

Consolidated Final-Year Project Ideas

This document outlines a refined list of innovative Final-Year Project (FYP) ideas, each addressing a significant real-world problem through novel AI-powered software solutions. Redundant ideas from the initial prompt and uploaded attachments have been merged and clarified. For each idea, we detail the unsolved problem, the innovative software solution, its core AI integration, and the relevant research context, along with technical and non-technical requirements.

1. AI-Driven Early Warning System for Zoonotic Disease Outbreaks

- **Unsolved Problem:** The current global health landscape lacks a truly integrated, real-time early warning system for zoonotic disease outbreaks. Existing methods rely on fragmented data and slow manual reporting, leading to delayed responses and increased risk of widespread crises. The challenge lies in fusing diverse data sources and identifying subtle patterns indicative of an emerging threat.
- **Innovative Software Solution:** Develop an AI platform that aggregates and analyzes real-time, multi-source data to predict potential zoonotic disease outbreaks. This platform would ingest data from veterinary records, wildlife sensor networks, environmental monitoring systems, and public health reports (including social media and news feeds). The system would use advanced Natural Language Processing (NLP) to extract relevant information from unstructured text, and Graph Neural Networks (GNNs) to model complex relationships between hosts, pathogens, and environmental factors. The AI would identify unusual patterns, anomalies, and correlations that precede outbreaks, issuing timely and actionable alerts to public health authorities. A web-based dashboard would visualize risk areas, predicted spread, and key indicators.
- **AI Integration:**
 - **Data Fusion:** AI algorithms (e.g., deep learning, ensemble methods) to integrate heterogeneous data streams (structured and unstructured).
 - **Pattern Recognition:** NLP for text analysis (e.g., sentiment analysis, entity recognition) and GNNs for identifying complex epidemiological patterns and transmission pathways.
 - **Predictive Modeling:** Time-series forecasting and classification models to predict outbreak likelihood, location, and potential severity.

- **Anomaly Detection:** Unsupervised learning techniques to flag unusual data points or trends that might indicate an emerging threat.
- **Research Context:** While AI is increasingly applied in epidemiology (e.g., for syndromic surveillance), a comprehensive, real-time, multi-source data fusion system specifically for zoonotic threats remains a significant gap. This project builds upon existing research in AI for infectious disease surveillance by emphasizing the integration of diverse data types and focusing on the animal-to-human transmission interface, which is often overlooked in human-centric public health systems. It extends concepts from projects like AMPLYFI's Zoonotic Early Warning System by aiming for broader data integration and more sophisticated predictive modeling.
- **Technical Requirements:**
 - **Data Ingestion:** APIs for various data sources (e.g., veterinary databases, weather APIs, social media APIs, sensor data feeds).
 - **Backend:** Python (Flask/Django) or Node.js (Express) for data processing, API endpoints, and model serving.
 - **Database:** NoSQL (e.g., MongoDB, Cassandra) for handling large volumes of diverse data, or Graph Database (e.g., Neo4j) for GNNs.
 - **AI/ML Frameworks:** TensorFlow/PyTorch for developing and deploying NLP and GNN models.
 - **Cloud Platform:** AWS/GCP/Azure for scalable compute and storage, potentially leveraging serverless functions for real-time processing.
 - **Frontend:** React/Angular/Vue.js for an interactive web dashboard with data visualization libraries (e.g., D3.js, Plotly).
 - **Geospatial Libraries:** GeoPandas, Folium for mapping and visualizing spatial data.
- **Non-Technical Requirements:**
 - **Data Access:** Collaboration with veterinary organizations, wildlife conservation groups, or public health agencies for data access (simulated data may be used for FYP).
 - **Ethical Considerations:** Data privacy, bias in AI models, and responsible use of predictive analytics in public health.
 - **Domain Expertise:** Consultation with epidemiologists, veterinarians, and public health experts.
 - **User Interface Design:** Intuitive and actionable dashboard for public health officials.

- **Scalability:** Design for potential future expansion to handle larger data volumes and more complex models.

2. AI-Powered Microplastic Detection and Analysis in Water Bodies

- **Unsolved Problem:** The pervasive issue of microplastic pollution in aquatic environments (oceans, rivers, lakes, drinking water) is severely hampered by the lack of efficient, real-time, and cost-effective detection and quantification methods. Current laboratory-based analyses are slow, expensive, and cannot provide the spatial and temporal resolution needed to understand pollution dynamics and identify hotspots.
- **Innovative Software Solution:** An AI-powered system designed for autonomous, in-situ detection and classification of microplastics in water bodies. The core of the solution involves a robust Convolutional Neural Network (CNN) trained on a diverse dataset of underwater images containing various types, sizes, and colors of microplastics. This CNN would be integrated with an imaging system (e.g., mounted on an Autonomous Underwater Vehicle (AUV) or a fixed buoy). The software would process the imagery in real-time, identify microplastic particles, classify them by type (e.g., fiber, fragment, pellet), and quantify their presence. The data would then be transmitted to a central platform, generating a live, interactive map of microplastic distribution, identifying pollution sources, and tracking their movement over time.
- **AI Integration:**
 - **Computer Vision:** CNNs for object detection and image segmentation to accurately identify and delineate microplastic particles from natural debris.
 - **Classification:** Deep learning models for classifying microplastic types based on visual features.
 - **Real-time Processing:** Optimized AI models for edge computing on AUVs or sensors to enable immediate analysis.
 - **Data Visualization:** AI-driven insights to create dynamic maps and dashboards showing pollution levels and trends.
- **Research Context:** While machine learning has been applied to microplastic detection in laboratory settings (e.g., using spectral analysis), its application in real-world, autonomous, and image-based systems for broad aquatic environments is still nascent. This project pushes the boundary by focusing on robust visual detection in challenging underwater conditions and integrating it into

a real-time mapping and monitoring system, moving beyond static lab analyses to dynamic environmental surveillance.

