

ALZHEIMER'S - MEDICAL IMAGE ANALYSIS USING SELF SUPERVISED AND SEMI SUPERVISED LEARNING APPROACHES

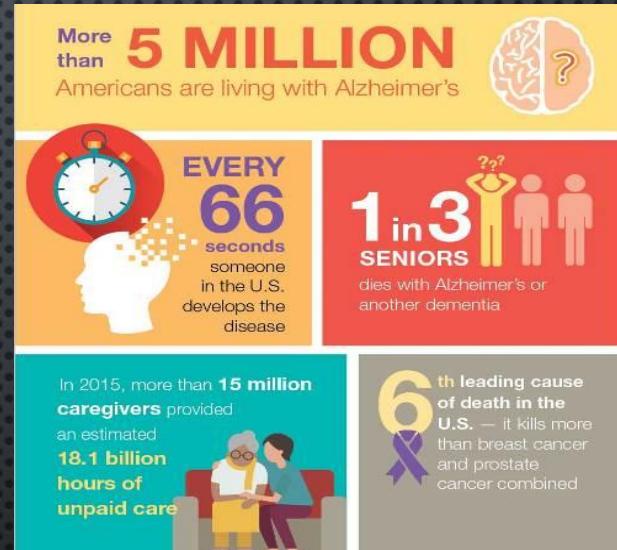
CMPE 297 - PROJECT PRESENTATION

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GRADUATE STUDENTS, SOFTWARE ENGINEERING, SJSU

ALZHEIMER'S

WHAT IS IT? IN NUMBERS?

