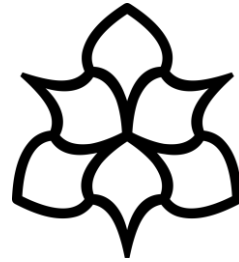


Advancing Medical Image Analysis for Ulcerative Colitis:

From Discriminative Analysis to Generative Multimodal Understanding



Xinqi Fan

Lecturer in Artificial Intelligence
Department of Computing and Mathematics
Manchester Metropolitan University

Before I begin, I would like to give a brief content notice.

This presentation includes some clinical and endoscopic images related to ulcerative colitis and inflammatory bowel disease.

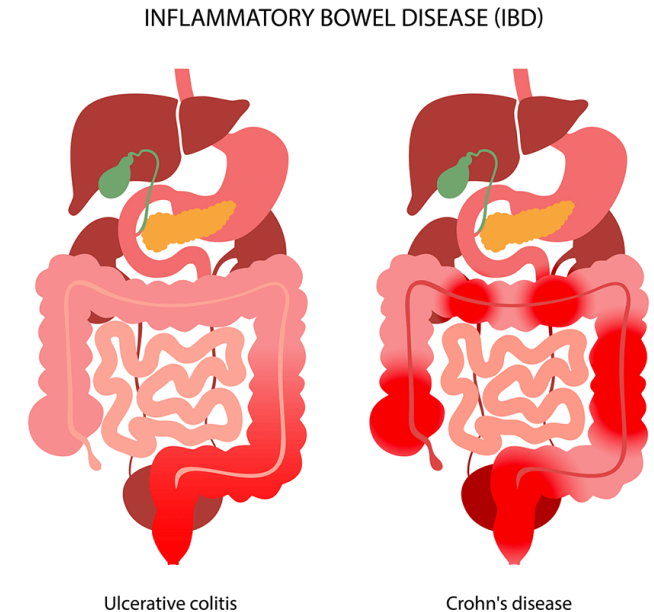
Some of these images may show bleeding, ulcers, or inflamed tissue, which some viewers may find **sensitive or graphic**. They are included only for educational and research purposes.

Please feel free to **look away briefly** if you find them uncomfortable.



Ulcerative Colitis

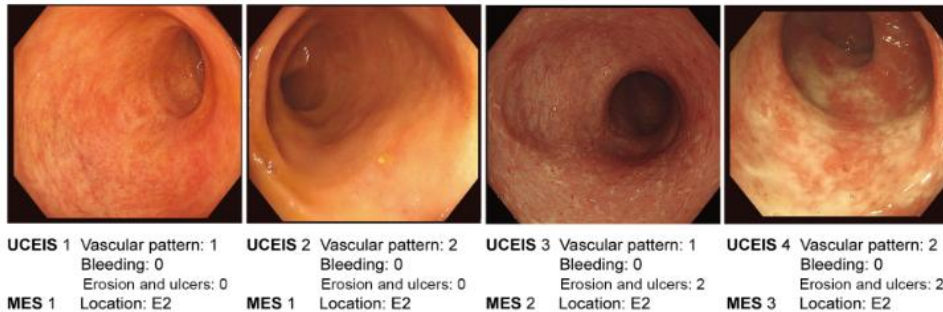
- Ulcerative colitis (UC) is a chronic inflammatory bowel disease (IBD)
- Characteristics
 - Mucosal inflammation and ulcer
 - Begins in the rectum
 - Spreads along and into the colon
- Common symptoms
 - Recurring diarrhoea, which may contain blood, mucus or pus
 - Tummy pain, needing to poo frequently
 - (may lead to) Extreme tiredness, loss of appetite and weight loss
- Who's affected
 - At least 1 in every 227 people in the UK has been diagnosed with UC (Crohn's & Colitis UK)
 - Can develop at any age, most often between 15 and 25 years old
- Complications
 - An increased risk of developing bowel cancer
 - Poor growth and development in children and young people



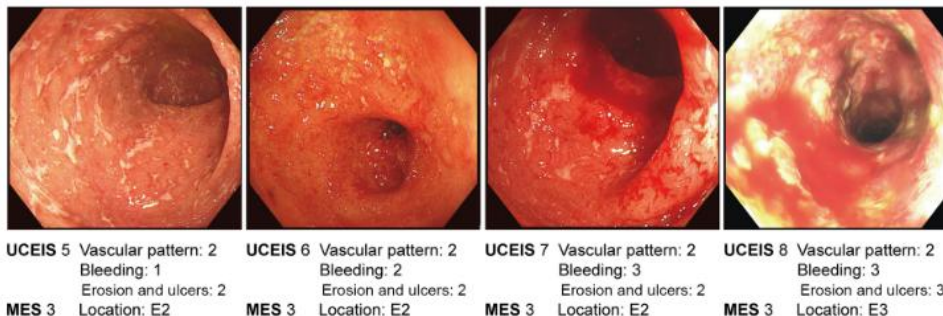
Severity Grading

- Clinicians evaluate the patient's colon for features such as
 - Vascular pattern
 - Bleeding
 - Erosions or ulcers
 - Friability
 - Erythema
- Two common severity grading systems

Mayo Endoscopic Subscore (MES)



Ulcerative Colitis Endoscopic Index of Severity (UCEIS)

