data.

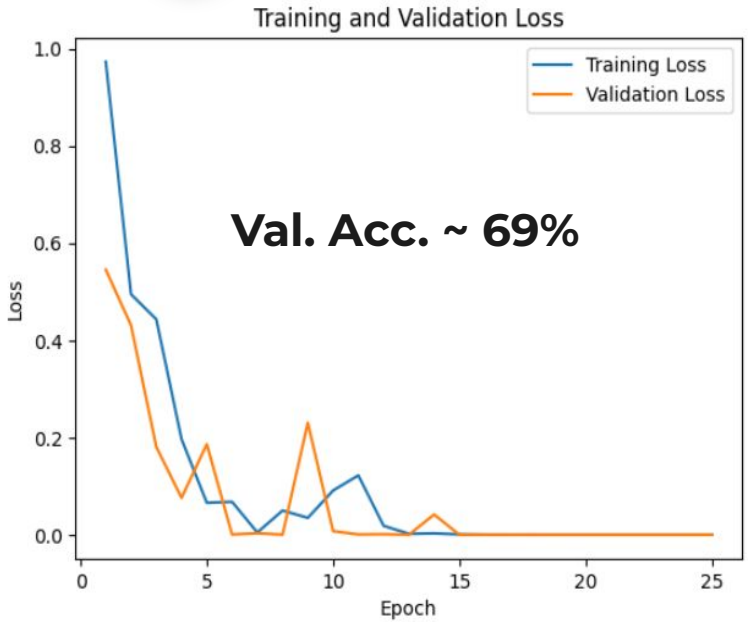
Mohith

Model Exploration

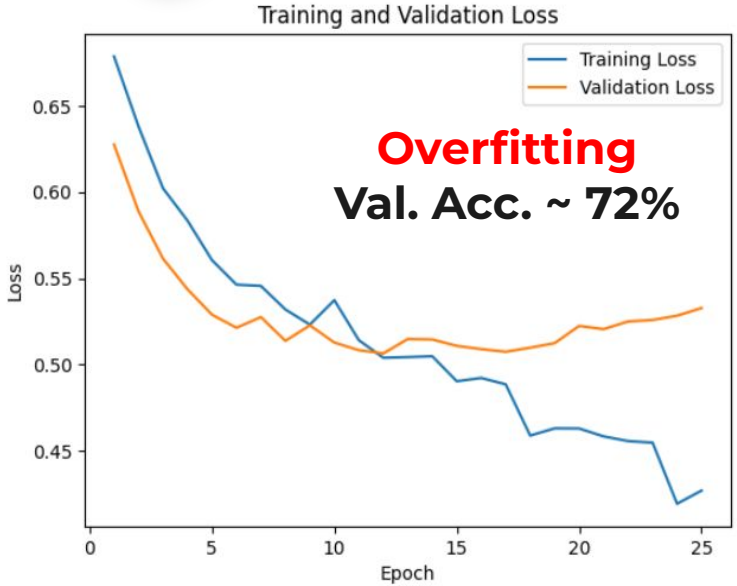
	No.	Model	Description	Training Time	Parameters	Validation Accuracy
Feature Engineering + ML Model	1	**CNN**	CNN Full Feature	11min *15 epoch*	19.7M	73%
	2	**CNN**	CNN Compressed	15min *50 epoch*	8.9M	79%
	3	**CNN**	CNN All In One (with manually extracted features)	15min *50 epoch*	8.9M	79%
	4	**CNN**	CNN Features + Random Forest	15min *50 epoch*	8.8M	69%
Language Model	5	**Transformer**	Language Transformer Model / Coordinates Data (only 100)	25 min. *5 epoch*	14M	15%
Vision Model	6	**ViT**	Pre-trained / fine-tuned / Original Data	1 hrs. *25 epoch*	85M	69%
	7	**ViT**	Pre-trained / fine-tuned / Encoder unfrozen / original Data	1 hrs. *25 epoch*	85M	72%
	8	**ViT**	Pre-trained / fine-tuned / Augmented Data	2 hrs. *25 epoch*	85M	99%
	9	**ViT**	Pre-trained / fine-tuned / Encoder unfrozen / Augmented Data	2 hrs. *25 epoch*	85M	98%