- **Technical Requirements:**

- **Hardware Integration:** Interfacing with camera systems (e.g., Raspberry Pi with camera module for prototyping, or simulated AUV data).
- **Edge Computing:** TensorFlow Lite or similar for deploying lightweight AI models on resource-constrained devices.
- **Backend:** Python (FastAPI/Flask) for data reception, storage, and API serving.
- **Database:** Time-series database (e.g., InfluxDB) for storing real-time pollution data.
- **AI/ML Frameworks:** PyTorch/TensorFlow for model training and deployment.
- **Frontend:** Web-based interface (React/Vue.js) with mapping libraries (e.g., Leaflet, Mapbox GL JS) for interactive visualization.
- **Data Augmentation:** Techniques to generate diverse training data for microplastics in varied underwater conditions.

- **Non-Technical Requirements:**

- **Dataset Collection:** Access to or creation of a diverse dataset of microplastic images in water (simulated or real).
- **Environmental Science Expertise:** Collaboration with marine biologists or environmental scientists for ground truth data and validation.
- **Ethical Considerations:** Ensuring data accuracy and avoiding false positives/negatives.
- **Deployment Challenges:** Addressing power constraints, data transmission in underwater environments, and sensor maintenance (for real-world deployment).

3. AI-Powered Personalized Mental Health Companion for Extreme Environments (Astronauts & Remote Workers)

- **Unsolved Problem:** Individuals in isolated, confined, and extreme environments (ICE), such as astronauts on long-duration space missions, polar researchers, or remote workers in hazardous locations, face significant mental health challenges including isolation, stress, and communication delays. Existing support systems are limited, and real-time, personalized psychological intervention is difficult to provide.

- **Innovative Software Solution:** An AI-powered mental health companion designed to provide personalized, real-time psychological support. The system would use multimodal AI, integrating Natural Language Processing (NLP) to analyze speech and text patterns (e.g., journal entries, voice logs), and potentially wearable sensor data (e.g., heart rate variability, sleep patterns) to detect subtle emotional cues and early signs of stress, anxiety, or depression. The AI would then dynamically generate and deliver tailored interventions, such as guided meditations, cognitive-behavioral therapy (CBT) exercises, mindfulness prompts, or even personalized conversational support, adapting to the user's current emotional state and historical responses. The system would operate largely autonomously, with a secure, asynchronous communication channel to human mental health professionals for oversight and intervention in critical situations. The AI would learn and adapt over time through reinforcement learning to optimize intervention effectiveness.
- **AI Integration:**
 - **Multimodal AI:** Fusion of NLP (speech-to-text, sentiment analysis, topic modeling) and physiological data analysis.
 - **Emotion Recognition:** Deep learning models trained on emotional speech and text datasets.
 - **Personalized Intervention Generation:** Generative AI (e.g., large language models fine-tuned for therapeutic dialogue) to create adaptive coping strategies and conversational responses.
 - **Reinforcement Learning:** To continuously adapt and optimize intervention strategies based on user engagement and feedback (implicit or explicit).
 - **Anomaly Detection:** To identify critical mental health states requiring human intervention.
- **Research Context:** While AI is being explored for general mental health support and for astronauts (e.g., AI companions like CIMON), a truly personalized, adaptive, and multimodal system capable of delivering therapeutic interventions in real-time within extreme, isolated environments remains largely undeveloped. This project extends current research by focusing on deep personalization, real-time adaptation of therapeutic content, and robust multimodal input analysis, addressing the unique constraints of ICE environments (e.g., communication delays, limited human oversight).
- **Technical Requirements:**
 - **Data Collection:** APIs for speech-to-text, text input, and simulated/real wearable sensor data.

- **Backend:** Python (FastAPI/Django) for data processing, AI model serving, and secure communication.
- **Database:** Secure, encrypted database for sensitive user data (e.g., PostgreSQL with encryption).
- **AI/ML Frameworks:** Hugging Face Transformers for NLP, TensorFlow/PyTorch for other deep learning models.
- **Frontend:** Mobile application (React Native/Flutter) for user interaction, and a web interface for human oversight.
- **Security & Privacy:** Robust encryption, access controls, and compliance with data privacy regulations (e.g., HIPAA for health data).
- **Non-Technical Requirements:**
 - **Ethical Guidelines:** Strict adherence to ethical guidelines for AI in mental health, ensuring user safety, privacy, and avoiding harmful biases.
 - **Clinical Validation:** Collaboration with psychologists or psychiatrists specializing in extreme environments (for validation, not direct implementation in FYP).
 - **User Acceptance:** Designing a system that fosters trust and engagement in a highly sensitive domain.
 - **Data Scarcity:** Strategies for training AI models with limited, sensitive data (e.g., federated learning, synthetic data generation).