A PROGRESSIVE, DEGENERATIVE
BRAIN CELL DISEASE THAT AFFECTS
MEMORY AND MENTAL FUNCTION

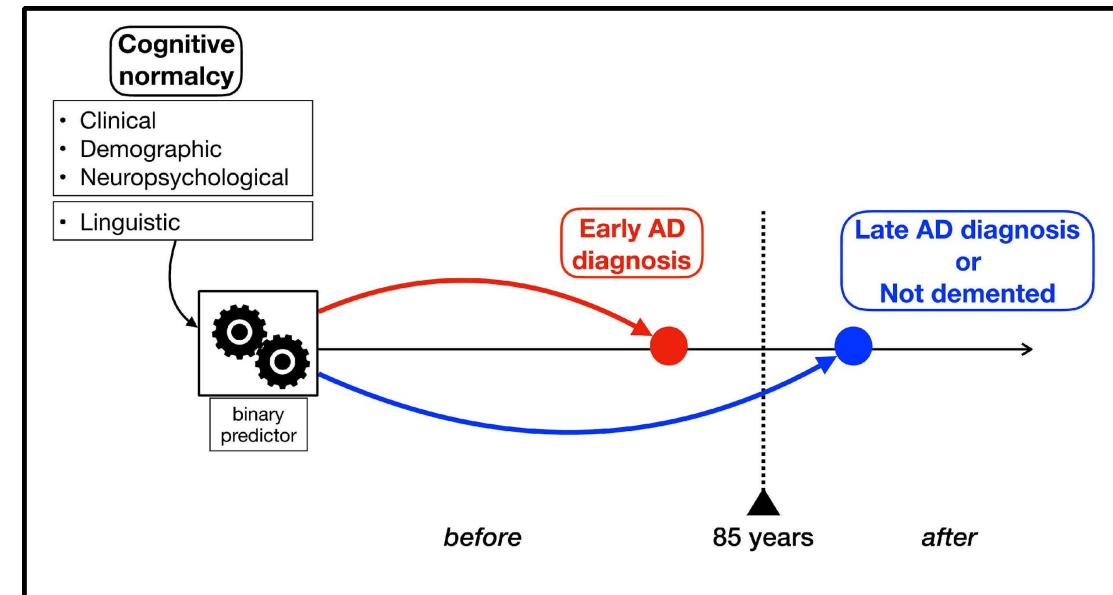


Pic Credit: Mayo Clinic Health System

ALZHEIMER'S ASSOCIATION REPORT:
EARLY DIAGNOSIS CAN SAVE \$7 TRILLION IN COSTS



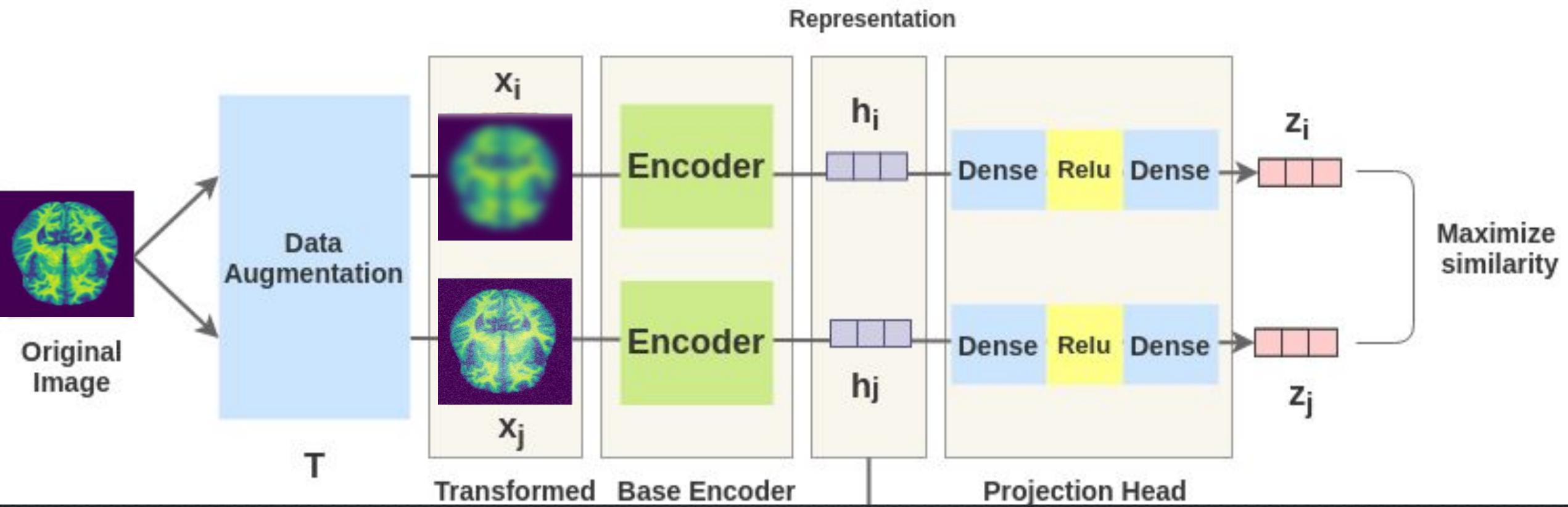
NEUROADIOLOGISTS MONITORING LESIONS



LINGUISTIC COGNITIVE NORMALCY TESTS

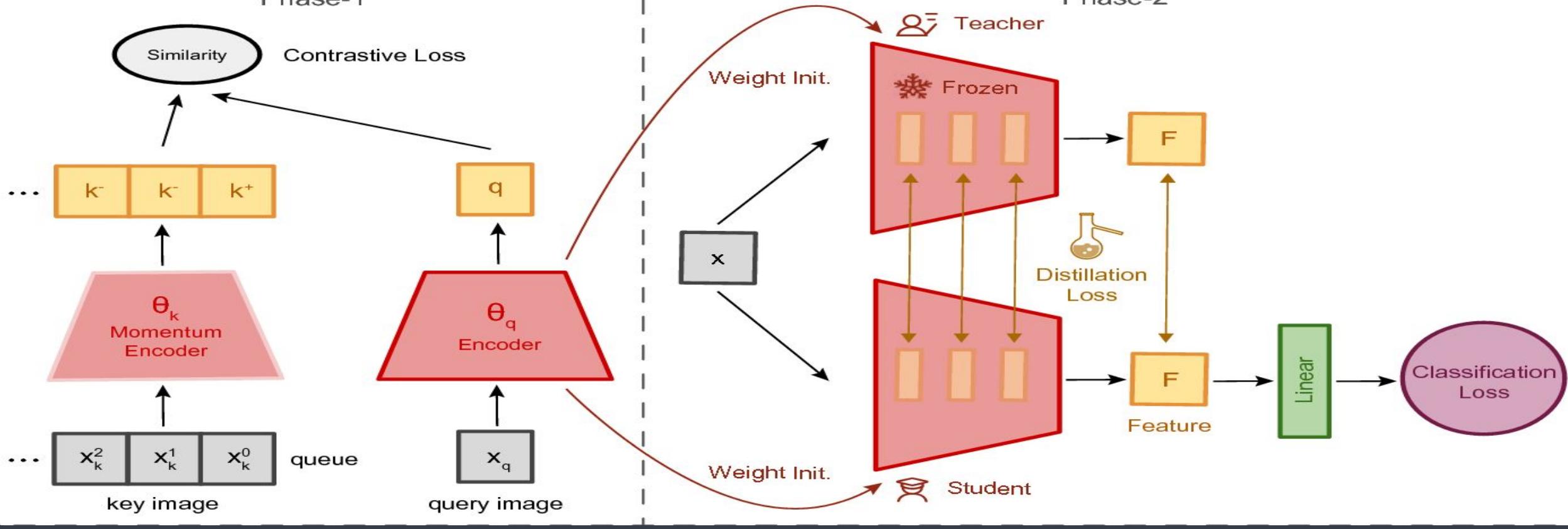
TRADITIONAL METHODS OF EARLY ALZHEIMER'S DETECTION

SimCLR Framework



Pic Credits: The illustrated SimCLR framework

SELF SUPERVISED CONTRASTIVE LEARNING VIA SIMCLR

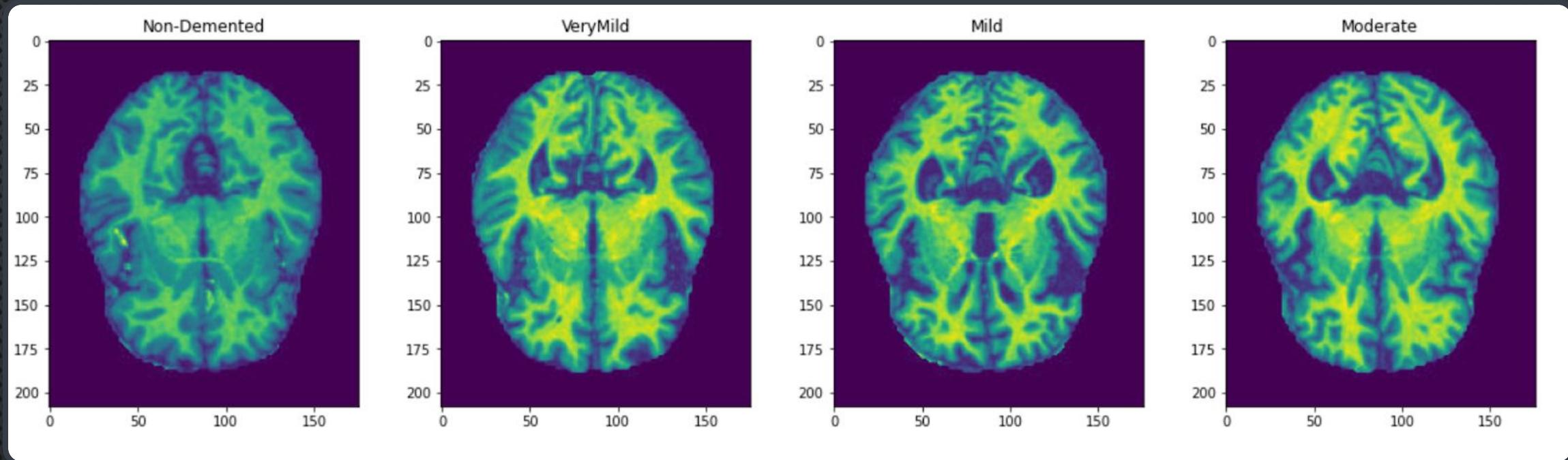


SELF SUPERVISED SIMCLR

SEMI SUPERVISED TUNING FOLLOWED BY KNOWLEDGE DISTILLATION FROM TEACHER TO STUDENT

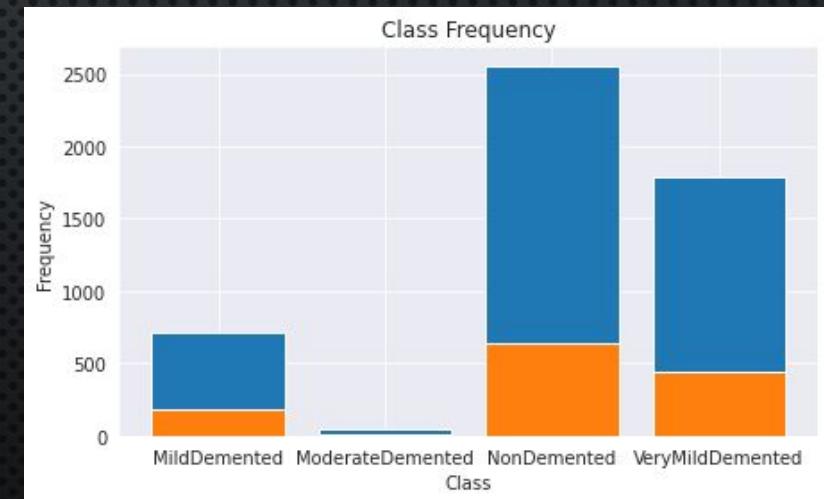
Pic Credits: Distilling visual priors from self supervised learning

SEMI SUPERVISED LEARNING USING SIMCLRV2



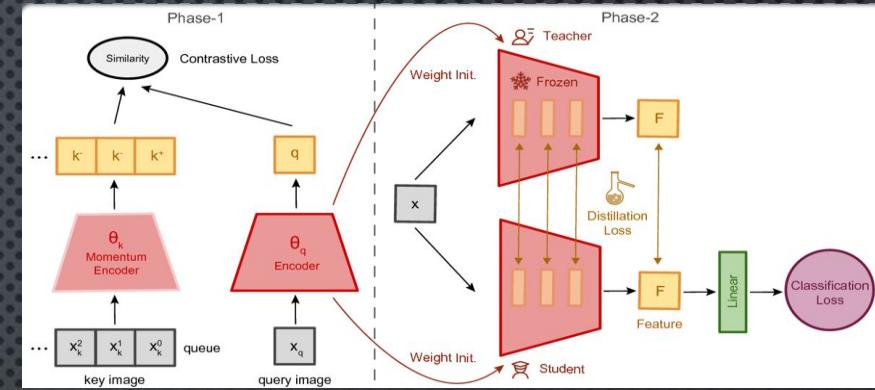
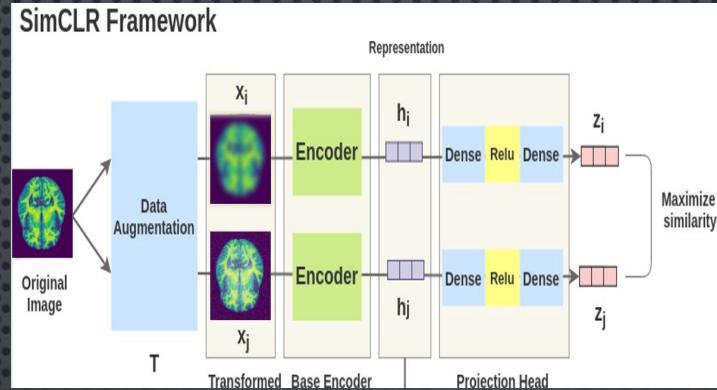
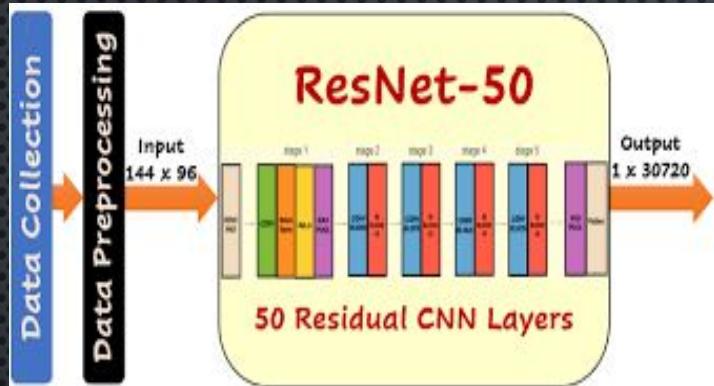
KAGGLE DATASET FOUR DIFFERENT STAGES OF ALZHEIMER'S

Training: 5121, Testing: 1279



simclr-checkpoints					
OBJECTS	CONFIGURATION	PERMISSIONS	PROTECTION	LIFECYCLE	
Buckets > simclr-checkpoints > simclrv2 > finetuned_100pct 					
UPLOAD FILES	UPLOAD FOLDER	CREATE FOLDER	MANAGE HOLDS	DOWNLOAD	DELETE
Filter by name prefix only ▾	 Filter	Filter objects and folders			
<input type="checkbox"/> Name	Size	Type	Created 	Storage class	Last modified
 r101_1x_sk0/	–	Folder	–	–	–
 r101_1x_sk1/	–	Folder	–	–	–
 r101_2x_sk0/	–	Folder	–	–	–
 r101_2x_sk1/	–	Folder	–	–	–
 r152_1x_sk0/	–	Folder	–	–	–
 r152_1x_sk1/	–	Folder	–	–	–
 r152_2x_sk0/	–	Folder	–	–	–
 r152_2x_sk1/	–	Folder	–	–	–
 r152_3x_sk1/	–	Folder	–	–	–
 r50_1x_sk0/	–	Folder	–	–	–
 r50_1x_sk1/	–	Folder	–	–	–
 r50_2x_sk0/	–	Folder	–	–	–
 r50_2x_sk1/	–	Folder	–	–	–