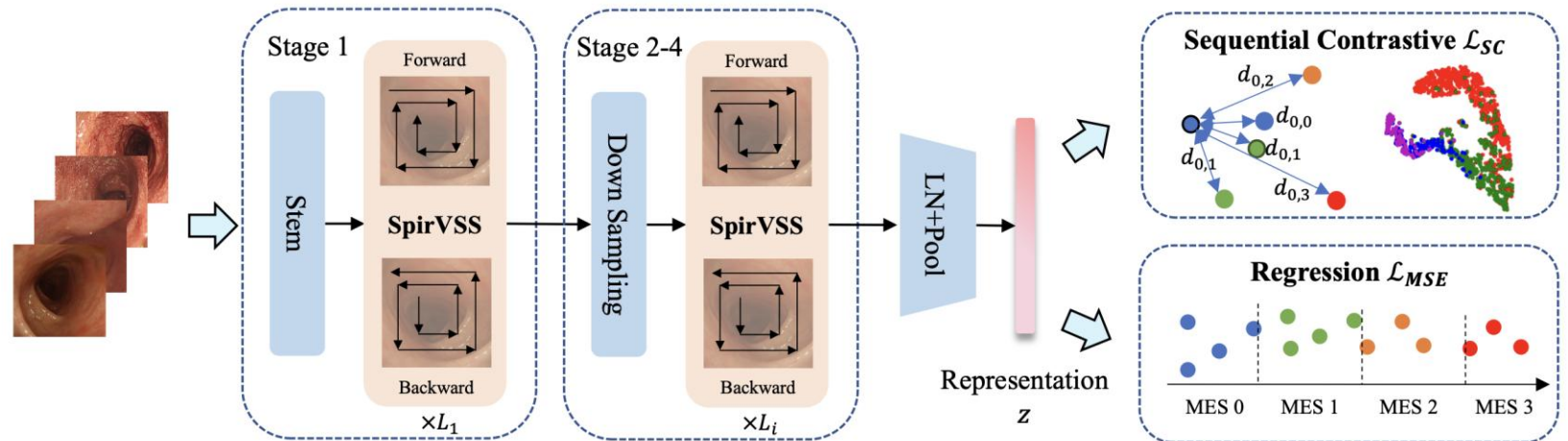
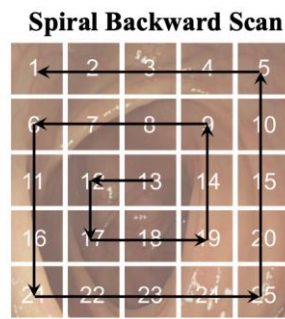
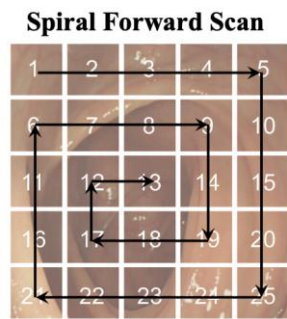
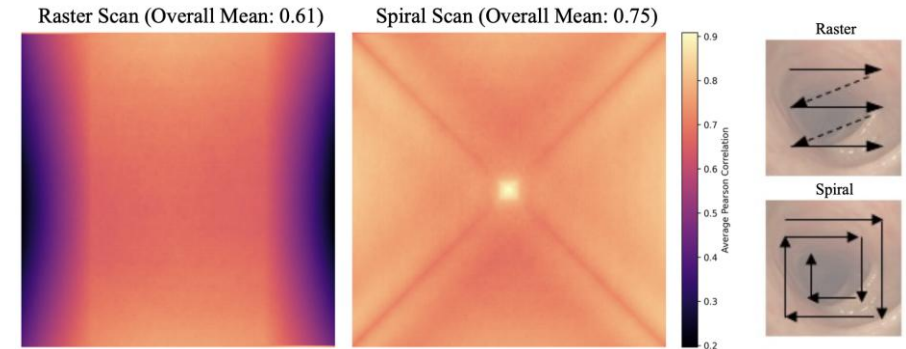


Score	Possible Reasoning
0 (Normal)	No visible problems
1 (Mild)	Erythema, mild friability
2 (Moderate)	Moderate friability, erosion
3 (Severe)	Spontaneous Bleeding, Deep Ulcers

Descriptor	Score	Rating
Vascular Pattern	0	Normal
	1	Patchy Obliteration
	2	Obliterated
Bleeding	0	None
	1	Mucosal
	2	Luminal Mild
	3	Luminal Moderate or Severe
Erosions and Ulcers	0	None
	1	Erosions
	2	Superficial ulcer
	3	Deep Ulcer

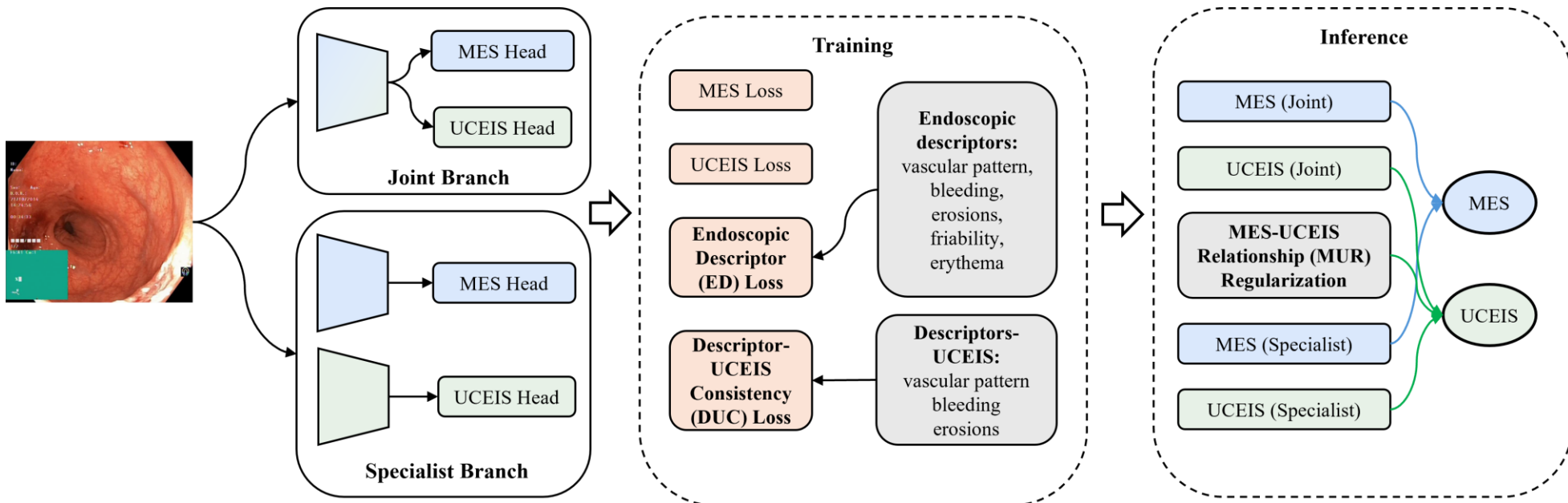
Spiral Scan for Endoscopic Images

- Problem of normal scans (raster)
 - Disconnected information
- UCMamba
 - Spiral scan mechanism
 - Effectively models the rotational spatial features by incorporating spiral scanning
- 2 UC datasets, 1 poly detection, 1 polyp segmentation