4. AI-Driven Urban Heat Island Prediction and Mitigation Planner

- **Unsolved Problem:** Urban Heat Islands (UHIs) significantly impact urban quality of life, energy consumption, and public health, yet city planners lack dynamic, predictive, and actionable tools to effectively mitigate them. Current approaches often rely on static models or general guidelines, failing to account for real-time urban dynamics and the complex interplay of environmental factors.
- **Innovative Software Solution:** A web-based AI tool that provides real-time prediction of UHI formation and offers dynamic, optimized mitigation strategies. The system would integrate diverse data sources including satellite imagery (Land Surface Temperature, vegetation indices), local weather station data, urban infrastructure data (building materials, road networks), and demographic information. Using advanced machine learning models (e.g., deep learning for image analysis, time-series models for temperature prediction), the AI would predict UHI hotspots and their intensity. Crucially, the platform would feature a generative AI component that simulates the impact of various mitigation

interventions (e.g., increased green spaces, cool roofs, permeable pavements) on urban temperatures. This allows city planners to run

‘what-if’ scenarios, visualize the projected cooling effects, and receive optimized recommendations for intervention placement and type. The platform would also track the effectiveness of implemented strategies over time.

- **AI Integration:**

- **Remote Sensing & Image Analysis:** Deep learning (e.g., CNNs) for processing satellite and aerial imagery to extract land cover, surface temperature, and vegetation health data.
 - **Predictive Modeling:** Time-series forecasting models (e.g., LSTMs, Transformers) for predicting urban temperatures and UHI intensity based on historical and real-time data.
 - **Generative AI & Simulation:** Generative adversarial networks (GANs) or other generative models to simulate the environmental impact of proposed urban planning changes and visualize their effects.
 - **Optimization Algorithms:** Reinforcement learning or other optimization techniques to recommend optimal placement and types of mitigation strategies.
 - **Data Fusion:** Algorithms to integrate heterogeneous geospatial, meteorological, and urban planning datasets.
- **Research Context:** While AI is increasingly used for UHI mapping and prediction, and some tools exist for urban climate simulation, a dynamic, real-time, and generative AI-powered platform that allows for interactive scenario planning and optimized mitigation recommendations is still a significant research gap. This project builds upon existing work in urban climate modeling and remote sensing by integrating advanced generative AI for predictive visualization and optimization, moving beyond static analysis to proactive, adaptive urban planning.

- **Technical Requirements:**

- **Data Sources:** Access to satellite imagery (e.g., Landsat, Sentinel, MODIS), meteorological data APIs, and urban GIS data.
- **Backend:** Python (FastAPI/Django) for data processing, AI model serving, and API endpoints.
- **Database:** PostgreSQL/PostGIS for geospatial data storage.
- **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning models, scikit-learn for traditional ML, and libraries for generative models.
- **Cloud Platform:** Scalable cloud infrastructure (AWS/GCP/Azure) for data storage, processing, and model deployment.

- **Frontend:** Web-based interactive dashboard (React/Vue.js) with advanced geospatial visualization libraries (e.g., CesiumJS, Mapbox GL JS) for 3D urban modeling and scenario visualization.
- **Simulation Engine:** Integration with or development of a lightweight urban climate simulation engine.
- **Non-Technical Requirements:**
 - **Urban Planning Expertise:** Collaboration with urban planners and climate scientists for model validation and user interface design.
 - **Data Acquisition:** Potential challenges in acquiring high-resolution, real-time urban data for specific cities.
 - **Policy Integration:** Understanding how the tool can inform and integrate with existing urban planning policies.
 - **User Adoption:** Designing an intuitive interface that is accessible and valuable to city planners and policymakers.

5. AI-Driven Personalized Learning for Neurodegenerative Disease Patients

- **Unsolved Problem:** Patients suffering from neurodegenerative diseases (e.g., Alzheimer's, Parkinson's, dementia) experience progressive cognitive decline, but current cognitive training and therapeutic tools are often generic, static, and fail to adapt to the individual's fluctuating abilities and disease progression. This leads to reduced engagement, suboptimal outcomes, and a lack of personalized support in their daily lives.
- **Innovative Software Solution:** An AI-powered adaptive learning and cognitive support application that continuously monitors a patient's cognitive performance, emotional state, and daily context, and dynamically adjusts therapeutic exercises and cognitive aids. The system would use multimodal input, including user interactions within the app (e.g., response times, accuracy in cognitive games), speech analysis (for fluency, word retrieval), and potentially sensor data from wearables (e.g., activity levels, sleep patterns). Through reinforcement learning, the AI would personalize the difficulty, type, and presentation of cognitive exercises in real-time, ensuring optimal challenge without causing frustration. It would also provide personalized feedback, gentle reminders, and adaptive prompts for daily tasks. The system could offer a hybrid interface, allowing caregivers or clinicians to monitor progress and adjust high-level parameters, while the AI manages the daily adaptive learning.

- **AI Integration:**

- **Multimodal Data Analysis:** Fusion of behavioral data (app interactions), speech data (NLP, speech recognition), and physiological sensor data.
- **Adaptive Learning:** Reinforcement learning algorithms to dynamically adjust exercise difficulty and content based on real-time performance and long-term progress.
- **Personalized Feedback & Prompting:** Generative AI to create context-aware, personalized feedback and prompts.
- **Cognitive State Inference:** Machine learning models to infer cognitive load, engagement, and emotional state from user interactions.
- **Predictive Analytics:** Forecasting cognitive decline trajectories to proactively adapt interventions.