PRETRAINED MODEL – FINE TUNED SIMCLR MODEL
R50_1X_SK0 TRAINED ON 100% IMAGENET



EXPERIMENT 1

TRAIN SIMCLR RESNET50 ON 1% IMAGENET, FINE TUNE ON ALZHEIMER'S IMAGES

EXPERIMENT 2

USE PRE-TRAINED SIMCLR ON 100% IMAGENET, FINE TUNE ON ALZHEIMER'S IMAGES

EXPERIMENT 3

USE PRE-TRAINED SIMCLR ON 100% IMAGENET, PERFORM KNOWLEDGE DISTILLATION USING ALZHEIMER'S IMAGES

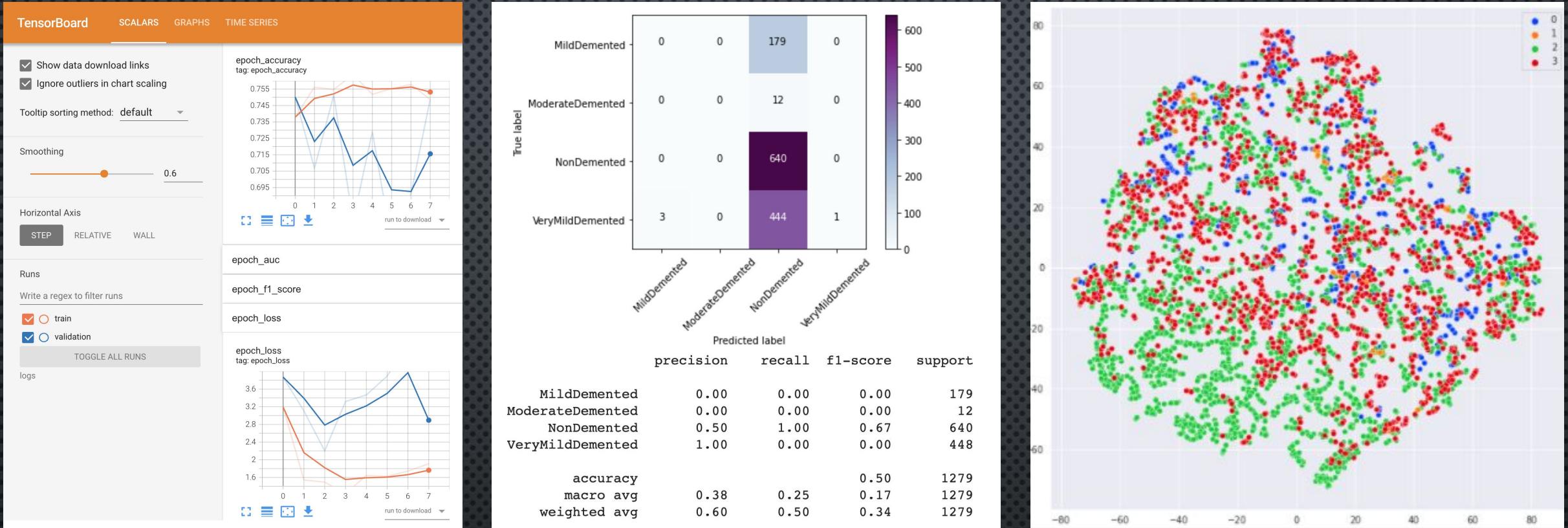
METHODOLOGY – COMPARE AND CONTRAST RESULTS FOR EXPERIMENTS 1- 3, PICK BEST MODEL

Model Configuration

Optimizer	<ul style="list-style-type: none">• RMSProp• Adam• LARS
Loss Function	Cross Entropy
Activation	Softmax
Learning Rate Scheduler	<ul style="list-style-type: none">• Exponential Decay• Cosine Decay• Step Decay
Early Stopping	Yes
Batch Size	16, 32, 64

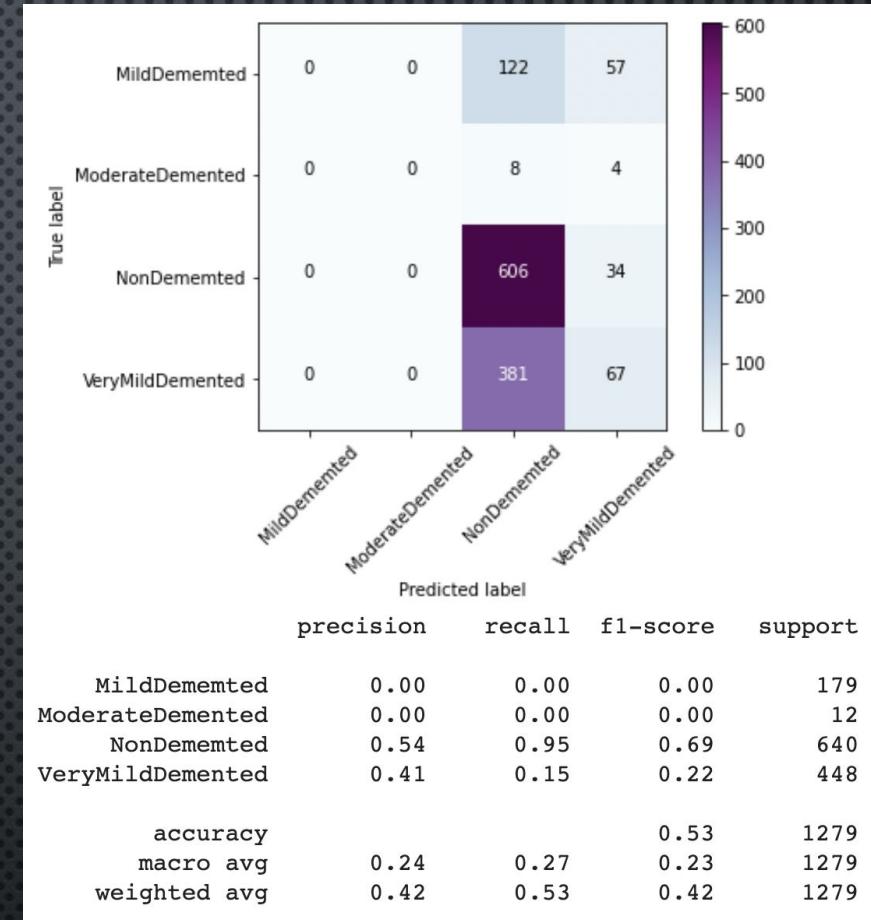
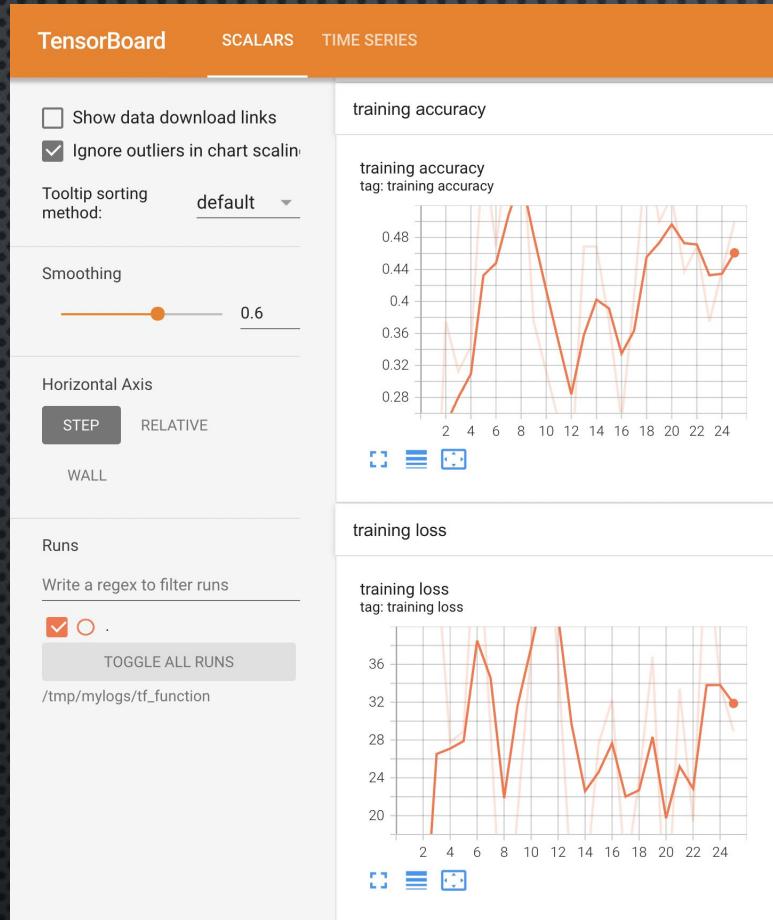
Evaluation Metric

Accuracy	Sample matching exactly as the ground truth. Best value at 1 and worst score at 0.
F1-Score	A harmonic mean of the precision and recall. Best value at 1 and worst score at 0.
Precision-Recall Curve	Important to consider for an imbalance dataset <ul style="list-style-type: none">• High precision = low false positive rate• High recall = low false negative rate• High scores for both means model returns accurate results and a majority of all positive results
AUC-ROC Curve	Ideal point at the top left corner of the plot <ul style="list-style-type: none">• a false positive rate of zero, and a true positive rate of one The area under the curve (AUC) shows how well the model is capable of distinguishing between classes

