DEGREE: MSc in Artificial Intelligence

Module: Multi-Modal Chatbots

Assignment Title: Developing an Early Plant-Disease Detection Multi-Modal Chatbot- **PlantGuard**

Assignment Type: Set exercise

Word Limit: 2500-3000 words

Weighting: 100%

Issue Date: 4/9/2025

Submission Date: 3/10/2025

Feedback Date: 24/10/2025

Plagiarism:

When submitting work for assessment, students should be aware of the InterActive/Canvas guidance and regulations in concerning plagiarism. All submissions should be your own, original work.

You must submit an electronic copy of your work. Your submission will be electronically checked.

Learner declaration
I certify that the work submitted for this assignment is my own and research sources are fully acknowledged. **Student signature:** **Date:**

Harvard Referencing:

The Harvard Referencing System must be used. The Wikipedia, UKEssays.com or similar websites must **not** be used or referenced in your work.

Overview:

Timely and accurate identification of foliar diseases is essential for protecting crop yields and reducing unnecessary chemical treatments. However, small-scale farmers often rely on manual visual inspection, which can lead to **delayed, inaccurate, or inconsistent diagnoses**.
In this assignment, you will develop **PlantGuard** — a **proof-of-concept multimodal chatbot** designed to support early detection of plant diseases through **AI-powered analysis**. Your system must be capable of:

- Processing a **photograph of a symptomatic leaf** taken with a mobile device
- Capturing a **spoken description** of observed symptoms
- Accepting **text-based follow-up questions** from the user

Learning Outcomes:

LO1. Innovate and design multi-modal chatbots that effectively process and respond to text, voice, and visual inputs, incorporate natural language processing and generation techniques to enhance conversational capabilities.

LO2. Effectively communicate and present comprehensive ethical considerations and regulatory compliance strategies for multi-modal chatbot development, addressing issues related to data privacy, bias mitigation, and responsible AI practices.

LO3. Engage in practical development projects, create and deploy multi-modal chatbots across various industries, gain hands-on experience in user-centric design, data integration, and address real-world challenges faced in the field.

Assignment Goals:

Objective:

You are tasked with developing a **multimodal chatbot** that processes:

- **Leaf images**
- **Voice descriptions of symptoms**
- **Text-based questions**

Your chatbot application should be able to:

- Diagnose common plant diseases (e.g., powdery mildew, blight)
- Recommend appropriate treatments
- Demonstrate the full AI pipeline, from data processing and model development to deployment and ethical analysis

Assignment Tasks and Weighting:

1. Environment Setup (10%)

You are required to set up a suitable development environment that supports multimodal AI

applications.

- **Libraries:** PyTorch, TorchVision, Transformers (Hugging Face), OpenCV, SpeechRecognition, and either Streamlit or Flask. If opting for a browser-based interface, you may also utilize **JavaScript** along with **HTML** and **CSS**, supported by frameworks or libraries such as **React.js** or **Vue.js** for a dynamic frontend.
- **API Keys:** Configure access to cloud-based APIs if using services like Google Speech-to-Text or Hugging Face Inference API.

2. Data Acquisition & Exploration (15%)

2.1. Visual Data

- **Dataset:** PlantVillage (54 000+ leaf images, 38 classes) or any other publicly available leaf image datasets like ImageNet-1K datasets.
- **Sub-Task:**
  - Load and display sample images
  - Plot class distributions and compare representative healthy vs. diseased leaves.

2.2. Voice/Text Data

- **Synthetic Voice Descriptions:** Use synthetic audio recordings to simulate farmers describing plant symptoms. You may generate these using any free and publicly available online platforms, such as **LuvVoice**. Ensure that the recordings are clear, contextually relevant, and diverse enough to reflect different symptom descriptions.
- **FAQ Corpus:** Text Q&A pairs on plant-care best practices.
- **Sub-Task:**
  - Transcribe a selection of audio files and tokenize the text data
  - Explore vocabulary and semantic coverage across question categories

3. Preprocessing (15%)

3.1. Image Pipeline

- Resize and normalize the input data.
- Apply augmentation techniques such as horizontal flips, rotations, and color jitter to improve generalization

3.2. Audio Pipeline

- Convert WAV files to Mel-Frequency Cepstral Coefficients (**MFCCs)** features using librosa or a similar tool.

3.3. Text Pipeline

- Apply different NLP techniques to clean and structure the input text such as Lowercase, Stopword filtering, tokenization, etc.,

4. Model Design (20%)

4.1. Vision Model

- Fine-tune a pre-trained convolutional neural network (e.g., ResNet50/101 or any other suitable architecture such as EfficientNet, DenseNet, or MobileNet-V2 etc.) on any publicly available leaf image datasets like PlantVillage (via TensorFlow Datasets) or ImageNet-1K dataset to boost disease detection accuracy.
- Adapt the final classification layer to match the number of disease categories in your target dataset, if required.