- **Research Context:** While AI is being explored in digital therapeutics for cognitive training, and some apps exist for neurodegenerative diseases, the level of real-time, multimodal adaptation and deep personalization proposed here is largely absent. Existing solutions often lack the continuous monitoring and reinforcement learning mechanisms needed to truly adapt to the highly variable progression of neurodegenerative conditions. This project extends research in adaptive learning systems and digital health by applying advanced AI techniques to a highly sensitive and complex domain, aiming for truly individualized care.

- **Technical Requirements:**

- **Mobile Development:** Cross-platform framework (React Native/Flutter) for the patient-facing application.
- **Backend:** Secure Python (Flask/Django) or Node.js (Express) backend for data processing, AI model serving, and caregiver/clinician interface.
- **Database:** Encrypted database (e.g., PostgreSQL) for sensitive patient data, with robust access control.
- **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning models, scikit-learn for traditional ML, and specialized libraries for reinforcement learning.
- **Speech Processing:** Libraries for speech-to-text and speech analysis.
- **Wearable Integration:** APIs for integrating data from common wearables (e.g., Apple HealthKit, Google Fit, or specific research-grade sensors).
- **Security & Compliance:** Adherence to healthcare data privacy regulations (e.g., HIPAA, GDPR).

- **Non-Technical Requirements:**

- **Ethical Considerations:** Paramount importance of data privacy, informed consent, and avoiding any potential harm or distress to vulnerable patients. Bias in AI models must be carefully addressed.
- **Clinical Collaboration:** Essential collaboration with neurologists, neuropsychologists, and caregivers for design, validation, and ethical oversight.
- **User Experience (UX) Design:** Intuitive, simple, and non-frustrating interface for patients with cognitive impairments.
- **Accessibility:** Ensuring the app is accessible to individuals with varying degrees of motor, visual, and auditory impairments.
- **Longitudinal Data Collection:** Strategies for collecting and managing long-term patient data for model improvement.

6. AI-Enabled Disaster Response Coordination Platform

- **Unsolved Problem:** Disaster response efforts are frequently hindered by fragmented communication, inefficient resource allocation, and a lack of real-time situational awareness, especially in rapidly evolving crises. This leads to delayed aid, misallocation of resources, and increased casualties. There is no single, integrated platform that can effectively synthesize multi-modal data and automate coordination across diverse agencies.
- **Innovative Software Solution:** A comprehensive AI-powered platform designed to enhance disaster response coordination. The system would ingest and analyze incoming reports from various sources, including social media (text, images, videos), emergency calls, sensor data (e.g., seismic, weather, drone footage), and official agency updates. Using advanced NLP, computer vision, and audio analysis, the AI would automatically extract critical information (e.g., location of victims, type of damage, resource needs), prioritize urgent requests, and identify emerging patterns. The platform would then use optimization algorithms to recommend optimal resource allocation (e.g., deployment of rescue teams, medical supplies, food), identify efficient routes, and coordinate actions among different response agencies (e.g., fire, police, medical, NGOs). A real-time, interactive dashboard would provide a unified operational picture, allowing commanders to make data-driven decisions and track the status of ongoing operations. The system would also include predictive modeling for disaster progression and secondary hazards.

- **AI Integration:**

- **Multimodal Data Analysis:** NLP for text and speech, Computer Vision for image/video analysis (e.g., damage assessment, victim detection), and audio analysis for distress signals.
- **Information Extraction & Prioritization:** Deep learning models to extract entities, events, and relationships from unstructured data, and classify urgency.
- **Optimization Algorithms:** Graph theory, linear programming, or reinforcement learning for resource allocation, logistics, and route optimization.
- **Situational Awareness:** AI-driven fusion of disparate data streams to create a coherent, real-time operational picture.
- **Predictive Modeling:** Time-series analysis and spatial modeling to forecast disaster progression and potential secondary impacts.

- **Research Context:** While disaster informatics is an active research area, and AI is being applied to specific aspects like damage assessment or social media analysis, a truly integrated, multi-modal platform that automates decision support and coordination across multiple agencies in real-time remains a significant challenge. This project addresses the gap by unifying diverse data streams and leveraging AI for comprehensive situational awareness, intelligent resource allocation, and proactive response planning, moving beyond fragmented tools to a holistic coordination system.

- **Technical Requirements:**

- **Data Ingestion:** APIs for social media platforms, emergency call systems, sensor networks, and drone feeds.
- **Backend:** Scalable backend (e.g., Python with FastAPI/Django, or Java with Spring Boot) for high-throughput data processing and AI model serving.
- **Database:** Distributed database (e.g., Cassandra, MongoDB) for handling large volumes of real-time, unstructured data.
- **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning, scikit-learn for traditional ML, and optimization libraries.
- **Cloud Infrastructure:** Robust and highly available cloud platform (AWS/GCP/Azure) for disaster resilience.
- **Frontend:** Interactive web dashboard (React/Angular/Vue.js) with GIS capabilities for mapping and visualization.
- **Communication Protocols:** Secure and reliable communication channels for inter-agency coordination.

