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1.Introduction:

1.1 Project Overview:

Project Name: WCE Curated Colon Disease Classification Using Deep Learning

Project Objective:

The primary objective of this project is to train the deep learning model to accurately classify various colon diseases, such as polyps, tumours, inflammation, or other abnormalities. The main goal of the project is likely to develop a deep learning model that can analyse images or videos obtained through wireless capsule endoscopy and accurately classify different types of colon diseases.

Key Components and Features:

1. **Data Collection:** The project begins with the acquisition of pertinent data, comprising Wireless Capsule Endoscopy (WCE) images, clinical reports, and relevant metadata. This dataset serves as the foundation for AI analysis.

2. **AI Models:** AI models are designed and trained to analyse the collected WCE data. These models may encompass machine learning algorithms, deep learning networks, and image processing techniques specific to WCE images. The AI models offer various functionalities, including:
   - **Colon Disease Monitoring:** It continuously capture images or videos of the colon, enabling a dynamic and real-time assessment of its condition.
   - **Tracking Progress:** It tracks the evolution of detected abnormalities, helping to assess the severity and progression of colon diseases.
   - **Clinical Support:** It provides healthcare professionals with valuable information for diagnosis, treatment planning, and patient management.
   - **Health Recommendations:** Providing healthcare providers with actionable insights and recommendations based on AI analysis.
   - **User Interfaces:** The project may include user-friendly interfaces for healthcare providers and expectant parents. These interfaces can display real-time data, predictions, and recommendations in an easily understandable format.

3. **Integration with Healthcare Systems:** Seamless integration with electronic health records (EHRs) and hospital information systems to ensure that healthcare providers have access to AI-generated insights during prenatal care appointments.

4. **Alerts and Notifications:** The AI system can generate alerts and notifications for healthcare providers in the event of critical health indicators or potential complications, enabling timely intervention.

Benefits:

- **Early Detection**: DL algorithms can analyse WCE images with high sensitivity, enabling the early detection of abnormalities such as polyps, tumours, and inflammation in the colon. Early detection is crucial for timely intervention and improved patient outcomes.

- **Continuous Monitoring:** It helps in tracking changes, disease progression, and the effectiveness of interventions, contributing to personalized and dynamic healthcare management**.**

- **Cost-Effective:** DL can contribute to cost-effective screening and monitoring strategies.

- **Improved Patient Experience:** DL can contribute to a more comfortable and less intrusive experience for patients. This can encourage greater patient participation in screenings and monitoring.

Challenges:

- **Data Privacy and Security:** Handling sensitive health data requires robust security measures to protect patient privacy.

- **Regulatory Compliance:** Compliance with healthcare regulations, such as HIPAA in the United States, is critical.

- **Interoperability:** Ensuring that the AI system can seamlessly integrate with existing healthcare infrastructure is a technical challenge.

- **Ethical Considerations:** Ethical considerations around consent, transparency, and decision making should be addressed in the project.

1.2 Purpose:

The purpose of a Wireless Capsule Endoscopy (WCE) Curated Colon Disease Classification Using Deep Learning project is to Detect colon diseases at an early stage when intervention and treatment can be more effective. Deep learning models can learn to identify subtle abnormalities in WCE images that might be challenging for human observers to detect. Enable real-time analysis of WCE images during the examination.

Deep learning algorithms can be optimized for efficiency, providing timely insights to healthcare professionals as the capsule moves through the gastrointestinal tract. Contribute to medical research and insights into colon diseases. The curated dataset and the results of deep learning analysis can provide valuable information for understanding disease patterns, refining diagnostic criteria, and advancing medical knowledge.

2.Literature Survey:

2.1 Existing Problem:

Existing problems of Wireless Capsule Endoscopy (WCE) for Curated Colon Disease Classification using Deep Learning, several pressing challenges persist. First and foremost, the scarcity of high-quality, annotated WCE images hampers the effective training of deep learning models. The inherent complexity of these models poses interpretability issues, making it challenging for healthcare professionals to comprehend and trust the decision-making processes.

Additionally, achieving real-time processing of WCE images during procedures is a hurdle, impacting the efficiency of healthcare providers and potentially delaying timely interventions. The integration of deep learning models into established clinical workflows encounters compatibility issues and resistance to procedural changes. Ethical concerns surrounding patient privacy and data handling further complicate the deployment of AI in healthcare. Regulatory approval and validation for AI models in medical applications demand rigorous evidence of safety and efficacy, contributing to a lengthy and resource-intensive approval process.

2.2 References:

Se-Resnet: A Novel Method for Gastrointestinal (GI) Diseases Classification from Wireless Capsule Endoscopy (WCE) Images.