- For models like ResNet-50 or ResNet-101, consider freezing the backbone layers during the initial training epochs to preserve learned representations while stabilizing the classification head.

4.2. Speech & Text Models

- **Speech**: Develop a CNN-LSTM classifier using **MFCCs** to classify voice-based symptom descriptions.
- **Text:** Fine-tune a BERT-based question answering model on a curated plant-care FAQ dataset to support natural language queries.

4.3. Multi-Modal Fusion

- Extract semantic embeddings from both the vision and text pipelines
- Concatenate the embeddings and feed them into a Multilayer Perceptron (MLP) with a unified classification head to generate the final disease prediction.

5. Training & Evaluation (20%)

5.1. Training Loops

- Design **independent training loops** for each modality (image, audio, text)
- Implement a final **joint fine-tuning phase** for the multimodal architecture
- Optionally use **TensorBoard** or similar tools to log and track training metrics.

5.2. Evaluation Metrics

- **Vision Model:** Accuracy, F1 per class, etc,
- **Speech/Text Models:**
  - WER (Word Error Rate) for speech → text,
  - Exact Match (EM) and F1-score for text QA.
- **Multi-Modal:** Overall diagnostic accuracy.

6. Deployment & User Testing (10%)

6.1 UI Prototype: You are expected to develop a professional, user-friendly web application that enables multimodal interaction with your chatbot. You may choose from one of the following technologies for frontend development:

- **Python-based frameworks:** such as **Streamlit** or **Flask**
- **Web technologies:** such as **JavaScript** in combination with **HTML** and **CSS**

Regardless of the chosen technology stack, your user interface should include the following core components:

- **Image Upload Widget:** to allow users to upload photographs (e.g., leaf images) for visual analysis.
- **Voice Input Widget:** to record or upload audio descriptions of symptoms.
- **Text Input Field:** to enable users to submit textual queries for follow-up questions or additional clarification.

The interface must ensure seamless, intuitive, and responsive user interactions across all modalities (image, voice, text). Accessibility and cross-browser compatibility are encouraged.

6.2 Containerization:

You must containerize your application using:

- A Dockerfile to define the runtime environment and install dependencies
- A docker-compose configuration to orchestrate multiple services (e.g., model backend, UI frontend).

This ensures **reproducibility**, **portability**, and alignment with **real-world deployment standards**.

7. Ethical & Regulatory Considerations (10%)

You are expected to address the following ethical and legal dimensions:

- **Data Privacy:** Ensure voice recordings comply with GDPR or equivalent regulations. No personally identifiable data should be stored.
- **Bias Mitigation:** Address dataset imbalance (e.g., underrepresented disease classes) using techniques such as **SMOTE** or **class reweighting**, if required.
- **Responsible AI:**
  - Provide confidence scores for each prediction
  - Clearly state that this tool provides agronomic advice, not medical or professional diagnoses

Submission Guidelines

Prepare a comprehensive report showcasing your chatbot design, implementation, and evaluation:

- Include screenshots or embedded visuals illustrating UI designs, model architecture, training progress, and evaluation metrics.
- Ensure all code is well-commented with clear replication instructions.
- Your report must be clear, organized, and visually appealing, using the **BSBI assignment template** available on Canvas.
- Upload your submission as a single file (PDF or DOC) on the BSBI portal.
- Python scripts or Jupyter notebooks should be uploaded to a repository platform (e.g., GitHub) with a **shared link included**.
- Cite all sources using the Harvard Referencing System.
- Submit your assignment electronically by the specified deadline.

GRADING DESCRIPTORS: LEVEL 7

EXPERIMENTATION & INNOVATION								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Deals with complex issues both systematically and creatively demonstrating self-direction and originality in tackling and solving problems	Little to no ability to use techniques to deal with complex issues systematically (including those of ethics and sustainability) and creatively to solve problems and/or make decisions.	Low utilisation of established techniques to deal with complex issues systematically (including those of ethics and sustainability) and creatively to solve problems and/or make decisions, but with limitations in techniques or approach.	Limited research or advanced scholarship to their area of study by using a range of information and established and advanced techniques	Competent understanding of solving problems, through own research or advanced scholarship displaying a comprehensive understanding of established and advanced techniques	Good understanding of solving problems through own research and advanced scholarship critically selecting and displaying a comprehensive understanding of established and advanced techniques.	Very Good problem-solving skills displaying a comprehensive understanding of techniques applicable to their own research or advanced scholarship	Excellent range of extremely well-developed problem-solving displaying an understanding of techniques applicable to their own research or advanced scholarship beyond which is taught.	Exceptional problem-solving skills with sophisticated evaluation and application of a wide range of advanced information and techniques to undertake projects.
Comprehensive understanding of techniques applicable to their own research or advanced scholarship	Little to no understanding of techniques applicable to their own research or advanced scholarship or their limitations and ambiguities.	Low understanding of techniques applicable to their own research or advanced scholarship including their limitations and ambiguities.	Limited understanding of key techniques applicable to their own research or advanced scholarship including their limitations and ambiguities.	Competent understanding of techniques applicable to their own research or advanced scholarship including their limitations and ambiguities	Good understanding of techniques applicable to their own research or advanced scholarship and a some understanding of more specialised techniques.	Very good understanding of techniques applicable to their own research or advanced scholarship and a some understanding of more specialised techniques.	Excellent understanding of techniques applicable to their own research or advanced scholarship and mastery of some more specialised areas.	Exceptional understanding of techniques applicable to their own research or advanced scholarship and mastery of some more specialised areas.