- **Non-Technical Requirements:**

- **Inter-Agency Collaboration:** Critical engagement with disaster response agencies (e.g., FEMA, Red Cross, local emergency services) for requirements gathering, data access (simulated for FYP), and validation.
- **Ethical Considerations:** Ensuring fairness in resource allocation, data privacy of victims, and avoiding algorithmic bias in critical situations.
- **Usability:** Designing a user interface that is intuitive and effective under high-stress conditions.
- **Training & Adoption:** Strategies for training responders and ensuring adoption of the new platform.

7. AI-Powered Food Authenticity and Safety Verification

- **Unsolved Problem:** Food fraud, adulteration, and contamination pose significant public health risks and economic losses globally. Current verification methods are often laboratory-based, time-consuming, expensive, and not readily available for rapid, on-site assessment by consumers, retailers, or even regulators. This lack of immediate, accessible verification tools allows fraudulent or unsafe products to enter the supply chain.
- **Innovative Software Solution:** A mobile application powered by AI that enables rapid, on-site verification of food authenticity and safety. The app would leverage the smartphone's camera and potentially integrate with portable, low-cost external sensors (e.g., miniature spectrometers, chemical sensors) via Bluetooth. The AI core would use computer vision to analyze visual cues (e.g., texture, color, packaging details) and machine learning models to interpret sensor data, comparing them against a comprehensive database of authentic food profiles and known contaminants. For example, it could detect adulteration in olive oil, identify mislabeled fish species, or flag potential spoilage in fresh produce. The app would provide instant feedback to the user (e.g.,

a 'verified' or 'suspicious' rating, with explanations). A backend system would continuously update the AI models with new data from verified sources and user contributions (with validation).

- **AI Integration:**

- **Computer Vision:** Deep learning (CNNs) for image analysis to identify visual characteristics of food products, packaging, and potential signs of adulteration or spoilage.

- **Sensor Data Analysis:** Machine learning models (e.g., SVMs, Random Forests, Neural Networks) to interpret data from portable spectrometers or chemical sensors for compositional analysis.
 - **Anomaly Detection:** Unsupervised learning to identify deviations from authentic food profiles.
 - **Knowledge Graph/Database:** AI-driven knowledge base to store and retrieve information about food types, common adulterants, and safety standards.
 - **Real-time Inference:** Optimized AI models for on-device inference to provide immediate feedback.
- **Research Context:** While AI and spectroscopy are used in laboratory settings for food analysis, their integration into a user-friendly, mobile, and real-time on-site verification tool is a novel application. Existing solutions are typically expensive, require specialized training, or are not designed for consumer use. This project aims to democratize food authenticity and safety verification by leveraging accessible mobile technology and advanced AI, extending lab-based research to field-deployable solutions.
- **Technical Requirements:**
 - **Mobile Development:** Cross-platform mobile app (React Native/Flutter) for user interface and camera/sensor integration.
 - **Backend:** Python (FastAPI/Django) for managing the food profile database, updating AI models, and serving APIs.
 - **Database:** PostgreSQL or similar for structured food data, potentially a vector database for image/spectral embeddings.
 - **AI/ML Frameworks:** TensorFlow Lite/PyTorch Mobile for on-device inference, and full TensorFlow/PyTorch for model training.
 - **Sensor Integration:** Bluetooth Low Energy (BLE) for connecting to external portable sensors.
 - **Cloud Infrastructure:** For model training, data storage, and backend services.
- **Non-Technical Requirements:**
 - **Data Collection:** Building a comprehensive dataset of authentic and adulterated food samples (images and sensor data) is crucial and challenging. Collaboration with food science labs or regulatory bodies is essential.
 - **Regulatory Compliance:** Understanding food safety regulations and standards.
 - **User Trust:** Building trust in the accuracy and reliability of the app.

- **Ethical Considerations:** Avoiding misidentification, ensuring data privacy, and clear communication of results.
- **Accessibility:** Designing for ease of use by a wide range of users.

8. AI-Assisted Debris Tracking for Space Sustainability

- **Unsolved Problem:** The increasing amount of orbital debris (space junk) poses a significant and growing threat to active satellites and future space missions. Tracking tiny, unpredictable fragments, especially in Low Earth Orbit (LEO), is extremely challenging due to their small size, high velocities, and chaotic paths. This lack of precise tracking and prediction capabilities risks catastrophic collisions, threatening critical global services like GPS, weather forecasting, and communication.
- **Innovative Software Solution:** An AI-centric dashboard and simulation tool that processes diverse space surveillance data to predict debris trajectories with unprecedented accuracy and facilitate collision avoidance. The system would ingest data from ground-based radar, optical telescopes, and potentially in-orbit sensors. The core AI would leverage Graph Neural Networks (GNNs) to model the complex gravitational and atmospheric drag forces affecting debris, even with incomplete datasets. It would also employ advanced time-series forecasting models to predict chaotic debris paths. The dashboard would provide space agencies with a real-time, interactive visualization of orbital debris, highlight potential collision risks, and allow mission planners to simulate avoidance maneuvers for active spacecraft. The AI would continuously learn from new observations and near-miss events to refine its predictive models.
- **AI Integration:**
 - **Data Fusion:** Algorithms to integrate heterogeneous data from radar, optical, and in-situ sensors.
 - **Trajectory Prediction:** Graph Neural Networks (GNNs) for modeling complex orbital dynamics and time-series forecasting models (e.g., LSTMs, Transformers) for predicting chaotic paths.
 - **Anomaly Detection:** To identify unexpected debris behavior or new, untracked objects.
 - **Simulation & Optimization:** AI-driven simulation engine to model collision scenarios and optimize avoidance maneuvers.
 - **Uncertainty Quantification:** Bayesian networks or other probabilistic models to quantify prediction uncertainty, crucial for decision-making.