Joint-Specialist Learning with Endoscopic Descriptor Guidance

- Existing models lack clinical knowledge modelling
- Prediction endoscopic descriptors
- Regulate description to UCEIS
- Model MES or UCEIS clinical relationship



Severity Assessment Results

Local validations

- Out-of-fold results

MES

ID	Backbone	Branch	Input	Acc $\uparrow$	F1 $\uparrow$	AUC $\uparrow$	Sens. $\uparrow$	Spec. $\uparrow$	PPV $\uparrow$
M1	Swin-T	Joint	320 ²	0.753	0.758	0.832	0.755	0.910	0.763
M2	Swin-T	Joint	384 ²	0.758	0.764	0.833	0.755	0.911	0.775
M3	ConvNeXT-T	Specialist	384 ²	0.738	0.744	0.819	0.734	0.903	0.757
M4	Swin-T	Specialist	384 ²	0.747	0.757	0.829	0.750	0.907	0.766
M5	ConvNeXT-T	Specialist	320 ²	0.753	0.756	0.829	0.749	0.909	0.765

UCEIS

ID	Backbone	Branch	Input	Acc $\uparrow$	F1 $\uparrow$	AUC $\uparrow$	Sens. $\uparrow$	Spec. $\uparrow$	PPV $\uparrow$
U1	Swin-T	Joint	320 ²	0.461	0.454	0.694	0.457	0.932	0.454
U2	Swin-T	Joint	384 ²	0.464	0.462	0.694	0.457	0.936	0.469
U3	ConvNeXT-T	Specialist	320 ²	0.448	0.448	0.686	0.443	0.930	0.459
U4	Swin-T	Specialist	384 ²	0.435	0.428	0.679	0.430	0.928	0.429
U5	Swin-T	Specialist	320 ²	0.461	0.451	0.689	0.447	0.931	0.463

Challenge leaderboard results

- First place in MES track**
 - Up to ~0.3 increase in some metrics
- Second place in UCEIS track

Task	Leaderboard Submission ID	Acc $\uparrow$	F1 $\uparrow$	AUC $\uparrow$	Sens. $\uparrow$	Spec. $\uparrow$	PPV $\uparrow$
Task I MES	9765379	0.405	0.460	0.672	0.527	0.818	0.588
	9765395	0.450	0.436	0.655	0.485	0.825	0.453
	9765412	0.344	0.232	0.494	0.246	0.742	0.242
	9765489	0.325	0.289	0.541	0.301	0.781	0.318
	JSL-EDG (Ours)	0.701	0.654	0.782	0.665	0.899	0.647
Task II UCEIS	9765397	0.244	0.198	0.565	0.224	0.906	0.231
	9765415	0.116	0.077	0.498	0.104	0.892	0.089
	9765380	0.428	0.358	0.651	0.374	0.927	0.366
	JSL-EDG (Ours)	0.428	0.357	0.650	0.374	0.927	0.357



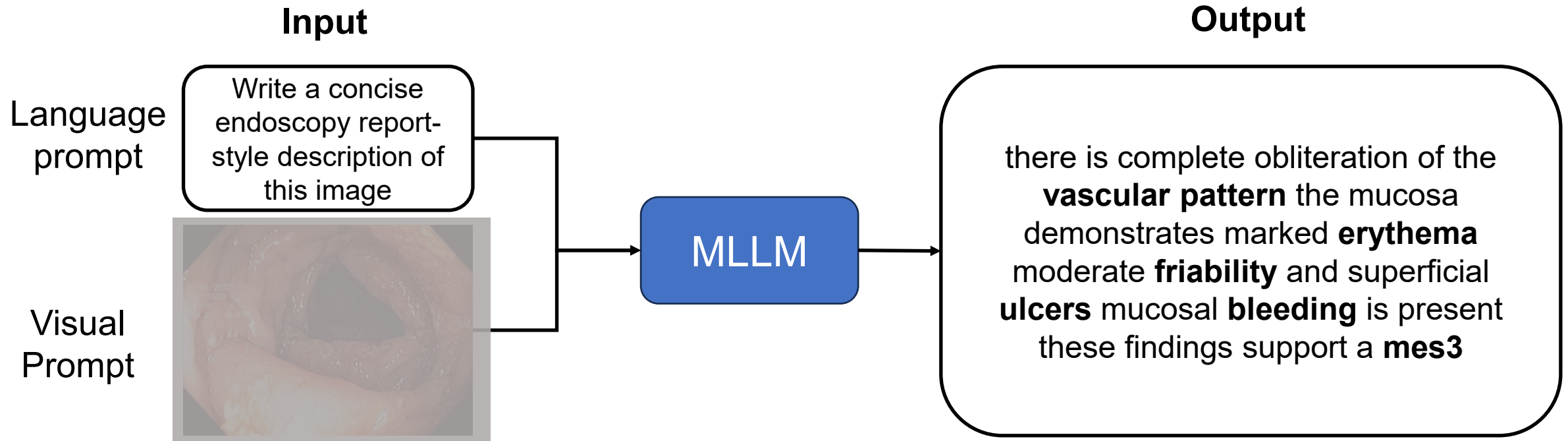
From Score Prediction to Generative Understanding

- Automatic **scoring** systems
 - Help clinicians with objective severity grades
 - Save time
 - Reduce interobserver variability
- Automatic **captioning** systems
 - Generate explainable descriptions of what it sees in an image

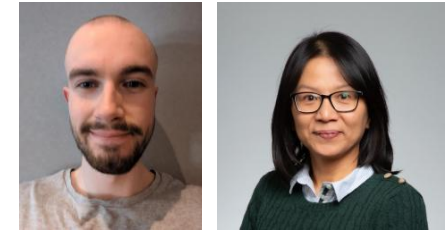
Explainability	Links score to visible findings
Clinical Trust	Showing why a score was decided allows clinicians to trust the system more
Training/Education	Allows junior clinicians to learn why something was graded a specific way
Reporting Support	Descriptions generated in a structured way promotes standardised documentation