GRADING DESCRIPTORS: LEVEL 7

RESEARCH & ANALYSIS								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of their academic discipline, field of study or area of professional practice	Little to no knowledge of the subject with limited breadth or depth or deficiencies in major areas or currency.	Low knowledge of the subject lacking coherence, breadth, or detail with only some reference to ideas or arguments at the forefront of any part of the subject.	Limited knowledge to deal with terminology, facts and concepts some of which is informed by the forefront of defined areas of the subject.	Competent knowledge of ideas or arguments at the forefront of any part of the subject sufficient to deal with current issues in the discipline, generally more descriptive than critical or analytical.	Good knowledge of ideas or arguments at the forefront of any part of the subject showing a clear, critical insight into the discipline as whole and current issues/problems.	Very good knowledge of ideas or arguments at the forefront of the subject some of which are significantly beyond what has been taught and show a critical insight into the discipline and current issues/problems.	Excellent knowledge of ideas or arguments at the forefront of the subject many of which are significantly beyond what has been taught and show a critical insight into the discipline and current issues/problems.	Exceptional knowledge of ideas or arguments at the forefront of the subject most of which are significantly beyond what has been taught and show a critical insight into the discipline and current issues/problems.
Conceptual understanding that enables the student to display originality in the application of knowledge	Little to no conceptual understanding or argument and a focus on descriptive explanations which do not comment on arguments of others or alternative views.	Low conceptual understanding and arguments are weak or poorly constructed, and the work does not critically evaluate the arguments of others or consider alternative views.	Limited conceptual understanding and argument construction with critical evaluation of alternative views or comment on advanced scholarship.	Competent conceptual understanding and argument construction with critical evaluation of a range of views and consistent engagement with advanced scholarship.	Good conceptual understanding which critically evaluate and synthesise other views and information with a thoughtful interpretation of advanced scholarship.	Very good conceptual understanding which systematically synthesises a wide range of views with a critical insight into advanced scholarship.	Excellent conceptual understanding which critically apply a wide range of views through a perceptive use of advanced scholarship.	Exceptional conceptual understanding of publishable quality with systematic engagement and usage of advanced scholarship.

GRADING DESCRIPTORS: LEVEL 7

ENGAGING WITH PRACTICE								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in the discipline	Little to no evidence of background investigation, analysis, research, enquiry, ethical awareness, and/or study.	Low evidence of background investigation, analysis, research, enquiry, ethical awareness, and/or study.	Limited background investigation, analysis, research, enquiry , ethical awareness, and/or study using established techniques, with the ability to extract relevant points.	Competent investigation, analysis, research, enquiry, ethical awareness, and/or study using established techniques accurately, and can critically appraise and use academic sources.	Good background investigation, analysis, research, enquiry, ethical awareness, and/or study using established techniques accurately, and possesses a well-developed ability to critically appraise a wide range of sources.	Very good, independent, extensive and appropriate investigation, analysis, research, enquiry, ethical awareness, and/or study beyond the usual range, and critically evaluates this to advance the work and/or direct arguments.	Excellent independent, extensive and appropriate investigation, analysis, research, enquiry, ethical awareness, and/or study well beyond the usual range, and critically evaluates this to advance the work and/or direct arguments.	Exceptional investigation, analysis, research, enquiry, ethical awareness, and/or study which demonstrates carefully considered depth and breadth and critically synthesises this to advance the work and/or direct arguments.
Originality in the application of knowledge	Little to no technical, creative or artistic skills related to their area of study.	Low technical, creative or artistic skills related to their area of study.	Limited technical, creative or artistic skills required for area of study.	Competent technical, creative or artistic skills required for area of study.	Good technical, creative or artistic skills required for area of study.	Very good range of technical, creative or artistic skills.	Excellent range of technical, creative or artistic skills	Exceptional range of technical, creative or artistic skills
Independently advance your own knowledge and understanding, and to develop new skills to a high level.	Little to no contribution to group activity and/or undertaking further training at a high/advanced level.	Low contribution to group activity and/or undertaking further training at a high/advanced level.	Limited contribution to group activity and/or undertaking further training at a high/advanced level.	Competent contribution to group activity and/or independently undertakes further training at a high/advanced level.	Good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Very good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Excellent contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and leadership	Exceptional contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and strong leadership.