- **Research Context:** While space agencies (e.g., ESA, NASA) have sophisticated debris tracking systems and simulation tools (like STK), these often rely on manual modeling and struggle with the sheer volume and unpredictability of small fragments. This project innovates by applying advanced neural network architectures (GNNs) to learn from incomplete and noisy datasets, extending terrestrial tracking concepts to the unique challenges of space. The emphasis on probabilistic forecasting and AI-driven simulation for avoidance maneuvers represents a significant leap beyond current capabilities.
- **Technical Requirements:**
 - **Data Ingestion:** APIs or data feeds from space surveillance networks (simulated data for FYP).
 - **Backend:** High-performance computing backend (e.g., Python with distributed computing frameworks like Dask or Spark) for processing large datasets and running simulations.
 - **Database:** Time-series database or specialized geospatial database for orbital data.
 - **AI/ML Frameworks:** PyTorch/TensorFlow for GNNs and other deep learning models.
 - **Cloud Infrastructure:** Scalable cloud resources for computation and storage.
 - **Frontend:** Web-based interactive 3D visualization dashboard (e.g., CesiumJS, Three.js) for orbital mechanics and collision scenarios.
 - **Physics Engine:** Integration with or development of a simplified orbital mechanics simulation engine.
- **Non-Technical Requirements:**
 - **Data Access:** Collaboration with space agencies or research institutions for access to (simulated) orbital data.
 - **Domain Expertise:** Consultation with astrodynamacists and space debris experts.
 - **Ethical Considerations:** Implications of AI-driven decision-making in space operations.
 - **Computational Resources:** The project may require significant computational power for training and simulation.

9. AI-Driven Personalized Learning for Neurodiverse Conditions (Generalization of Rare Neurodiverse Conditions)

- **Unsolved Problem:** Individuals with diverse neurodevelopmental conditions (e.g., autism spectrum disorder, ADHD, dyslexia) often struggle with traditional learning environments that are not tailored to their unique cognitive profiles, sensory sensitivities, and learning styles. Existing educational tools lack the adaptive intelligence to provide truly personalized, real-time support that respects neurodiversity and promotes inclusive learning.
- **Innovative Software Solution:** An AI-powered adaptive learning platform that provides highly personalized educational content and cognitive training exercises for individuals with various neurodiverse conditions. The system would use multimodal AI (integrating voice analysis, eye-tracking, keyboard/mouse interaction patterns, and potentially wearable sensor data) to infer a user's cognitive state, engagement level, and specific learning challenges in real-time. The AI would then dynamically adjust the presentation format (e.g., visual vs. auditory, text complexity), content difficulty, pace, and feedback mechanisms. For example, it could detect signs of sensory overload and offer calming exercises, or identify attention drift and introduce interactive elements. The platform would also incorporate elements to support executive functions, social-emotional learning, and communication skills, all adapted to the individual's profile. A hybrid web interface would allow educators, therapists, or parents to monitor progress, set goals, and provide high-level input, while the AI manages the micro-adaptations. Federated learning could be explored to train models on diverse user data while preserving privacy.
- **AI Integration:**
 - **Multimodal Data Analysis:** Fusion of behavioral data (app interactions, eye-tracking), speech data (NLP, speech recognition), and physiological sensor data.
 - **Adaptive Learning & Reinforcement Learning:** To dynamically adjust content, difficulty, and feedback based on real-time performance and long-term progress.
 - **Cognitive State Inference:** Machine learning models to infer attention, engagement, cognitive load, and emotional state.
 - **Personalized Content Generation:** Generative AI to create varied learning materials and adaptive prompts.

- **Federated Learning:** For privacy-preserving model training across diverse user groups.
- **Research Context:** While AI is increasingly used in education, and some tools exist for specific learning disabilities, a comprehensive, multimodal, and truly adaptive platform that caters to the broad spectrum of neurodiversity with real-time personalization is still a significant gap. This project generalizes and extends the concept of

personalized learning for neurodegenerative diseases to a broader scope of neurodiverse conditions, incorporating more diverse input modalities and adaptive strategies.

- **Technical Requirements:**

- **Mobile/Web Development:** Cross-platform application (React Native/Flutter for mobile, React/Vue.js for web) for interactive learning modules.
- **Backend:** Scalable Python (FastAPI/Django) or Node.js (Express) backend for data processing, AI model serving, and educator/therapist interface.
- **Database:** Secure, encrypted database (e.g., PostgreSQL) for user profiles, progress data, and learning content.
- **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning, scikit-learn for traditional ML, and specialized libraries for reinforcement learning and federated learning.
- **Multimodal Sensor Integration:** APIs for eye-tracking devices, speech-to-text, and potentially wearable sensors.
- **Content Management System (CMS):** For managing and updating learning content.
- **Security & Privacy:** Robust encryption, access controls, and compliance with educational and health data privacy regulations (e.g., FERPA, GDPR).