Image Captioning

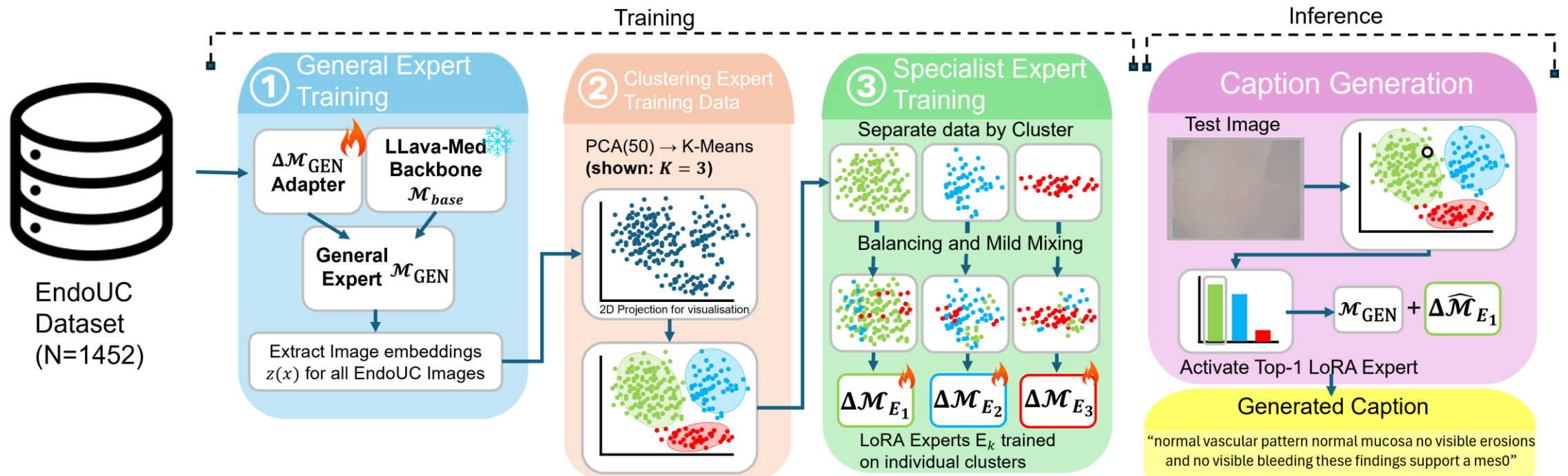
- Accurately provide a descriptive assessment of an endoscopic image
- Captioning is difficult with medical images: Limited data, and complex images



Generative Mixture of Low-rank Experts

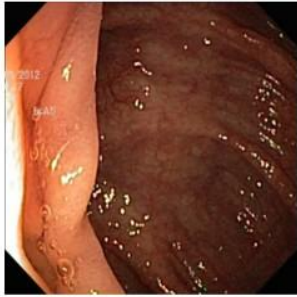


- Mixture of LoRA Experts (MoLE)
 - Inspired by standard Mixture-of-Experts (MoE)
 - Train a general expert (GEN) on all EndoUC data
 - Extract image embeddings from GEN
 - Cluster image embeddings
 - Train specialist LoRA experts for each cluster
 - Route each test image to the nearest expert and generate the caption



Generative Multimodal Understanding Results

■ Qualitative results



MES: 0

Ground Truth Caption:

normal vascular pattern normal mucosa no visible erosions and no visible bleeding these findings support a mes0

Predicted Caption:

normal vascular pattern normal mucosa no visible erosions and no visible bleeding these findings support a mes0



MES: 1

Ground Truth Caption:

there is patchy obliteration of the vascular pattern the mucosa demonstrates no visible erythema no visible friability and no visible erosions no visible bleeding is present these findings support a mes1

Predicted Caption:

there is patchy obliteration of the vascular pattern the mucosa demonstrates **moderate** erythema **low** friability and no visible erosions no visible bleeding is present these findings support a mes1



MES: 2

Ground Truth Caption:

there is complete obliteration of the vascular pattern the mucosa demonstrates marked erythema moderate friability and erosions no visible bleeding is present these findings support a mes2

Predicted Caption:

there is complete obliteration of the vascular pattern the mucosa demonstrates marked erythema moderate friability and erosions **mucosal bleeding** is present these findings support a mes2



MES: 3

Ground Truth Caption:

there is complete obliteration of the vascular pattern the mucosa demonstrates marked erythema severe friability and deep ulcers luminal severe bleeding is present these findings support a mes3

Predicted Caption:

there is complete obliteration of the vascular pattern the mucosa demonstrates marked erythema severe friability and deep ulcers luminal severe bleeding is present these findings support a mes3

Generative Multimodal Understanding Results

- Quantitative Results
 - First place in image caption track



Model/ID	CosSim↑	ROUGE↑	BLEU↑	METEOR↑
9765400	0.640	0.769	0.700	0.757
9765414	0.834	0.890	0.860	0.891
UCMoLE	0.846	0.896	0.867	0.896

Validation Results

Model	External Data	RAG	METEOR↑
UCMoLE w/o S.E.	×	×	0.8957 ± 0.0070
UCMoLE	×	×	0.9218 ± 0.0072
UCMoLE	✓	×	0.9214 ± 0.0034
UCMoLE	✓	✓	0.9209 ± 0.0086
UCMoLE-Q	×	×	0.9132 ± 0.0067

Test Results

Model	External Data	RAG	CosSim↑	ROUGE↑	BLEU↑	METEOR↑
UCMoLE	×	×	0.846	0.896	0.867	0.896
UCMoLE	✓	×	0.823	0.881	0.85	0.882
UCMoLE	✓	✓	0.821	0.88	0.849	0.884
UCMoLE-Q	×	×	<u>0.825</u>	<u>0.882</u>	<u>0.852</u>	<u>0.885</u>

Additional MES Results

Top1_Accuracy	F1_Score	AUC	Sensitivity	Specificity	PPV
0.617	0.573	0.726	0.578	0.874	0.58

Generative Multimodal Understanding Demo

■ Demo

- Visual input
- (optional) Instructions
- Structured finding
- Evidence-based diagnosis

LARGE VISION-LANGUAGE MODEL-ASSISTED MEDICAL IMAGE ANALYSIS SYSTEM

Ulcerative Colitis Diagnosis Assistant

Based on UCMoLE: Cluster-Routed Mixture of Low-Rank Experts for Endoscopic Ulcerative Colitis Captioning.