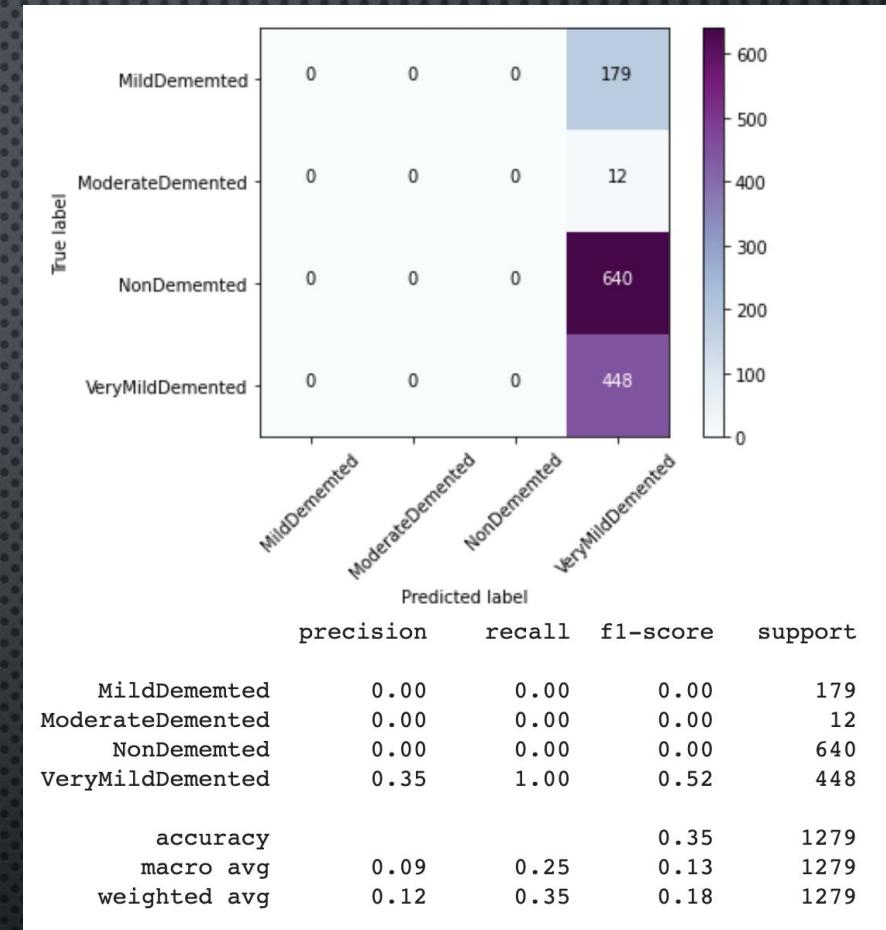
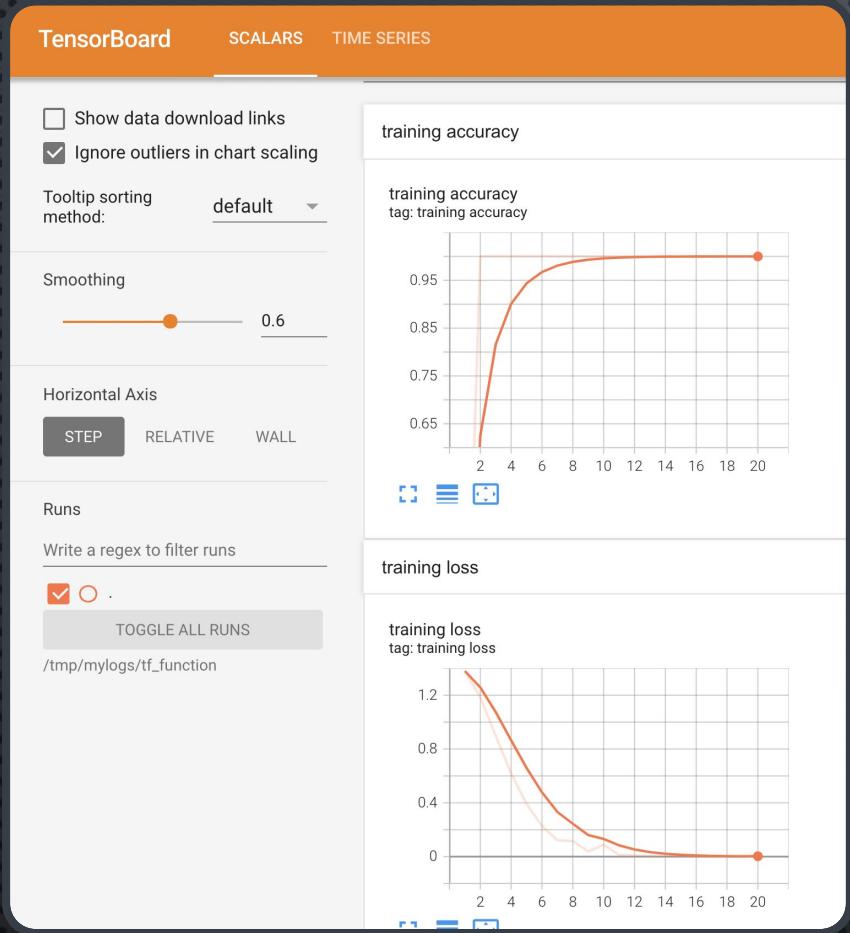


Weights and Bias Directory: Used to run experiments, save/ restore models

RESULTS – SIMCLR RESNET 50 WITH NON-LINEAR PROJECT HEAD

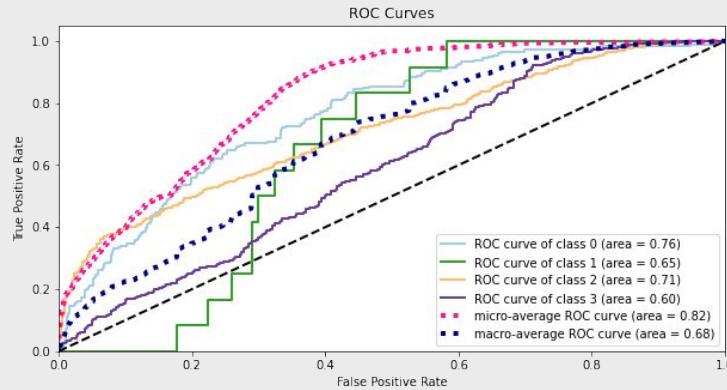


RESULTS – PRETRAINED SIMCLR WITH SIMCLRV2 ON ALZHEIMER IMAGES

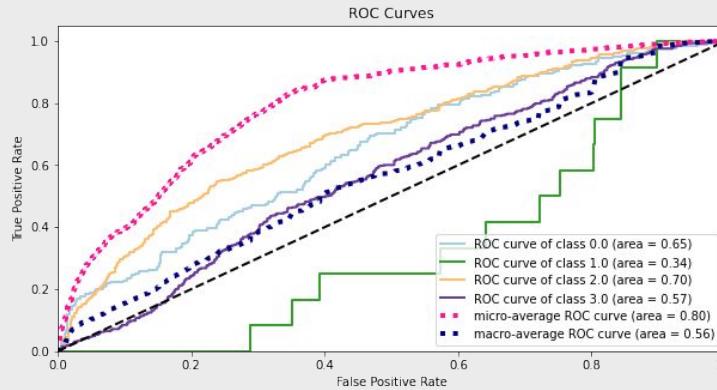


RESULTS – PRETRAINED SIMCLR WITH SIMCLRV2 KNOWLEDGE DISTILLATION ON ALZHEIMER IMAGES

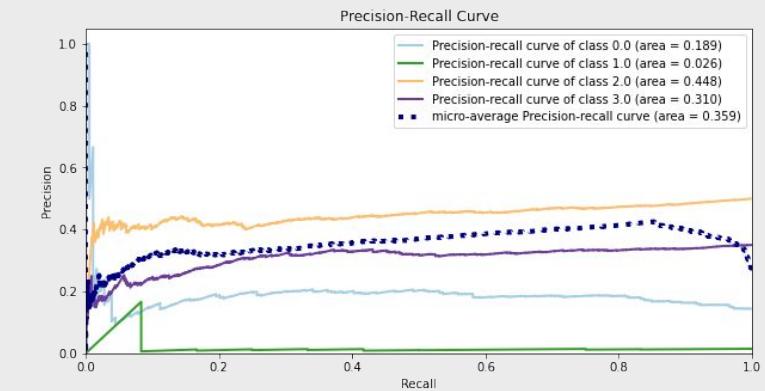
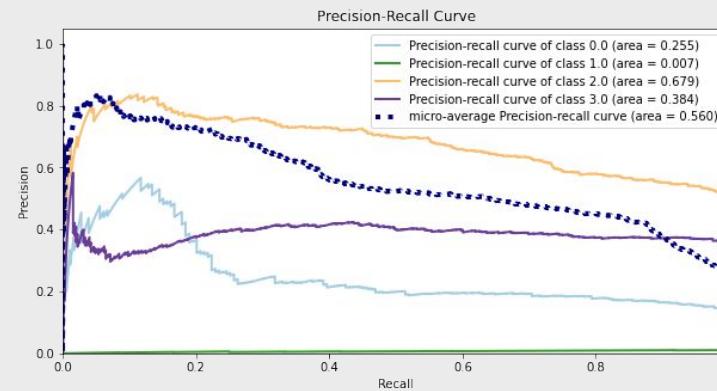
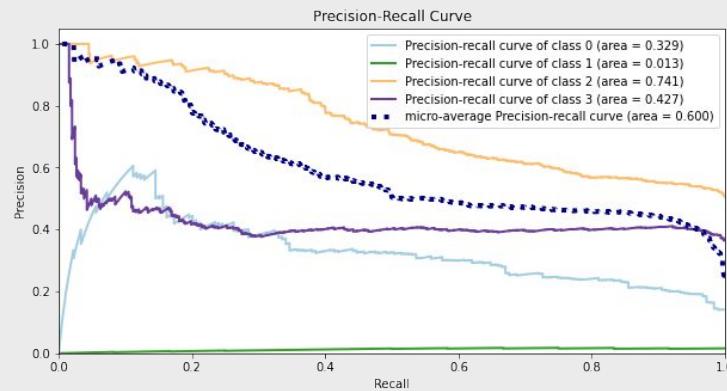
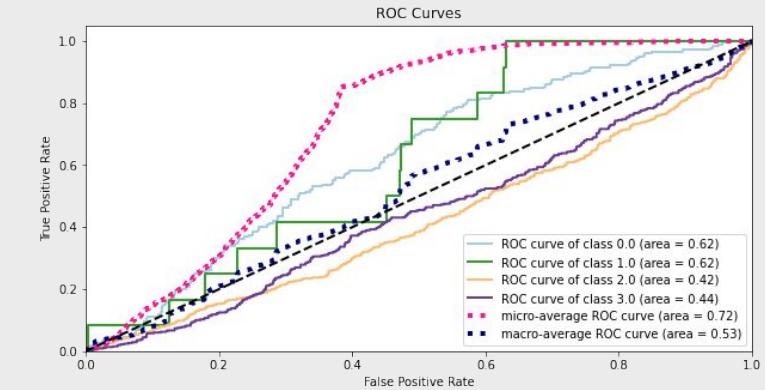
SIMCLR V1