- **Non-Technical Requirements:**

- **Neurodiversity Expertise:** Essential collaboration with neurodevelopmental specialists, educators, and individuals with neurodiverse conditions for design, content creation, and validation.
- **Ethical Considerations:** Paramount importance of data privacy, informed consent, avoiding algorithmic bias, and ensuring the system is empowering and inclusive.
- **User Experience (UX) Design:** Highly intuitive, customizable, and engaging interface that minimizes cognitive load and sensory overload.
- **Content Curation:** Development of a diverse and culturally sensitive learning content library.

- **Community Engagement:** Strategies for involving neurodiverse communities in the development and testing process.

10. Sustainable Urban Farming Optimization in Water-Scarce Regions

- **Unsolved Problem:** In arid and semi-arid urban areas, small-scale and vertical farming initiatives face significant challenges due to unpredictable water availability and inefficient resource management. This exacerbates food insecurity and environmental strain, as existing tools lack the ability to accurately forecast hyper-local resource needs and optimize farming practices under dynamic climate conditions.
- **Innovative Software Solution:** A web-based platform powered by AI that optimizes sustainable urban farming practices, particularly focusing on water conservation, in water-scarce regions. The platform would integrate diverse data sources: satellite imagery (for urban green spaces, heat maps), local weather data (real-time and forecasts), soil sensor data (moisture, nutrients), and potentially IoT data from vertical farms (hydroponic/aeroponic systems). The AI core would use machine learning models to predict optimal planting schedules, water usage, and nutrient delivery for various crops, adapting to micro-climates and real-time conditions. A key innovation would be the use of generative AI to simulate

‘what-if’ scenarios for crop yields under different watering strategies, allowing urban farmers to make data-driven decisions. The platform would also provide recommendations for water-efficient crop selection, rainwater harvesting, and greywater recycling systems. The AI would be trained on sparse data, making it suitable for hyper-local predictions in data-scarce environments.

- **AI Integration:**
 - **Predictive Modeling:** Time-series forecasting for water demand and crop growth, and classification models for crop selection.
 - **Generative AI & Simulation:** Generative models to simulate crop yield outcomes under various resource management scenarios.
 - **Optimization Algorithms:** To recommend optimal water and nutrient allocation.
 - **Data Fusion:** Algorithms to integrate satellite, weather, and sensor data for hyper-local predictions.
 - **Sparse Data Learning:** Techniques to train robust models on limited and incomplete datasets.

- **Research Context:** While AI is used in large-scale agriculture and vertical farming, a dedicated platform that addresses the unique challenges of urban farming in water-scarce regions, with a focus on hyper-local prediction and generative simulation, is a novel contribution. This project extends research on precision agriculture by adapting it to the urban context and emphasizing water conservation, moving beyond generic recommendations to dynamic, data-driven optimization.
- **Technical Requirements:**
 - **Data Ingestion:** APIs for satellite imagery, weather data, and IoT sensor data.
 - **Backend:** Python (FastAPI/Django) for data processing, AI model serving, and API endpoints.
 - **Database:** Time-series database (e.g., InfluxDB) for sensor data and PostgreSQL/PostGIS for geospatial data.
 - **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning and generative models, scikit-learn for traditional ML.
 - **Cloud Platform:** For scalable data storage, processing, and model deployment.
 - **Frontend:** Web-based dashboard (React/Vue.js) with data visualization and simulation interface.
- **Non-Technical Requirements:**
 - **Collaboration with Urban Farmers:** Working with local urban farmers and community gardens for data collection, user feedback, and validation.
 - **Domain Expertise:** Consultation with agronomists and water management experts.
 - **Data Scarcity:** Developing strategies to handle limited data availability in urban farming contexts.
 - **Usability:** Designing an intuitive and accessible platform for users with varying levels of technical expertise.

11. Equitable Access to Education for Remote Indigenous Communities

- **Unsolved Problem:** Indigenous communities in remote areas often face significant educational disparities due to a lack of access to quality educational resources, language barriers, and a disconnect between standard curricula and their cultural heritage. Existing online learning platforms are rarely designed to address these specific needs, leading to cultural erosion and limited educational outcomes.

- **Innovative Software Solution:** An AI-powered e-learning platform designed to provide equitable and culturally relevant education to remote indigenous communities. The platform would feature real-time, AI-driven translation and adaptation of educational content into indigenous dialects, using advanced NLP models trained in collaboration with community elders and linguists. A key innovation would be the integration of a hybrid web app that allows community members to contribute to and refine the AI models through federated learning, ensuring cultural accuracy and preserving linguistic nuances while protecting community data. The platform would also incorporate culturally relevant examples, stories, and learning modules, and support offline access for areas with limited internet connectivity. The AI would personalize the learning path for each student, adapting to their pace and learning style.
- **AI Integration:**
 - **Machine Translation:** Advanced NLP models for real-time translation and adaptation of educational content into low-resource indigenous languages.
 - **Federated Learning:** To train and refine AI models on community-contributed data while preserving privacy and data sovereignty.
 - **Personalized Learning:** AI algorithms to create adaptive learning paths for each student.
 - **Speech-to-Text & Text-to-Speech:** For oral languages and to support different learning styles.
 - **Content Curation:** AI-powered tools to help educators create and adapt culturally relevant content.
- **Research Context:** While AI is being used for language translation and personalized learning, its application to preserve and integrate indigenous languages and cultures into education in a community-driven, privacy-preserving manner is a significant and underexplored area. This project extends research on low-resource NLP and federated learning by applying it to a critical social good problem, innovating beyond generic e-learning platforms to create a truly equitable and culturally sustaining educational tool.
- **Technical Requirements:**
 - **Mobile/Web Development:** Cross-platform application (React Native/Flutter or Progressive Web App) with offline capabilities.
 - **Backend:** Python (FastAPI/Django) for content management, AI model serving, and federated learning coordination.
 - **Database:** For storing educational content and user progress.