Endoscopy image

UC endoscopy image

Drop Image Here

- or -

Click to Upload

Instruction (optional)

Start

Diagnose

Clear

Diagnosis

The generated diagnosis will appear here. You can edit it directly.

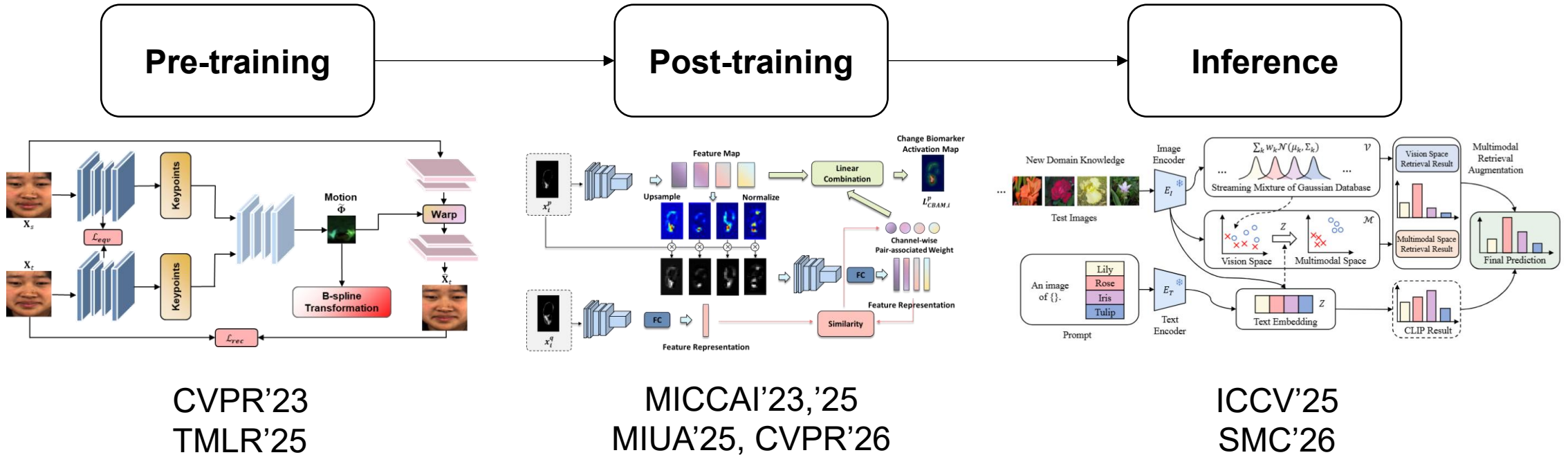
Format diagnosis

Formatted diagnosis

Select Format diagnosis to convert the editable narrative into structured findings and scores.

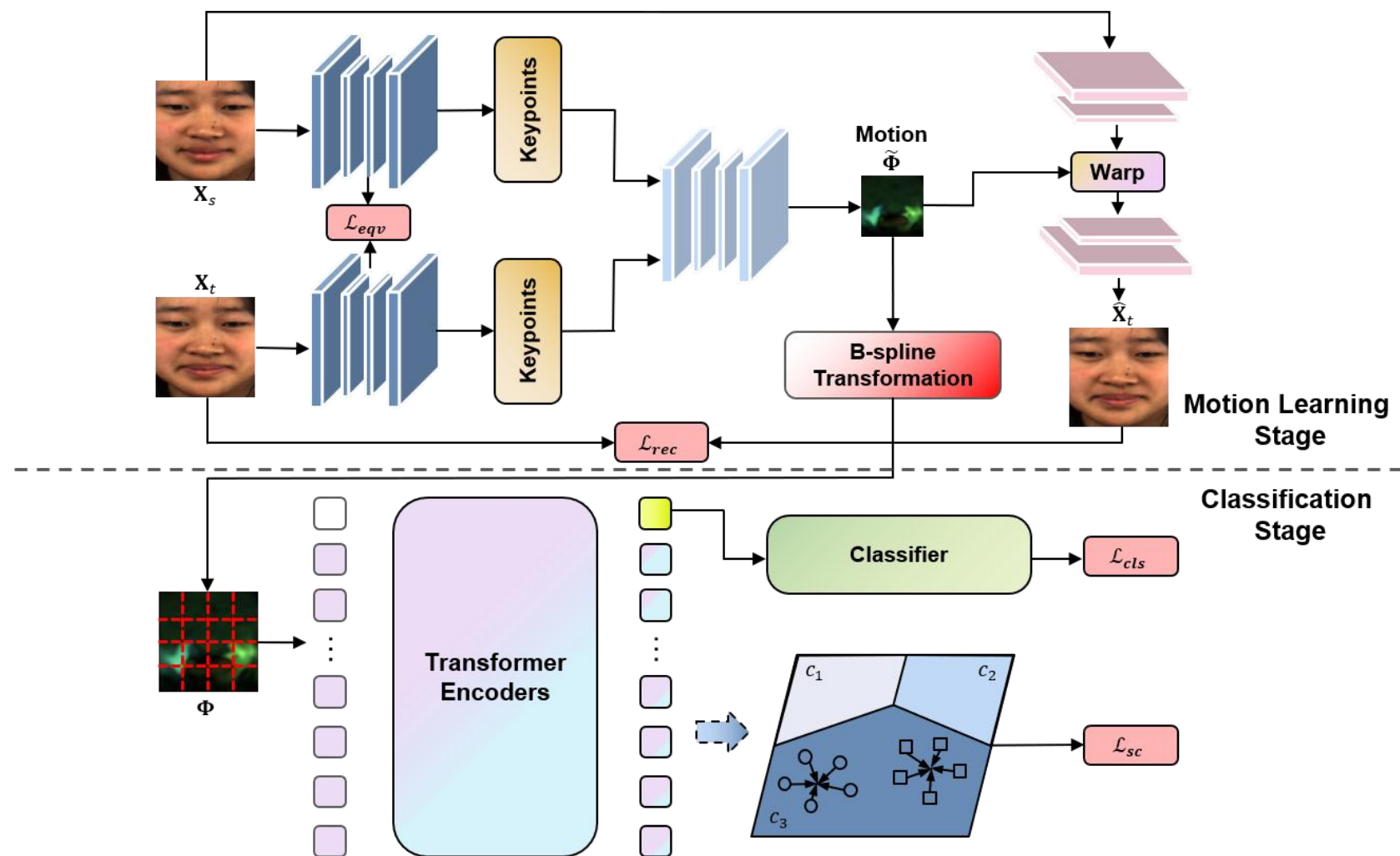
Our Research Overview

- Trustworthy: Robust, Interpretable, Adaptable
- Pre-training: **Robust** and **general** self-supervised **representation**
- Post-training: **Interpretable** and **explainable** deep learning methods
- Inference: Test-time **adaptation** and **self-improvement** system