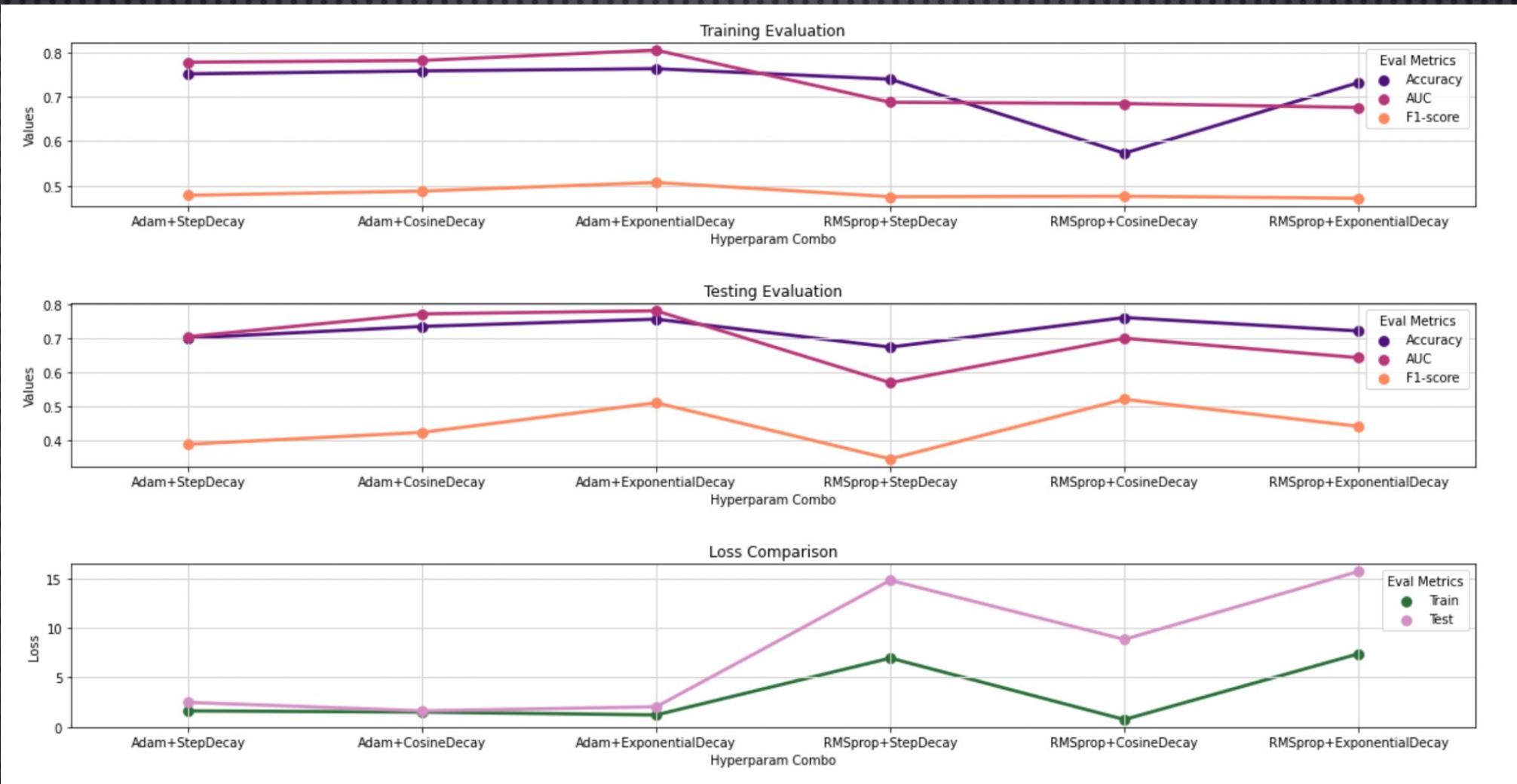
SIMCLR V2 (Fine-tuned On Alzheimer)



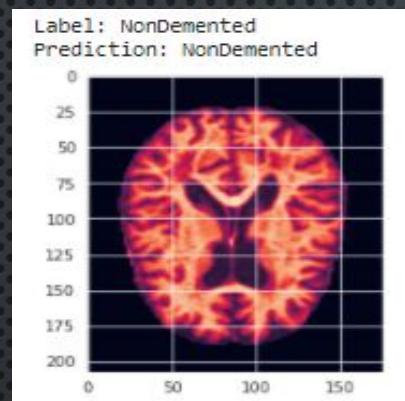
SIMCLR V2 (Distillation to Student)



METHODOLOGY COMPARISONS



HYPERPARAMETER TUNING COMPARISON ON SIMCLR RESNET 50 WITH NON-LINEAR PROJECT HEAD



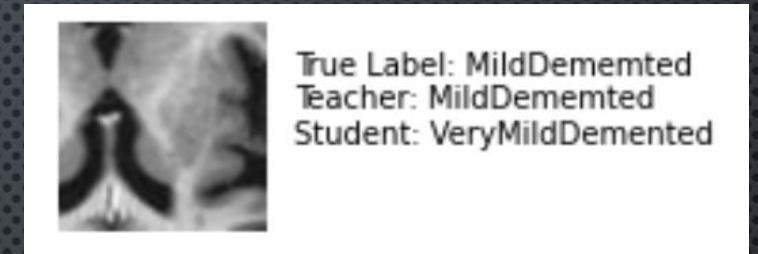
EXPERIMENT 1

TRAIN SIMCLR RESNET50
ON 1% IMAGENET, FINE
TUNE ON ALZHEIMER'S
IMAGES



EXPERIMENT 2

USE PRE-TRAINED SIMCLR ON
100% IMAGENET, FINE TUNE
ON ALZHEIMER'S IMAGES



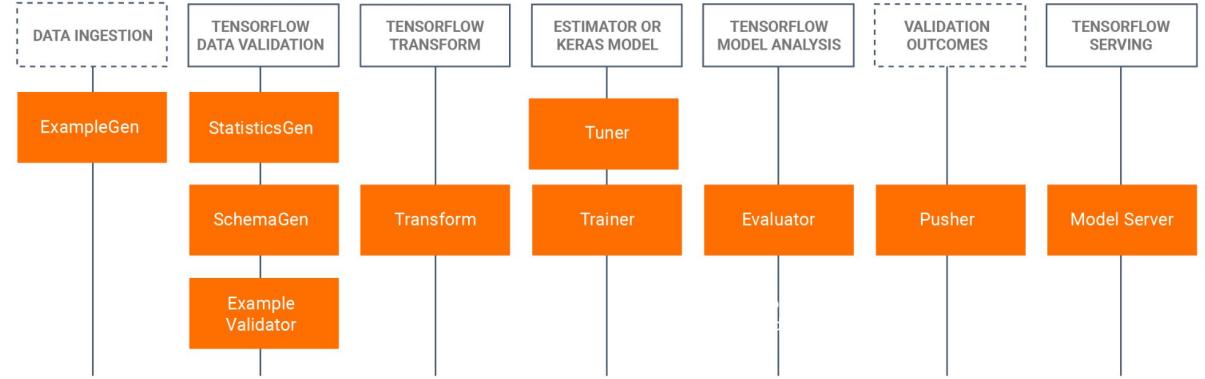
EXPERIMENT 3

USE PRE-TRAINED SIMCLR ON
100% IMAGENET, PERFORM
KNOWLEDGE DISTILLATION
USING ALZHEIMER'S IMAGES

RESULTS – PREDICTION ON SAMPLE IMAGES



TensorFlow Extended



MLOPS WITH TFX & KUBEFLOW

The image shows two screenshots of the Google Cloud Platform interface.

Kubernetes Engine Overview:

- Left Sidebar:** Shows navigation links for Kubernetes Engine, Clusters, Workloads, Services & Ingress, Applications, Configuration, and Storage.
- Top Bar:** Includes the Google Cloud Platform logo, project name "alzheimers", a search bar, and buttons for "+ CREATE", "+ DEPLOY", and "REFRESH".
- Content Area:** Displays the "OVERVIEW" tab for a cluster named "cluster-1" located in "us-west1-b". The cluster has 3 nodes, 12 vCPUs, and 45 GB of memory. A message indicates it was last refreshed 8 hours ago.

AI Platform Notebooks:

- Left Sidebar:** Shows navigation links for Vertex AI, Dashboard, Datasets, Features, Labeling tasks, Workbench, Pipelines, Training, Experiments, Models, Endpoints, and Batch predictions.
- Top Bar:** Includes the Google Cloud Platform logo, project name "alzheimers", a search bar, and buttons for "+ NEW NOTEBOOK", "REFRESH", "START", "STOP", "RESET", and "DELETE".
- Content Area:** Displays the "USER-MANAGED NOTEBOOKS" tab. It contains two informational messages about the transition of the Notebooks service to Vertex AI Workbench and the default JupyterLab version. Below this, it shows a table of existing notebooks.