Locality-constrained dictionary learning classification method of wce images

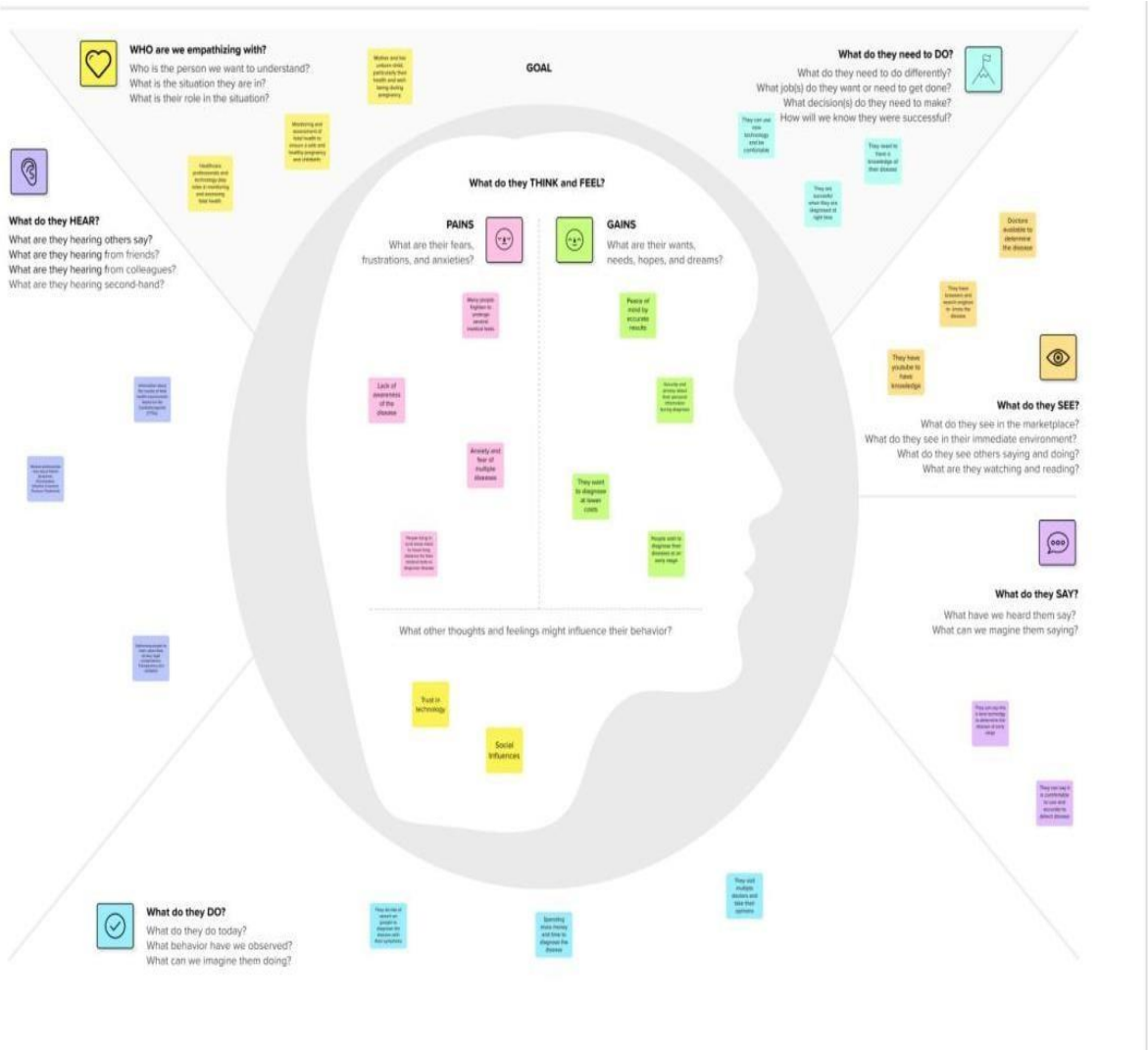
2.3 Problem Statement Definition:

The Wireless Capsule Endoscopy for colon disease classification, the primary challenge lies in the development of robust deep learning models capable of accurately and efficiently analysing WCE images. The project aims to address key issues such as the scarcity of diverse and annotated training data, the interpretability of complex deep learning models, real-time processing challenges during procedures, and the seamless integration of AI into existing clinical workflows.