Model Training

A Pre-trained ViT



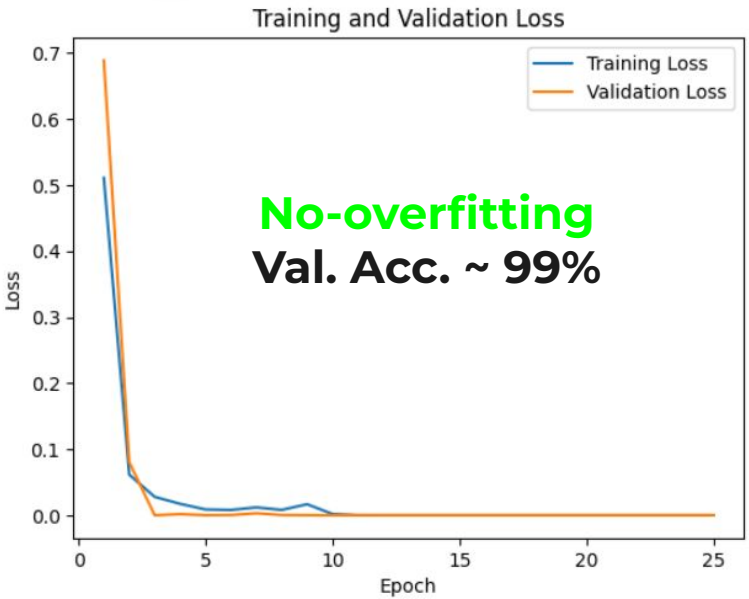
B Pre-trained ViT + Unfrozen embeddings



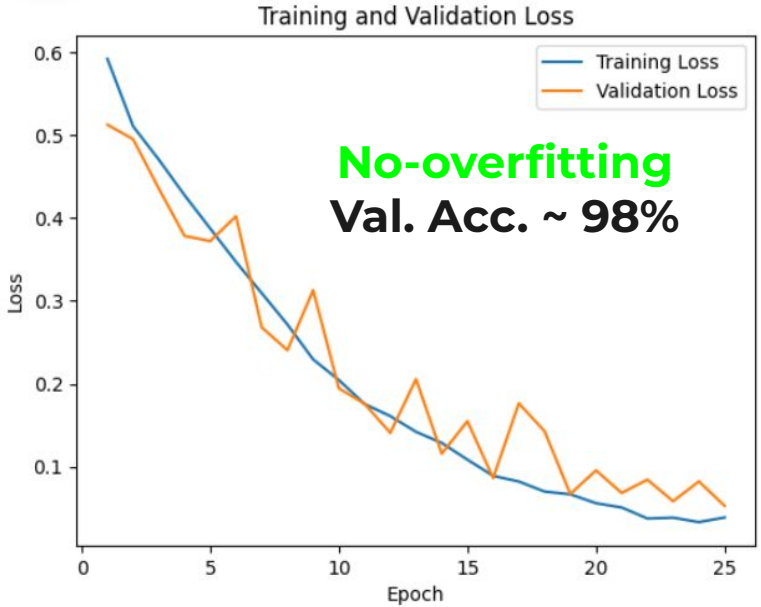
Small data size and lack of features were our biggest challenges and it caused overfitting and poor validation accuracy.

Model Training

C **Pre-trained ViT + Data Augmentation**



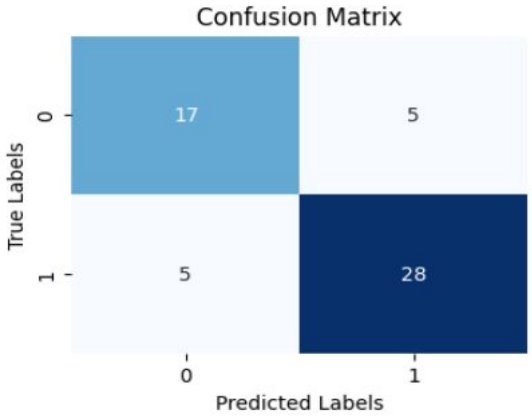
D **Pre-trained ViT + Data Augmentation + Unfrozen embeddings**



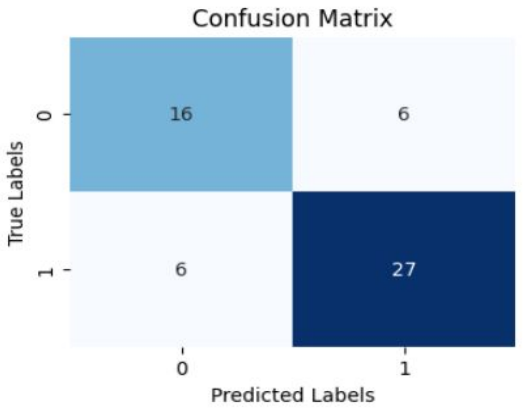
Data-augmentation fixed the over-fitting problem.
ViT model along with data augmentation has the best validation accuracy.

Model Evaluation

A **Pre-trained ViT + Data Augmentation**

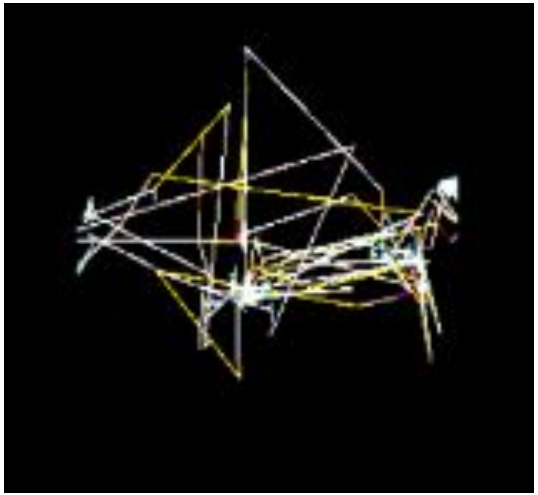


B **Pre-trained ViT + Data Augmentation + Unfrozen embeddings**



Model	Class	Precision	Recall	Test Accuracy
A	0	77%	77%	82%
	1	85%	85%	
B	0	73%	73%	78%
	1	82%	82%	

Model Deficiency - Recall



True Positive

✓	Cyan
✗	White
✓	Yellow
✗	Total Eye Movement

False Negative

Absence of characteristic features i.e. total eye movement and saccade led to false negative.

Extended Capstone - Future Ideas

Technical

- Improve Language Transformer Model by improving coordinates selection
- Set up lab to collect our own eye scanpath data

Non-Technical

- Clinical partnership outreach to improve product
- Website enhancement to professional startup standard

Mohith

... to improve people's lives

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