Notebook name	Zone	Auto-upgrade	Environment	Machine type	GPUs	Permissions
tensorflow-2-1-20211108-102946	us-west1-b	—	TensorFlow:2.1	2 vCPUs, 7.5 GB RAM	None	Service account

CREATE KUBERNETES CLUSTER

CREATE AI PLATFORM NOTEBOOK

KUBEFLOW SETUP

← kubeflow-pipelines-alzheimers

Recurring run
configs
0 active

Experiment description

Manage

Runs

Active Archived

Run name	Status	Duration	Pipeline Version	Recurring Run	Start time
Run of kubeflow-pipelines-alzheimers_20211118212751 (2dc21)	?	-	kubeflow-pipelines-alzheimers_202111182...	-	11/18/2021, 6:58:38 PM
Run of kubeflow-pipelines-alzheimers_20211118212751 (b7800)	✓	0:24:06	kubeflow-pipelines-alzheimers_202111182...	-	11/18/2021, 1:28:26 PM
Run of kubeflow-pipelines-alzheimers_202111183227 (dc31c)	!	0:26:10	kubeflow-pipelines-alzheimers_202111181...	-	11/18/2021, 10:32:51 AM

KUBEFLOW JOB PENDING

← kubeflow-pipelines-alzheimers

Recurring run
configs
0 active

Experiment description

Manage

Runs

Active Archived

Run name	Status	Duration	Pipeline Version	Recurring Run	Start time
Run of kubeflow-pipelines-alzheimers_20211118212751 (2dc21)	✓	0:04:38	kubeflow-pipelines-alzheimers_202111182...	-	11/18/2021, 6:58:38 PM
Run of kubeflow-pipelines-alzheimers_20211118212751 (b7800)	✓	0:24:06	kubeflow-pipelines-alzheimers_202111182...	-	11/18/2021, 1:28:26 PM
Run of kubeflow-pipelines-alzheimers_202111183227 (dc31c)	!	0:26:10	kubeflow-pipelines-alzheimers_202111181...	-	11/18/2021, 10:32:51 AM

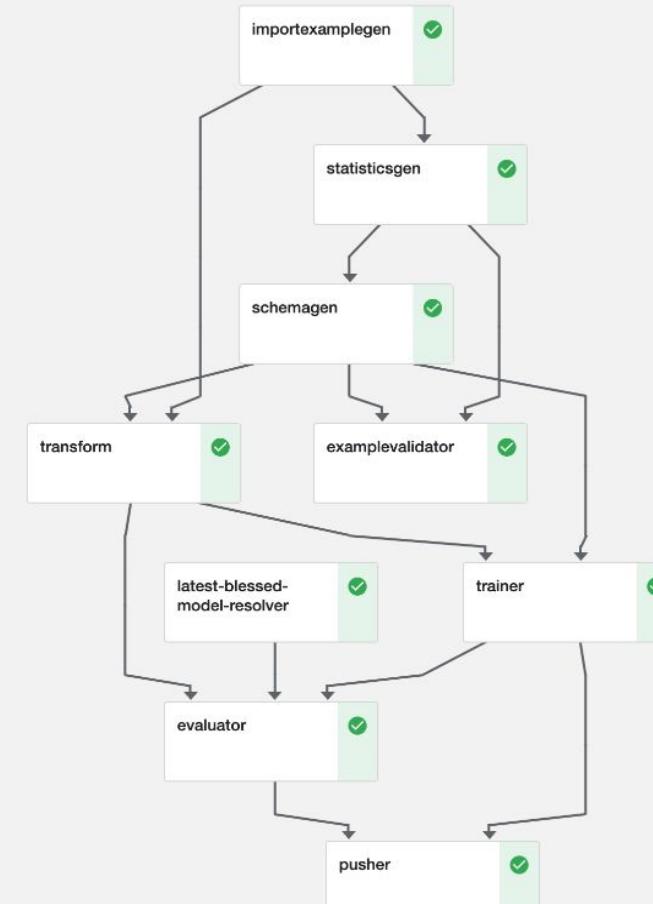
KUBEFLOW JOB SUCCEEDED

KUBEFLOW PIPELINE

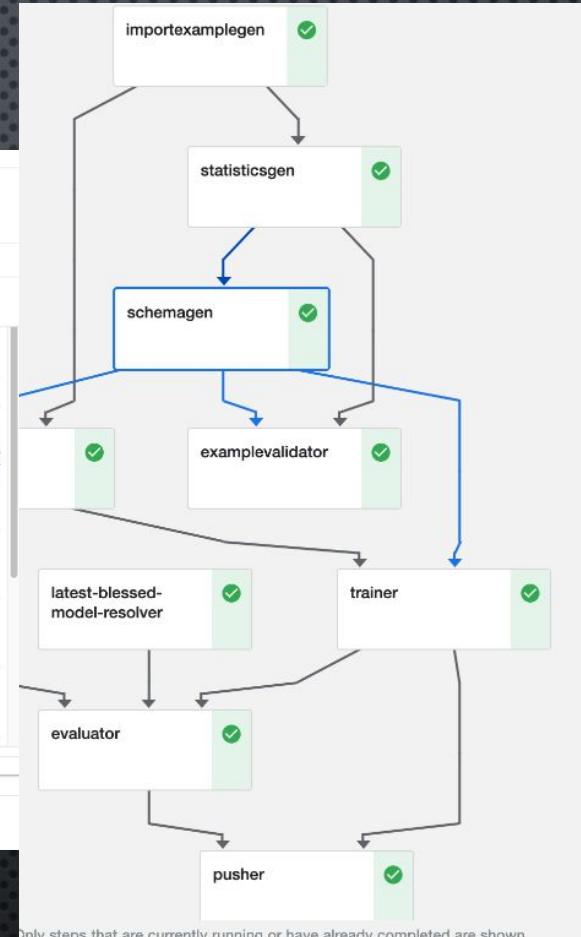
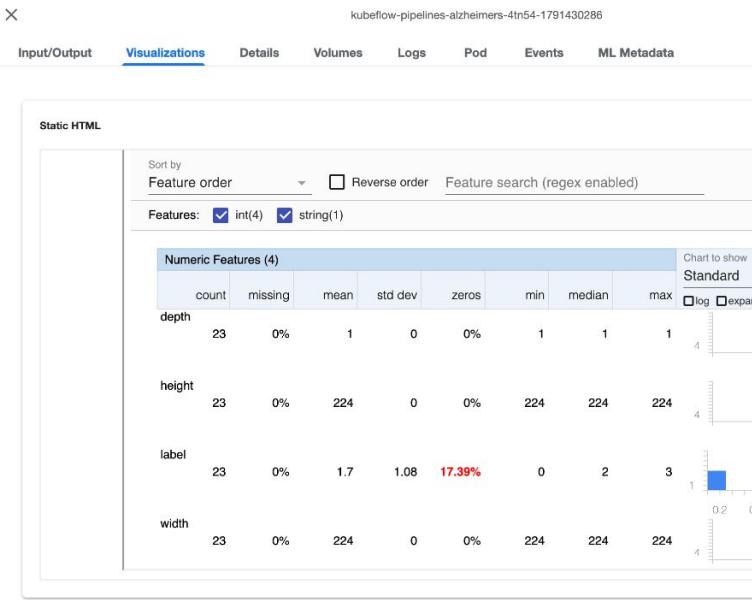
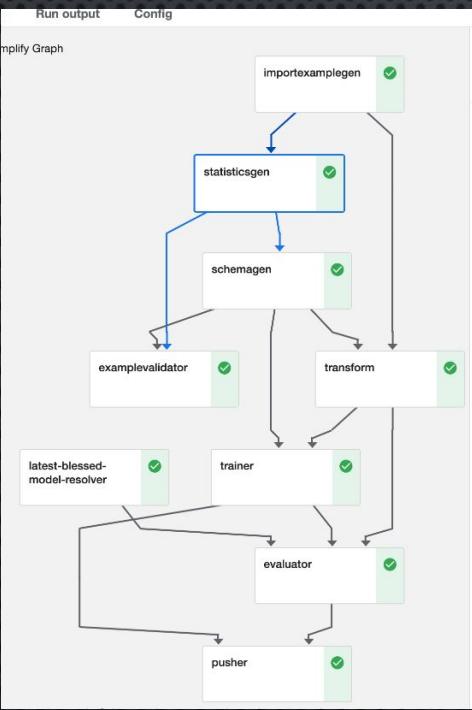
← ✓ Run of kubeflow-pipelines-alzheimers_20211118212751

Graph Run output Config

Simplify Graph



KUBEFLOW PIPELINE GRAPH



Input/Output **Visualizations** **Details** **Volumes** **Logs**

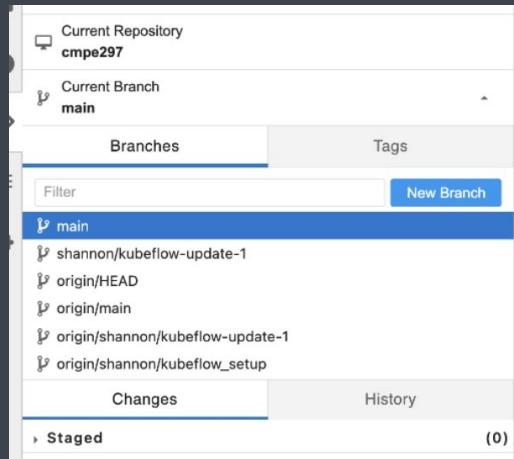
Static HTML

Feature name	Type	Presence	Valency	Domain
'depth'	INT	required	-	-
'height'	INT	required	-	-
'image'	BYTES	required	-	-
'label'	INT	required	-	-
'width'	INT	required	-	-