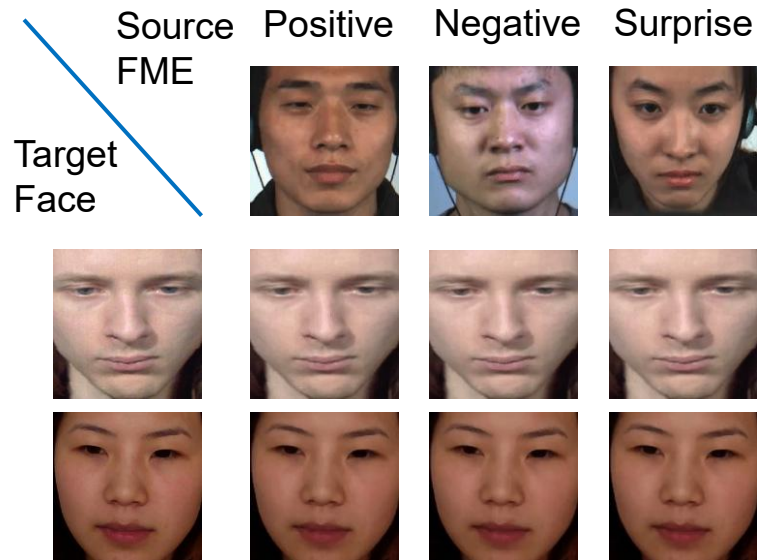
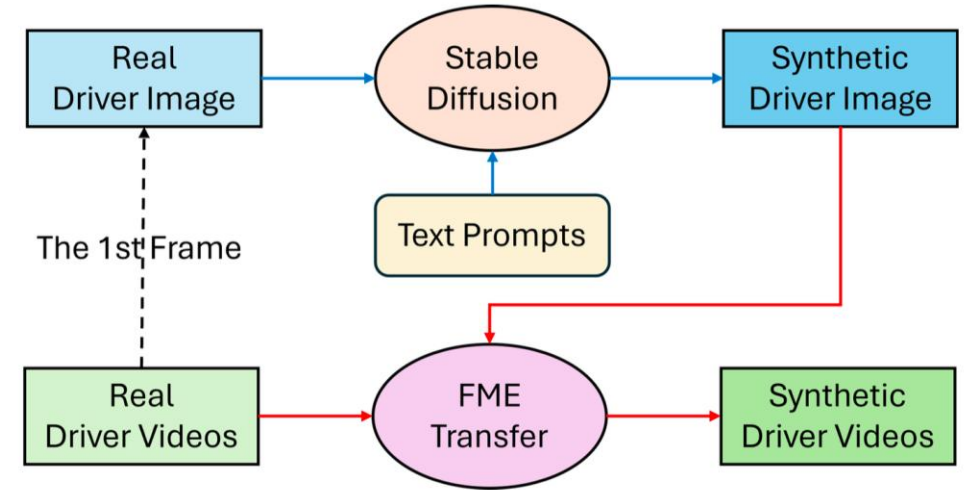
Self-supervised Learning for Robust Representations

- SelfME
- Motion Learning
 - Subtle representations
 - Without labels
- Classification
 - Symmetrical contrastive
 - Transformer