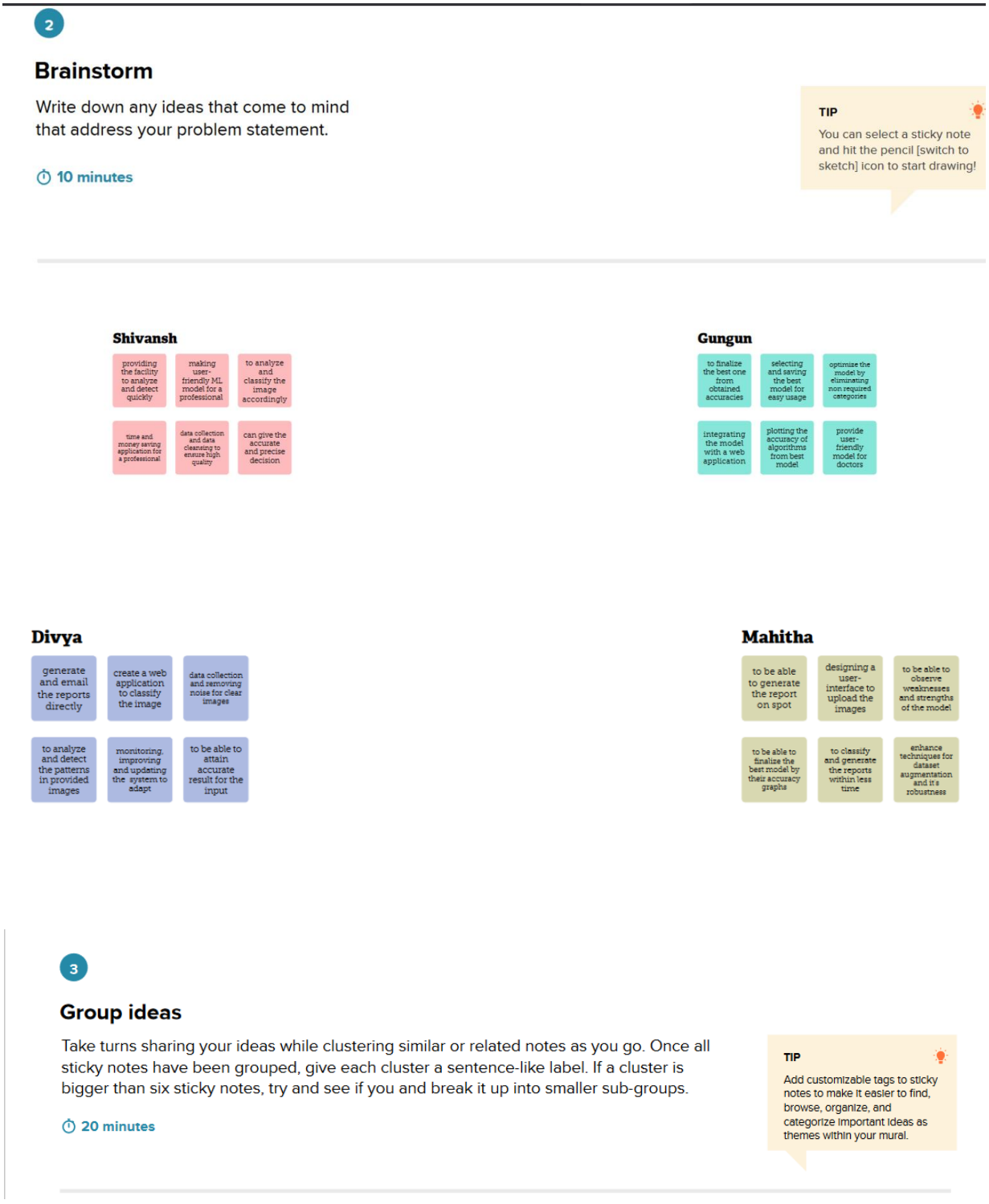
Ethical considerations surrounding patient privacy, regulatory approval, and validation, along with the variability in WCE image quality and the need to mitigate false positives and negatives, further complicate the effective deployment of deep learning for disease classification. This problem statement underscores the need for a comprehensive and multidisciplinary approach to overcome these challenges

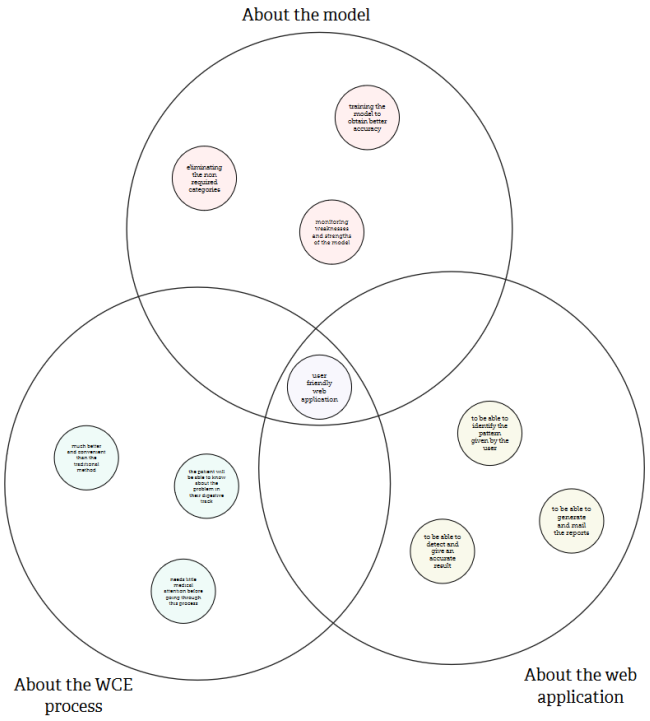
3.Ideation & Proposed Solution:

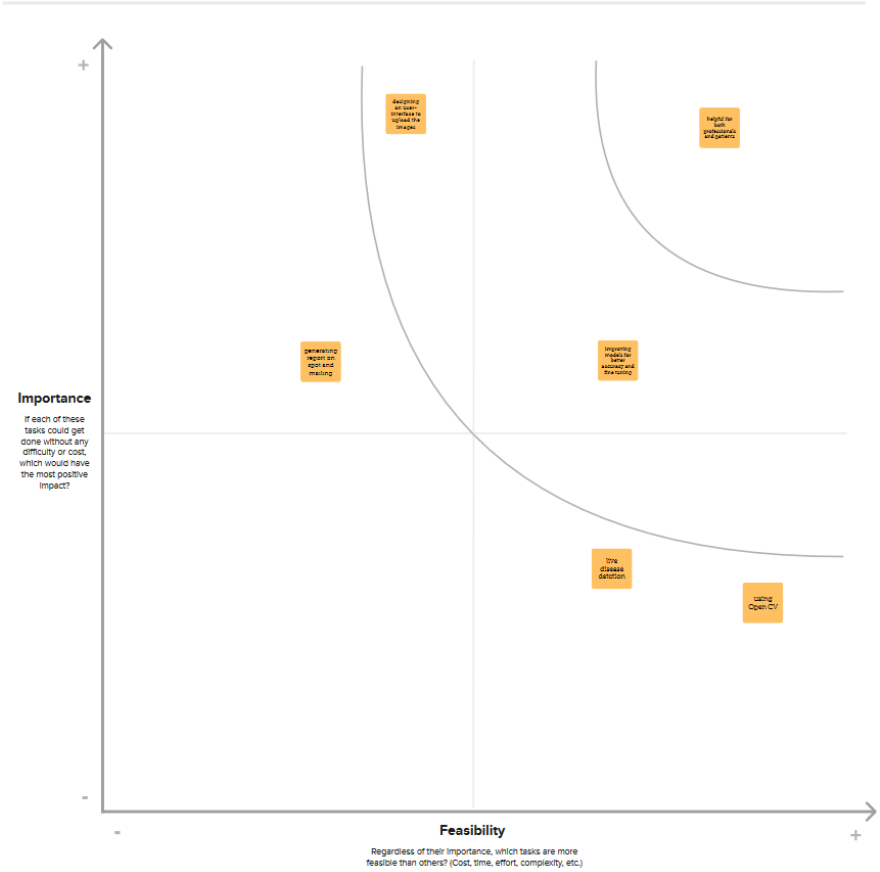
3.1 Empathy Map Canvas:



3.2 Ideation & Brain Storming:




About the model
training the model to obtain better accuracy
eliminating the non required categories
monitoring weaknesses and strengths of the model
user friendly web application
much better and convenient than the traditional method
the patient will be able to know about the problem in their digestive tract
needs one medical session before going through the process
to be able to identify the pattern given by the user
to be able to generate and mail the reports
to be able to detect and give an accurate result
About the WCE process
About the web application


+
-
designing an user-interface to upload the images
helpful for medical professionals and patients
generating report on mail and mailing
improving models for better accuracy and fine tuning
time diseases definition
using Open CV
Importance
If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?
-
+
Feasibility
Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

4.Requirement Analysis:

4.1 Functional Requirement:

Functional requirements for a Wireless Capsule Endoscopy (WCE) system involve specifying the capabilities and behaviours that the system must have. The system should process WCE images in real-time during the procedure. It must identify and classify abnormalities promptly for immediate feedback to healthcare professionals. The system should be capable of classifying different types of colon diseases, such as polyps, tumours, and inflammation, based on WCE images.

The system must have a user-friendly interface for healthcare professionals to interact with during and after the WCE procedure. The system should support continuous monitoring of the patient's colon health over time. The system must be compatible with different WCE devices available in the market. It must support the documentation of findings for future reference and collaboration.

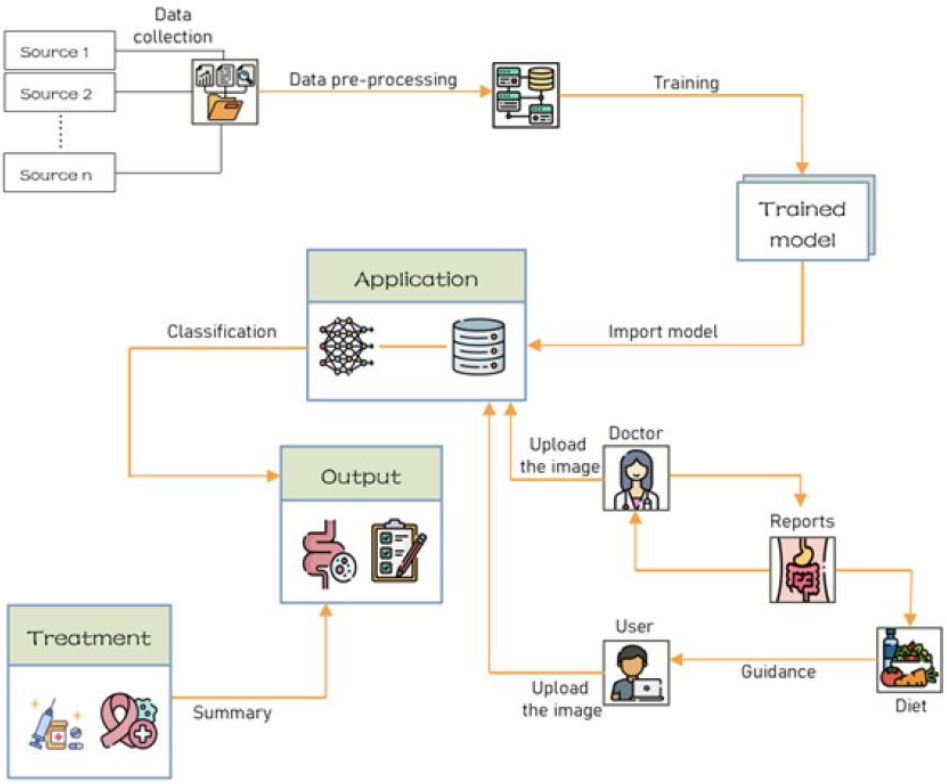
4.2 Non-Functional Requirement:

In developing the Wireless Capsule Endoscopy (WCE) project for colon disease classification, several non-functional requirements must be considered to ensure its effectiveness and reliability. The system should exhibit optimal performance, with real-time processing of WCE images within a specified response time and a defined throughput capacity. Reliability is crucial, necessitating high system availability and fault tolerance to hardware failures. Scalability is another non-functional requirement, ensuring the system can handle an increasing number of procedures and data over time while maintaining performance.