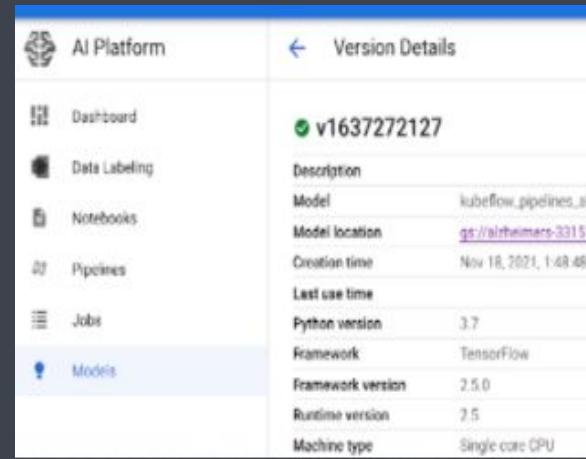
STATISTICS GEN ZOOMED IN

SCHEMA GEN ZOOMED IN

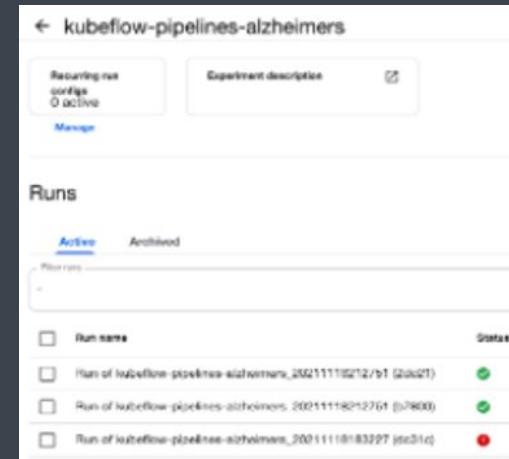
FEW KUBEFLOW PIPELINE STAGES ZOOMED IN



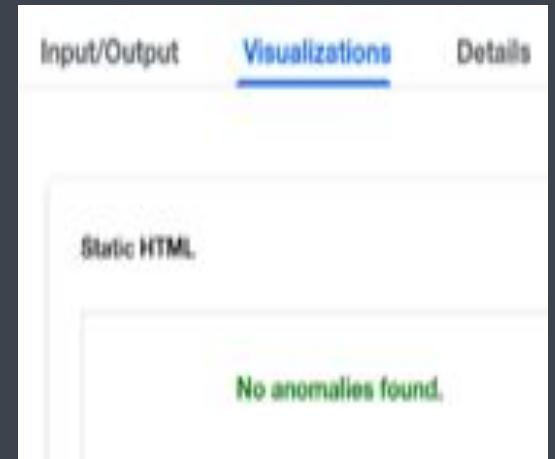
CI/ CD



MODEL VERSIONING,
GATING

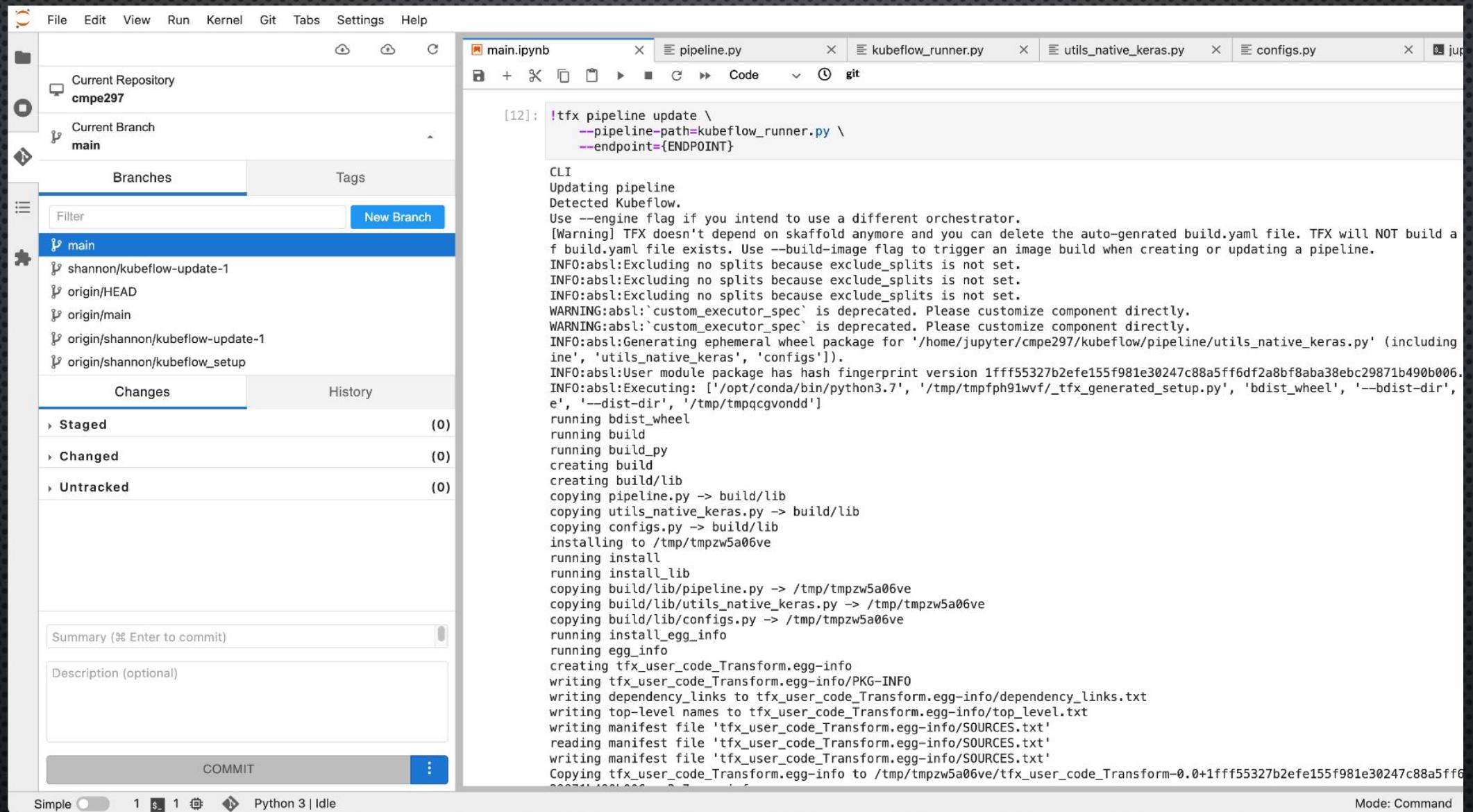


MONITOR PIPELINE
RUNS



MONITOR SKEW, DRIFT,
ANOMALY

ML OPS LEVEL 2 HIGH LEVEL CAPABILITIES



ML OP LEVEL 2 – CI/CD

Google Cloud Platform alzheimers stor

Cloud Storage Bucket details

alzheimers-331518-kubeflowpipelines-default

Location	Storage class	Public access	Protection
us (multiple regions in United States)	Standard	⚠ Subject to object ACLs	None

OBJECTS CONFIGURATION PERMISSIONS PROTECTION LIFECYCLE

Buckets > alzheimers-331518-kubeflowpipelines-default > tfx_pipeline_output > kubeflow-pipelines-alzheimers > Pusher > pushed_model > 27

UPLOAD FILES UPLOAD FOLDER CREATE FOLDER MANAGE HOLDS DOWNLOAD DELETE

Filter by name prefix only Filter objects and folders

Name	Size	Type	Created	Storage class	Last modified	Public access	Version history	Encryption
assets/	—	Folder	—	—	—	—	—	—
keras_metadata.pb	541.9 KB	Nov 18, 2...	Standard	Nov 18, 20...	Not public	—	Google-managed key	—
saved_model.pb	4.4 MB	Nov 18, 2...	Standard	Nov 18, 20...	Not public	—	Google-managed key	—
tflite	89.6 MB	Nov 18, 2...	Standard	Nov 18, 20...	Not public	—	Google-managed key	—
variables/	—	Folder	—	—	—	—	—	—