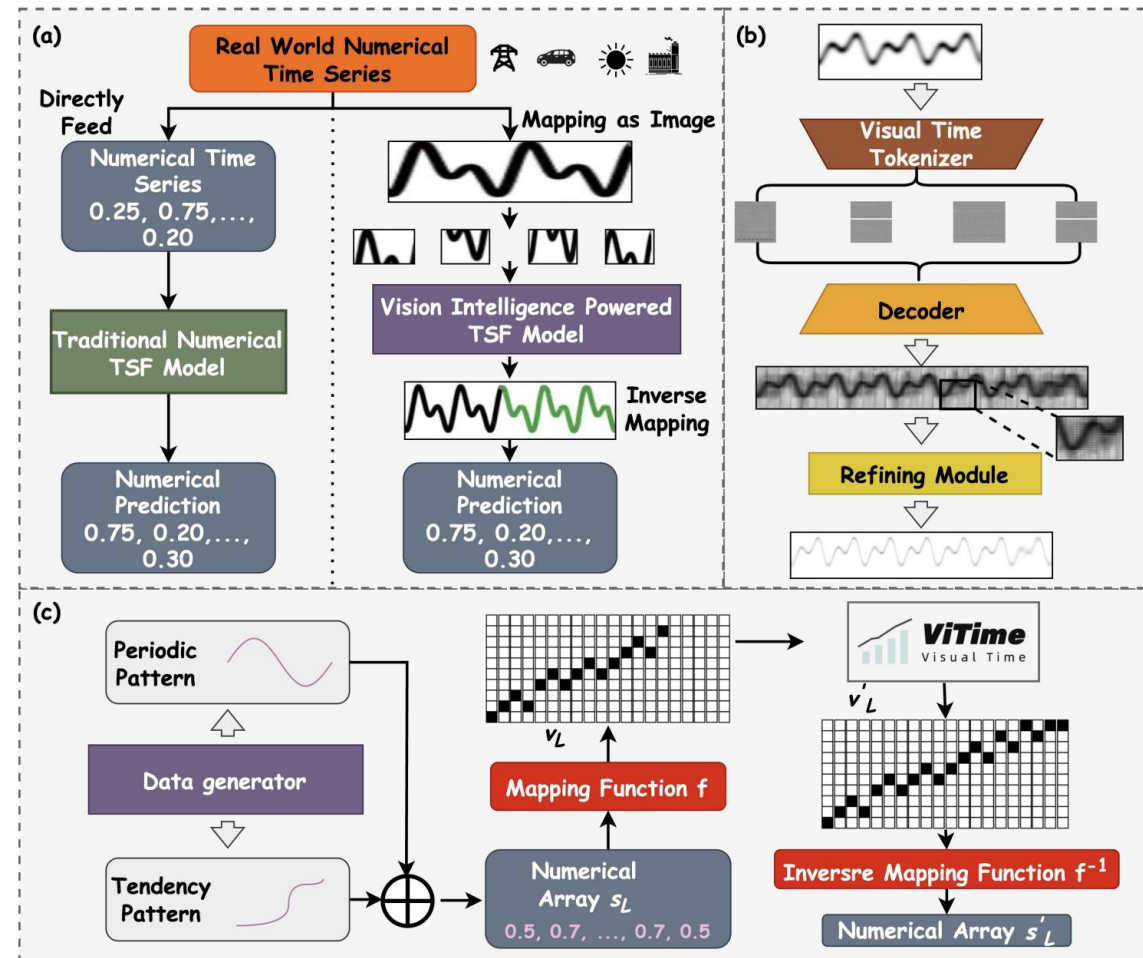
Unified Understanding and Generation

- Transfer motions between videos
- Investigated driver micro-expression studies
- Collaborated with Toyota



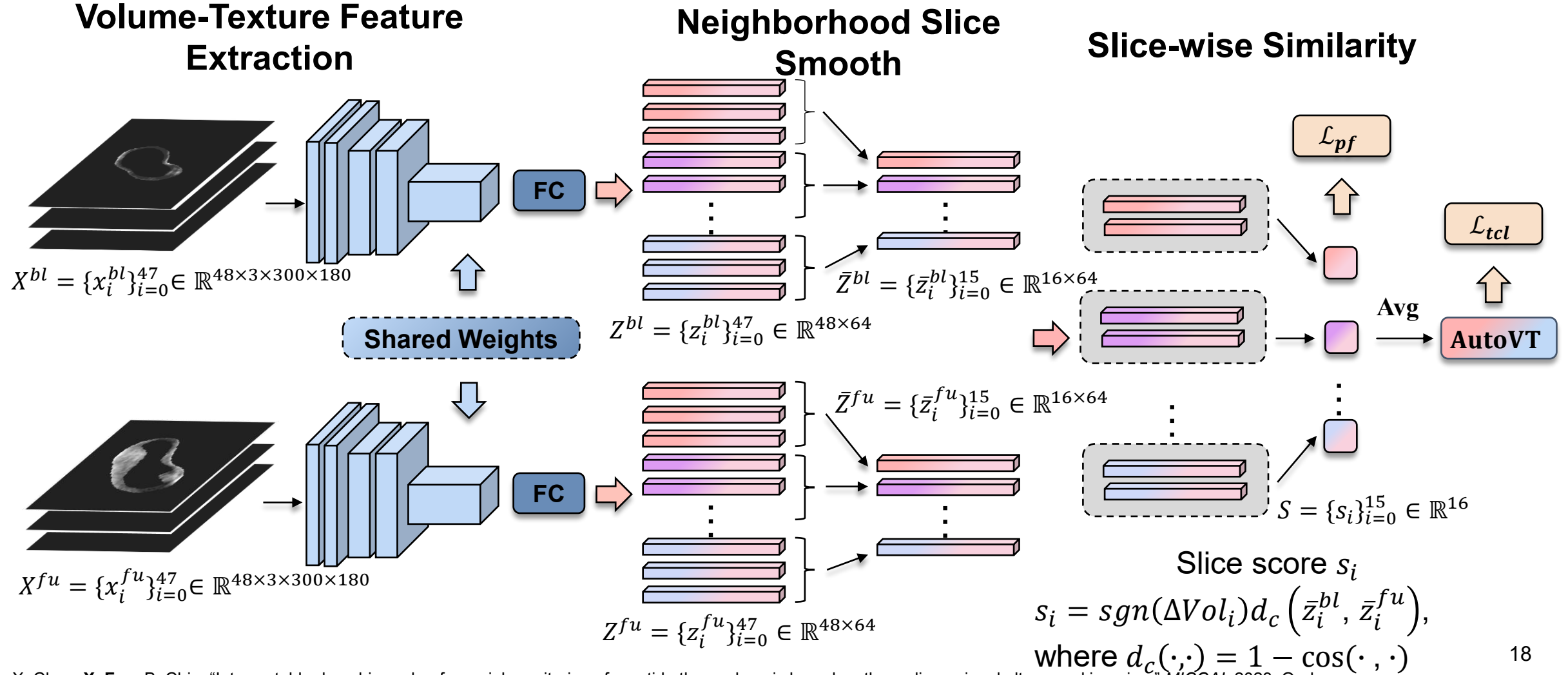
Your Time Series is Worth a Binary Image

- Foundation model
- Convert a time series into an image
- Apply image generation for time series forecasting