Usability is a key aspect, demanding a consistent and user-friendly interface to minimize training requirements for healthcare professionals. Interoperability is essential, requiring compatibility with various WCE devices and adherence to integration standards. Data storage and retention policies, user authentication mechanisms, auditability features, and user privacy considerations round out the non-functional requirements, collectively ensuring a secure, reliable, and efficient WCE system for colon disease classification.

5.Project Design:

5.1 Data Flow Diagrams & User Stories:



User stories:

User type	Functional requirement	USN	User story	Acceptance criteria	Priority	Release
Gastro Surgeon	User registration	USN - 1	I am able to login this app by providing my email, name and by providing a secure password	Create profile	High	Sprint - 1
Research collaborator	User registration	USN - 2	I can access this app by email and password and can update my profile	Update and access the profile	High	Sprint - 1
Patient 1	User registration	USN - 3	I can login to this app using my phone number and OTP	Create profile	Medium	Sprint - 2
Healthcare professional	Image classification	USN - 4	I am able to get the accurate predict for the scanned image in less time	Health analysis	High	Sprint - 1

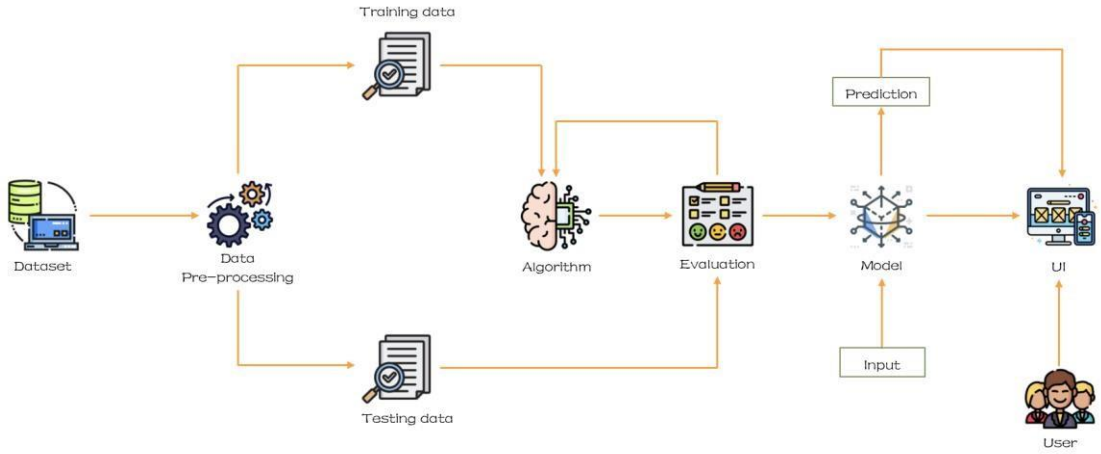
Guardian of a patient	Health care	USN - 5	I am able to balance my father's diet as prescribed after the reports are classified	Health analysis	Medium	Sprint - 2
Tester	Testing & quality assurance	USN - 6	I can conduct series of tests on this model to check accuracy and functionality	We could create website too	Medium	Sprint - 3
Patient 2	User support	USN - 7	I am able to get customer support via chat to seek assistance	Guidance to use	High	Sprint - 1
Nurse	Health care	USN - 8	I can get the reports for the image on spot accurately and they can be downloaded as a pdf file	Record the results	Medium	Sprint - 3

5.2 Solution Architecture:

This system employs Convolutional Neural Networks (CNNs) to advance colon disease monitoring through real-time classification using Wireless Capsule Endoscopy (WCE). By harnessing the capabilities of CNNs, the system enhances both the accuracy and efficiency of the monitoring process, ensuring effective detection of abnormalities and facilitating timely interventions.