VERSIONED
MODEL
STORE

Google Cloud Platform alzheimers ai platform

AI Platform Version Details

v1637272127

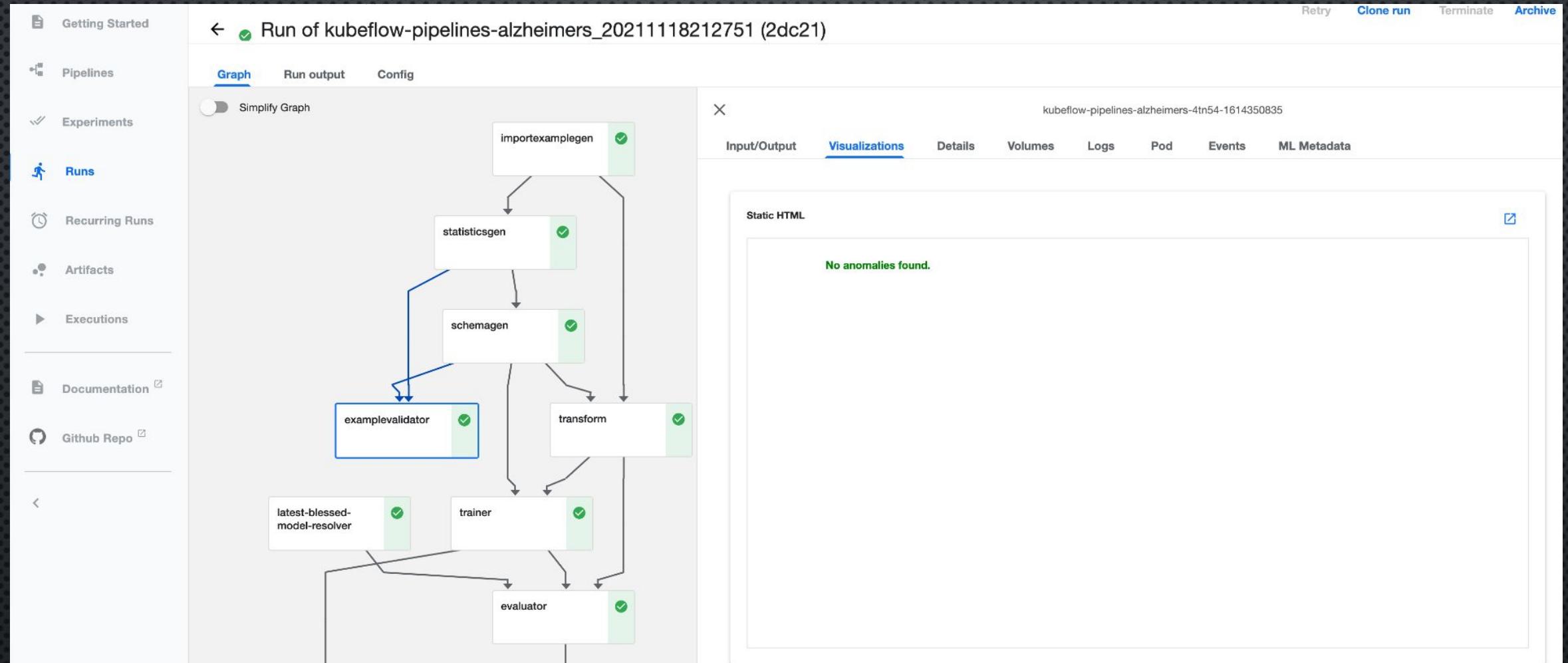
Description	
Model	kubeflow_pipelines_alzheimers
Model location	gs://alzheimers-331518-kubeflowpipelines-default/tfx_pipeline_output/kubeflow-pipelines-alzheimers/Pusher/pushed_model/27
Creation time	Nov 18, 2021, 1:48:48 PM
Last use time	
Python version	3.7
Framework	TensorFlow
Framework version	2.5.0
Runtime version	2.5
Machine type	Single core CPU

VERSIONED
MODEL META
DATA

ML OP LEVEL 2 – MODEL VERSIONING



ML OP LEVEL 2 – MODEL GATING



ML OP LEVEL 2 – MONITOR DATA SKEW, DRIFT, ANOMALY DETECTION

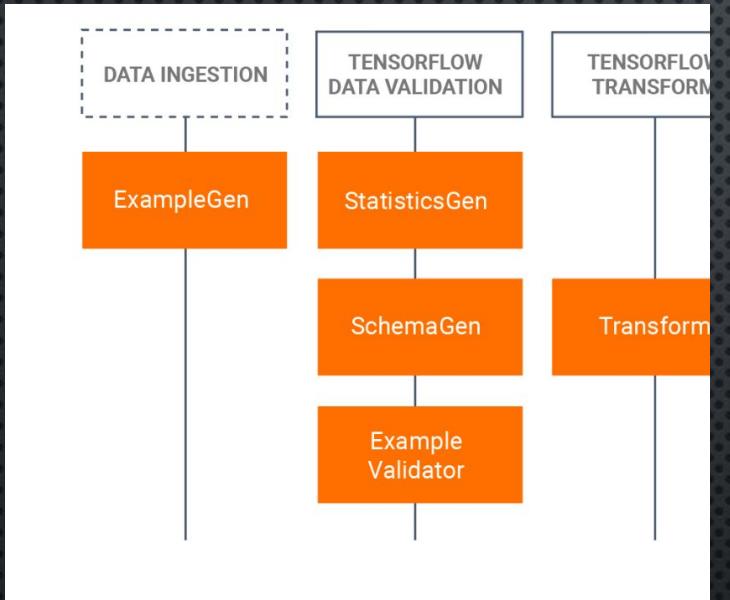
Google Cloud Platform alzheimers ai platform X ▾

AI Platform Jobs + NEW TRAINING JOB REFRESH CANCEL SHOW INFO PANEL

Filter Filter by prefix...

	Job ID	Type	HyperTune	HyperTune parameters	Target metric	Create time	Elapsed time	Logs	Labels	?
Dashboard	<input type="checkbox"/> tfx_20211118213041	Custom code training	No			Nov 18, 2021, 1:30:42 PM	16 min 14 sec	View Logs	tfx_execut... : tfx-compon... tfx_py_version : 3-7	▼
Data Labeling	<input type="checkbox"/> tfx_20211118192458	Custom code training	No			Nov 18, 2021, 11:24:59 AM	16 min 13 sec	View Logs	tfx_execut... : tfx-compon... tfx_py_version : 3-7	▼
Notebooks	<input type="checkbox"/> tfx_20211118184116	Custom code training	No			Nov 18, 2021, 10:41:17 AM	16 min 24 sec	View Logs	tfx_execut... : tfx-compon... tfx_py_version : 3-7	▼
Pipelines	<input type="checkbox"/> tfx_20211118014204	Custom code training	No			Nov 17, 2021, 5:42:05 PM	15 min 44 sec	View Logs	tfx_execut... : tfx-compon... tfx_py_version : 3-7	▼
Jobs	<input type="checkbox"/> tfx_20211118012846	Custom code training	No			Nov 17, 2021, 5:28:47 PM	16 min 54 sec	View Logs	tfx_execut... : tfx-compon... tfx_py_version : 3-7	▼
Models	<input type="checkbox"/> tfx_20211118010536	Custom code training	No			Nov 17, 2021, 5:05:37 PM	13 min 1 sec	View Logs	tfx_execut... : tfx-compon... tfx_py_version : 3-7	▼
	<input type="checkbox"/> tfx_20211118003202	Custom code training	No			Nov 17, 2021, 4:32:03 PM	12 min 55 sec	View Logs	tfx_execut... : tfx-compon... tfx_py_version : 3-7	▼

ML OP LEVEL 2 – MONITOR PIPELINE



TFX FLOW

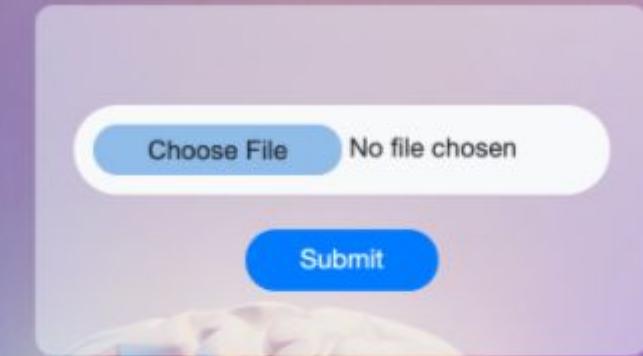


KUBEFLOW PIPELINES

	Job ID	Type	HyperTune
<input type="checkbox"/>	tfx_20211118213041	Custom code training	No
<input type="checkbox"/>	tfx_20211118192458	Custom code training	No
<input type="checkbox"/>	tfx_20211118184116	Custom code training	No
<input type="checkbox"/>	tfx_20211118014204	Custom code training	No
<input type="checkbox"/>	tfx_20211118012846	Custom code training	No
<input type="checkbox"/>	tfx_20211118010536	Custom code training	No
<input type="checkbox"/>	tfx_20211118003202	Custom code training	No

GCP AI PLATFORM SUPPORT

DEMO LINK – TFX, KUBEFLOW, GCP



FLASK WEB APP HOSTED GCP APP ENGINE
MAKES GOOGLE API CALLS TO LATEST DEPLOYED
MODEL ON GCP

[DEMO LINK – FLASK APP ENGINE](#)



CI/CD PIPELINE VIA GITHUB, TFX,
KUBEFLOW INTEGRATION



MODEL VERSIONING, MODEL GATING,
MONITOR PIPELINE, MONITOR SKEW, DRIFT,
ANOMALY VIA GOOGLE AI PLATFORM



REAL TIME PREDICTION VIA TENSORFLOW
SERVING, GOOGLE API & FLASK WEB
APPLICATION



HOSTED ON GCP APP ENGINE

BIG PICTURE

Diseases like Alzheimer's can start in the brain several years before symptoms start.



Healthy brain.

There can be up to 20 years between these stages



When Alzheimer's Research UK wants to diagnose dementia.

When we diagnose dementia today.



Brain damaged by Alzheimer's.

Pic Credits: Alzheimers Research UK

EARLY, ACCURATE DETECTION CRUCIAL TO MANAGE DISEASE

It's not until there has been significant damage to the brain, that we first see symptoms of dementia.