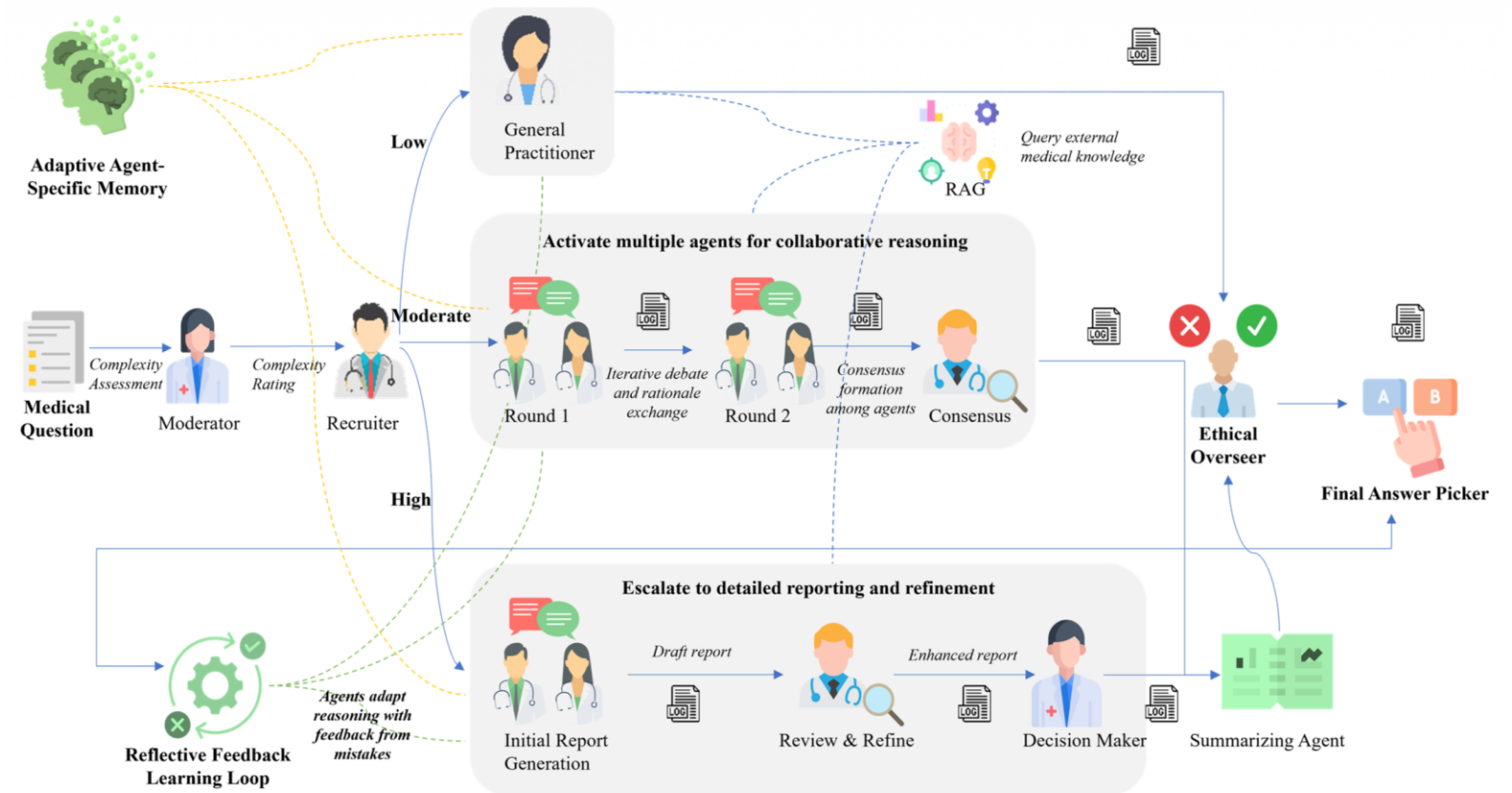
Interpretable Deep Biomarker

Siamese Change Biomarker Generation Network (SCBG-Net)



Multi-Agent Collaboration with Reflection

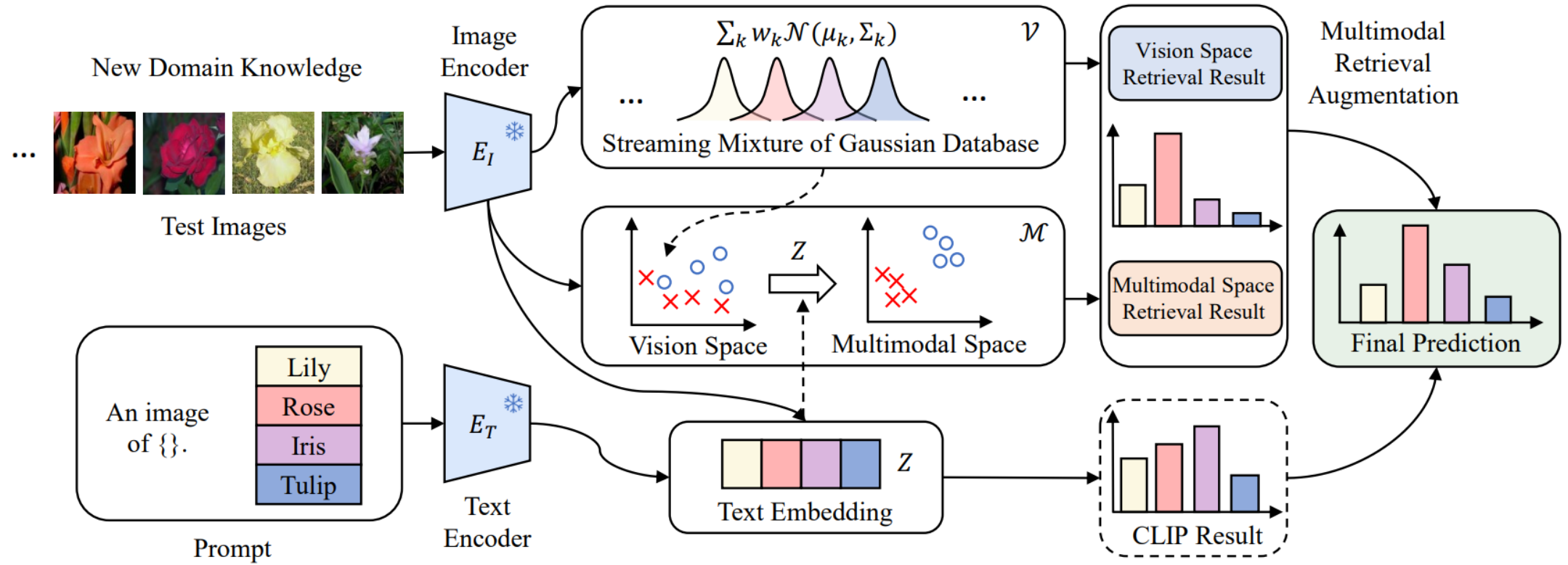
- Moderator for task difficulty assessment
- Multi-agent collaboration
- Reflection
- Memory updates



Self-Evolving Model After Deployment

■ Test-time Retrieval-augmented Adaptation

- Streaming mixture of Gaussian database
- Multimodal Retrieval Augmentation



Thank You!

Please feel free to discuss and ask questions.

We would like to invite you to visit and collaborate with us!

Please feel free to reach out to me.



扫二维码，添加我为朋友。

Email:
x.fan@mmu.ac.uk