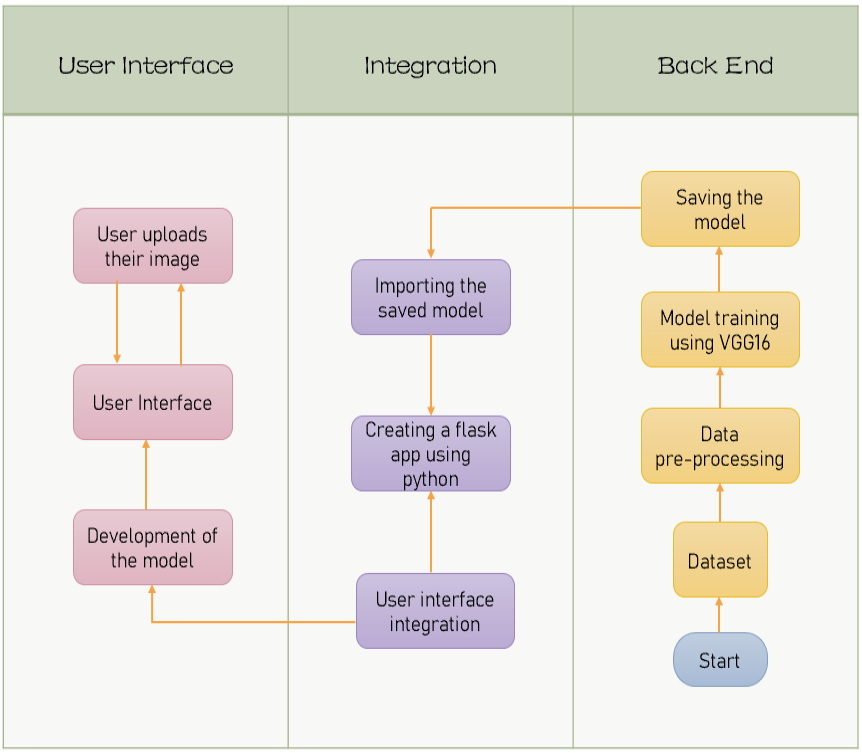
The incorporation of a continuous learning loop enables the system to adapt to new data and evolving patterns in colon health, sustaining a high level of accuracy in disease classification over time. In essence, this innovation has the potential to transform WCE-based colon disease monitoring, providing healthcare professionals with reliable insights and offering reassurance to individuals undergoing this non-invasive diagnostic procedure.

Solution Architecture Diagram



6. Project Planning & Scheduling

6.1 Technical Architecture:



Components & Technologies:

S.No	Component	Description	Technology
1.	Data collection sensors (not sure)	How user interacts with application e.g. Web UI, Mobile App, Chatbot etc.	HTML, CSS, JavaScript / Angular Js / React Js etc.
2.	Application Logic-1	Logic for a process in the application	Java / Python
3.	Application Logic-2	Logic for a process in the application	IBM Watson STT service
4.	Application Logic-3	Logic for a process in the application	IBM Watson Assistant
5.	Database	Data Type, Configurations etc.	MySQL, NoSQL, etc.
6.	Cloud Database	Database Service on Cloud	IBM DB2, IBM Cloudant etc.
7.	File Storage	File storage requirements	IBM Block Storage or Other Storage Service or Local Filesystem
8.	External API-1	Purpose of External API used in the application	IBM Weather API, etc.
9.	External API-2	Purpose of External API used in the application	Aadhar API, etc.
10.	Machine Learning Model	Purpose of Machine Learning Model	Object Recognition Model, etc.
11.	Infrastructure	Application Deployment on Local System / Cloud Local Server Configuration: Cloud Server Configuration:	Local, Cloud Foundry, Kubernetes, etc.

Application characteristics:

S.No	Characteristics	Description	Technology
1.	Open – Source frameworks	List the open-source frameworks used	Technology of Opensource framework
2.	Security implementations	List all the security / access controls implemented, use of firewalls etc.	e.g. SHA-256, Encryptions, IAM Controls, OWASP etc.
3.	Scalable architecture	Justify the scalability of architecture (3 – tier, Micro-services)	Technology used
4.	Availability	Justify the availability of application (e.g. use of load balancers, distributed servers etc.)	Technology used
5.	Performance	Design consideration for the performance of the application (number of requests per sec, use of Cache, use of CDN's) etc.	Technology used

6.2 Spirint Planning and Estimation:

Sprint	Functional Requirement(Epic)	User Story Number	User story/Task	Story points	Priority	Team members
Sprint -1	Registration	USN -1	As a user, I can register for the application by entering my email, password and confirming my password	2	High	Shivansh
Sprint -1	Login	USN -2	As a user, I will receive confirmation email once I have registered for the application	1	High	Divya

Sprint -2	Registration	USN -3	As a user, I can register for the application through Facebook	2	Low	Gungun
Sprint -1	Login	USN -4	As a user, I can log into the application using my email & password	2	Medium	Mahitha
Sprint -1	Dashboard	USN -5	As a user, I am able to contact the administration for help	1	High	Gungun

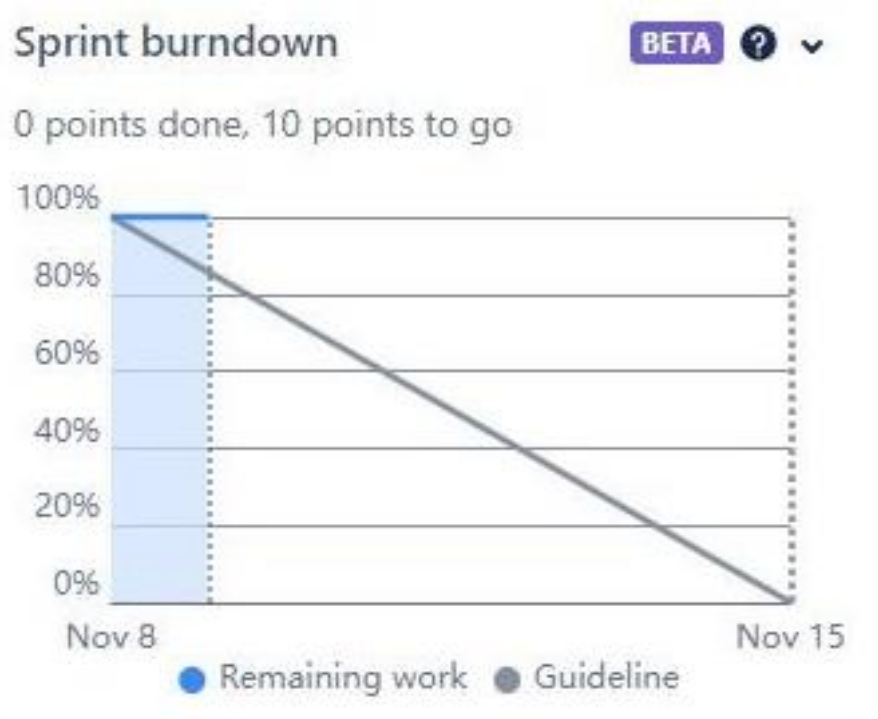
6.3 Sprint Delivery Schedule:

Sprint	Total story points	Duration	Sprint start date	Sprint end date (Planned)	Story points completed (as on planned date)	Sprint release (Actual)
Sprint -1	20	6 - days	24 Oct 2023	29 Oct 2023	20	29 Oct 2023
Sprint -2	20	6 - days	1 Nov 2023	6 Nov 2023	20	5 Nov 2023
Sprint -3	20	6 - days	7 Nov 2023	12 Nov 2023	17	15 Nov 2023
Sprint -4	20	6 - days	14 Nov 2023	19 Nov 2023	18	21 Nov 2023

Velocity:
Imagine we have a 25-days sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

AV= 25/20 = 1.25

Burndown Chart:
A burndown chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.



7. CODING & SOLUTIONING

7.1 Feature Selection

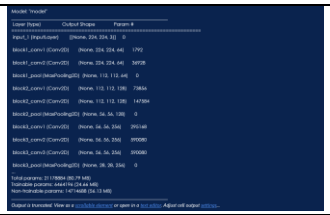
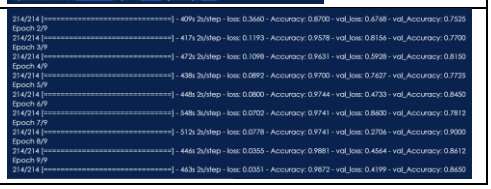
In our data analysis process, we conducted a thorough examination of the dataset to identify the key features that significantly influence the prediction of image related to colon. We employed correlation analysis to measure the relationships between different variables and their impact on the outcome.

Through this analysis, we identified a subset of features that exhibited strong correlations with colon disease classification, while other variables showed relatively weaker associations.

Hence, the main features to detect the pattern and classify the image were considered, leaving the weak features behind.

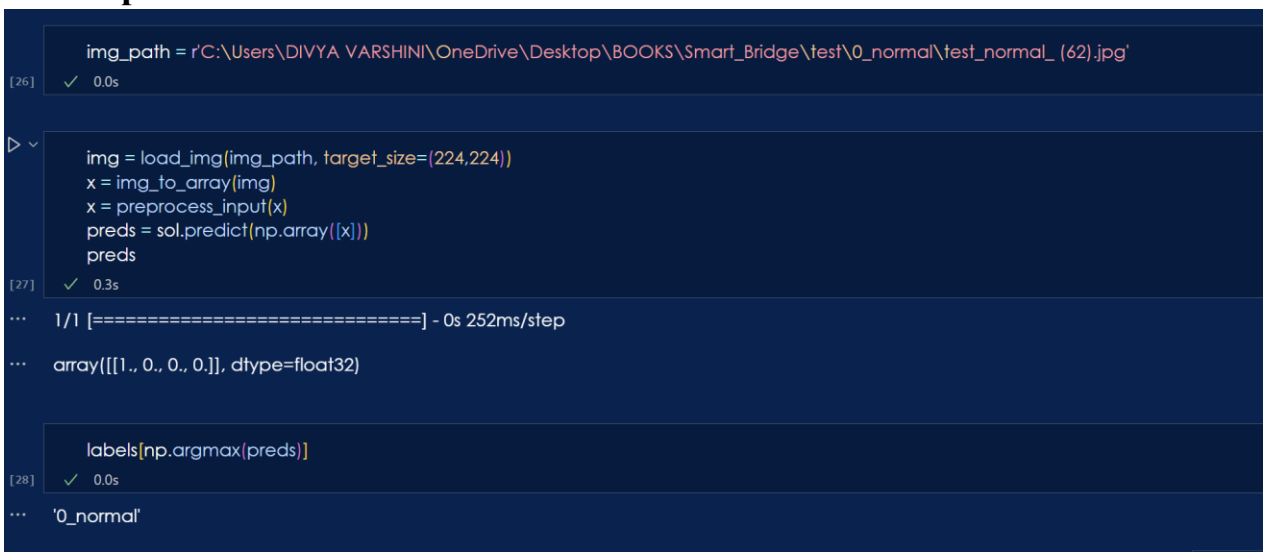
8. Performance Testing

8.1 Performance Metrics

S.No.	Parameter	Values	Screenshot
1.	Model Summary	-	
2.	Accuracy	Training Accuracy - 0.9872 Validation Accuracy - 0.8650	