GRADING DESCRIPTORS: LEVEL 7

REALISATION & COMMUNICATION								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.	Little to no clarity in the communication of ideas, problems and solutions to audiences.	Low clarity in the communication of ideas, problems and solutions to audiences.	Limited clarity in the communication of ideas, problems and solutions to audiences.	Competent communication of ideas, problems and solutions to audiences.	Good, confident and clear communication of ideas, problems and solutions to audiences in a range of means / media.	Very good, confident and clear communication of ideas, problems and solutions to audiences in a range of means / media.	Excellent communication of ideas, problems and solutions to audiences in a range of means / media.	Exceptional communication of ideas, problems and solutions to audiences in a range of means / media.

GRADING DESCRIPTORS: LEVEL 7

PERSONAL & PROFESSIONAL CONNECTIVITY								
	FAIL			**PASS**				
Threshold Criteria	**0-29%**	**30-39%**	**40-49%**	**50-59%**	**60-69%**	**70-79%**	**80-89%**	**90-100%**
Independently advance your own knowledge and understanding, and develop new skills to a high level.	Little to no contribution to group activity and/or undertaking further training at a high/advanced level.	Low contribution to group activity and/or undertaking further training at a high/advanced level.	Limited contribution to group activity and/or undertaking further training at a high/advanced level.	Competent contribution to group activity and/or independently undertakes further training at a high/advanced level.	Good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Very good contribution to group activity and/or independently undertakes further training at a high/advanced level with an understanding of team roles	Excellent contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and leadership	Exceptional contribution to group activity and/or independently undertakes further training at a high/advanced level with teamwork and strong leadership.
Qualities and transferable skills necessary for employment requiring: (a) the exercise of initiative, ethical and personal responsibility (b) decision-making in complex and unpredictable contexts	Little to no ability to manage learning and/or exercise initiative, ethical and personal responsibility and/or decision-making in complex and unpredictable situations	Low ability to manage learning and/or exercise initiative, ethical and personal responsibility and/or decision-making in complex and unpredictable situations	Limited ability to manage learning and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Competent ability to manage learning, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Good ability to systematically manage learning, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Very good ability to systematically manage learning, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations.	Excellent ability to manage learning on own initiative, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations	Exceptional ability to manage learning on own initiative, and exercise initiative, ethical and personal responsibility, and decision-making in complex and unpredictable situations
	Little to no use of appropriate terminology, limited vocabulary and many errors in spelling, grammar and syntax.	Low use of appropriate terminology, with many errors in spelling, vocabulary and syntax.	Limited expression, style and appropriate vocabulary with errors in spelling, grammar and syntax which affect understanding.	Competent expression, style, and appropriate vocabulary with some errors in spelling, grammar and syntax which do not affect understanding.	Good expression, style and appropriate vocabulary with some errors in spelling, grammar and syntax.	Very good expression, style and appropriate vocabulary with minimal errors in spelling, grammar and syntax.	Excellent expression, style and appropriate vocabulary with minimal errors in spelling, grammar and syntax.	Exceptional expression, style and appropriate vocabulary with no errors in spelling, grammar and syntax.

GRADING DESCRIPTORS: LEVEL 7

	Little to no evidence of basic numeracy or digital literacy, hardware and software skills	Low evidence of basic numeracy or digital literacy, hardware and software skills competency.	Limited evidence of numeracy or digital literacy, hardware and software skills competency.	Adequate evidence of numeracy or digital literacy, hardware and software skills competency.	Good evidence of numeracy or digital literacy, hardware and software skills competency.	Very good evidence of numeracy or digital literacy, hardware and software skills	Excellent evidence of numeracy or digital literacy, hardware and software skills competency.	Exceptional evidence of numeracy or digital literacy, hardware and software skills competency.

	competency.					competency.		
	Does not demonstrate achievement of professional competence when assessed against the requirements of a professional, statutory or regulatory body (PSRB).			The student has demonstrated achievement of professional competence when assessed against the requirements of a PSRB.				
	Inaccurate use of terminology with limited vocabulary and many errors in spelling, grammar and syntax. Inaccurate terminology, with many errors in spelling, vocabulary and syntax.			The student has adhered to the appropriate rules and/or conventions set by regulators or the industry.				