9. Results

9.1 Output Screenshots



```
[29] ✓ 0.0s
```

```
img_path = r'C:\Users\DIVYA VARSHINI\OneDrive\Desktop\BOOKS\Smart_Bridge\test\3_esophagitis\test_esophagitis_ (28).jpg'
```

```
[30] ✓ 0.3s
```

```
img = load_img(img_path, target_size=(224,224))
x = img_to_array(img)
x = preprocess_input(x)
preds = sol.predict(np.array([x]))
preds
```

```
1/1 [==============================] - 0s 197ms/step

array([[0., 0., 0., 1.]], dtype=float32)
```

```
[31] ✓ 0.0s
```

```
labels[np.argmax(preds)]
```

```
'3_esophagitis'
```

```
[32] ✓ 0.0s
```

```
img_path = r'C:\Users\DIVYA VARSHINI\OneDrive\Desktop\BOOKS\Smart_Bridge\test\1_ulcerative_colitis\test_ulcer_ (41).jpg'
```

```
[33] ✓ 0.2s
```

```
img = load_img(img_path, target_size=(224,224))
x = img_to_array(img)
x = preprocess_input(x)
preds = sol.predict(np.array([x]))
preds
```

```
1/1 [==============================] - 0s 176ms/step

array([[0.000000e+00, 1.000000e+00, 9.781533e-35, 0.000000e+00]],
      dtype=float32)
```

```
[34] ✓ 0.0s
```

```
labels[np.argmax(preds)]
```

```
'1_ulcerative_colitis'
```

10. Advantages and Disadvantages

10.1 Advantages:

Implementing a Wireless Capsule Endoscopy (WCE) system with AI capabilities in colon disease monitoring presents numerous advantages. Primarily, it enables the early detection of potential issues in the colon, facilitating prompt intervention and improved health outcomes.

This proactive approach reduces the risks associated with complications and lowers healthcare costs by minimizing the need for urgent interventions. Moreover, the system offers personalized, data-driven insights, elevating the quality of care for individuals undergoing colon screenings and providing assurance.

It empowers healthcare professionals with AI-generated information, facilitating more informed decision-making and efficient patient management. Additionally, this technology helps bridge healthcare disparities, ensuring that a broader demographic can access equitable, high-quality colon disease monitoring.

In summary, a WCE system with AI capabilities holds the potential to revolutionize colon disease monitoring, offering a comprehensive and proactive approach to enhance the health and well-being of individuals undergoing this non-invasive diagnostic procedure.

10.2 Disadvantages

While a Wireless Capsule Endoscopy (WCE) system with AI capabilities brings about significant advantages in colon disease monitoring, it is important to consider potential disadvantages and challenges. One notable concern is the reliance on technology, which may introduce complexities in terms of system maintenance, potential malfunctions, and the need for specialized expertise.

The interpretability of AI-generated insights poses another challenge, as complex algorithms may be perceived as "black boxes," making it difficult for healthcare professionals to fully understand and trust the decision-making process. Moreover, the initial implementation costs and the need for sophisticated equipment could pose financial barriers for healthcare facilities.

There may also be ethical considerations related to patient privacy and the responsible handling of sensitive health data. Lastly, addressing the potential for false positives or negatives in disease classification remains a challenge

11. Conclusion

In conclusion, the integration of AI technology into Wireless Capsule Endoscopy (WCE) for colon disease monitoring holds great potential in advancing healthcare outcomes. The substantial benefits, such as early disease detection, personalized care, and cost reduction, can significantly improve patient outcomes.

However, it is imperative to carefully address associated challenges, including data privacy, accessibility, and ethical considerations. Striking a well-balanced approach that prioritizes security, equity, and adherence to ethical guidelines is essential to unlock the full potential of AI in WCE-based colon disease monitoring. With proper safeguards and considerate implementation, AI in WCE has the capacity to revolutionize disease monitoring, contributing to more effective interventions and healthier outcomes for individuals undergoing this non-invasive diagnostic procedure.

12. Future Scope

The future scope of AI in Wireless Capsule Endoscopy (WCE) for colon disease monitoring holds immense potential, presenting numerous opportunities for advancement. As technology progresses, we can anticipate the development of even more accurate and sophisticated AI models capable of providing earlier and more precise detection of colon health issues.

The integration of wearable devices and telehealth solutions is poised to enhance accessibility and monitoring capabilities, enabling remote, real-time monitoring and support for individuals undergoing colon screenings. Moreover, the application of AI in colon disease monitoring can extend beyond issue detection to proactive health management, incorporating personalized recommendations for dietary and lifestyle adjustments tailored to individual needs.

Collaborative efforts between AI developers, healthcare professionals, and regulatory bodies will be pivotal in shaping the future of AI in WCE, ensuring its ethical and secure implementation. Ultimately, AI in WCE holds the potential to further revolutionize colon disease monitoring, fostering a more preventive, data-driven, and patient-centric approach for individuals undergoing this non-invasive diagnostic procedure, paving the way for a healthier future.

13. Appendix

Source Code: **https://github.com/smartinternz02/SI-GuidedProject-580786-1694703095**

Github: **https://github.com/smartinternz02/SI-GuidedProject-580786-1694703095**