- **AI/ML Frameworks:** Hugging Face Transformers for NLP, TensorFlow/PyTorch for model training, and frameworks for federated learning (e.g., TensorFlow Federated).
- **Offline Support:** Service workers and local storage for offline access.
- **Non-Technical Requirements:**
 - **Community Partnership:** Deep and respectful collaboration with indigenous communities, elders, and educators is paramount.
 - **Cultural Sensitivity:** Ensuring all content is culturally appropriate and respectful.
 - **Data Sovereignty:** Implementing robust data governance models that respect community ownership of data.
 - **Ethical Considerations:** Addressing potential biases in AI models and ensuring the technology is used to empower, not exploit, indigenous communities.

12. Predictive Maintenance for Renewable Energy Grids in Extreme Weather

- **Unsolved Problem:** Renewable energy infrastructure, such as solar panels and wind turbines, is often vulnerable to damage from extreme weather events (e.g., hurricanes, hailstorms, wildfires). This leads to costly failures, energy blackouts, and setbacks for sustainability goals. Current maintenance practices are often reactive or based on fixed schedules, lacking the ability to proactively predict and mitigate weather-induced failures.
- **Innovative Software Solution:** A cloud-based AI system that provides predictive maintenance for renewable energy grids by forecasting equipment failures in the face of extreme weather. The system would integrate real-time data from IoT sensors on solar panels and wind turbines (e.g., temperature, vibration, power output), with high-resolution weather forecasts and climate models. The AI would use time-series forecasting and anomaly detection models to identify early signs of stress or damage, and predict the likelihood of failure for specific components under anticipated weather conditions. A web-based interface would visualize risk levels for different assets, send automated alerts to operators, and recommend proactive maintenance actions (e.g., shutting down turbines, reinforcing structures). The system would also include a simulation component to model the potential impact of different weather scenarios on the grid.

- **AI Integration:**

- **Predictive Maintenance:** Time-series forecasting models (e.g., LSTMs, Transformers) to predict equipment failures.
- **Anomaly Detection:** To identify unusual sensor readings that may indicate impending failure.
- **Data Fusion:** Algorithms to integrate IoT sensor data with weather and climate models.
- **Risk Assessment:** AI models to quantify the risk of failure for each asset.
- **Simulation:** To model the impact of extreme weather events on the grid.

- **Research Context:** While predictive maintenance is a well-established field, its application to renewable energy grids with a specific focus on extreme weather events is an emerging and critical area. This project differs from generic IoT solutions by prioritizing AI-driven forecasting of weather-induced failures and integrating predictive simulation layers. It builds upon research in anomaly detection and time-series analysis to provide a holistic and proactive maintenance solution for a vital and vulnerable sector.

- **Technical Requirements:**

- **Data Ingestion:** APIs for IoT sensor data, weather forecasts, and climate models.
- **Backend:** Scalable backend (e.g., Python with FastAPI/Django) for data processing and AI model serving.
- **Database:** Time-series database (e.g., InfluxDB) for sensor data.
- **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning models, scikit-learn for traditional ML.
- **Cloud Platform:** For data storage, processing, and model deployment.
- **Frontend:** Web-based dashboard (React/Vue.js) for visualizing risks and alerts.

- **Non-Technical Requirements:**

- **Collaboration with Energy Companies:** Working with renewable energy operators for data access (simulated for FYP) and validation.
- **Domain Expertise:** Consultation with engineers and meteorologists.
- **Reliability:** Ensuring the accuracy and reliability of failure predictions.
- **Scalability:** Designing a system that can scale to manage large renewable energy farms.

13. AI for Biodiversity Monitoring in Uncharted Ocean Depths

- **Unsolved Problem:** The deep sea is the largest and least explored biome on Earth, and its rich biodiversity is increasingly threatened by climate change, pollution, and deep-sea mining. Monitoring this biodiversity is extremely challenging due to the harsh environment, vastness of the area, and the reliance on slow, manual analysis of underwater imagery. This impedes global conservation efforts and our understanding of life on our own planet.
- **Innovative Software Solution:** An AI platform designed for automated, real-time biodiversity monitoring in uncharted ocean depths. The platform would analyze footage from underwater drones (AUVs) and remotely operated vehicles (ROVs), using advanced computer vision models to identify, track, and classify marine species. A key innovation would be the use of unsupervised learning and few-shot learning techniques to classify previously unknown or rarely seen organisms, helping to accelerate the discovery of new species. The AI would also analyze environmental data (e.g., temperature, salinity, depth) to understand species distribution and habitat preferences. A web portal would provide researchers with access to the analyzed data, collaborative tools for data annotation and verification, and interactive maps of biodiversity hotspots.
- **AI Integration:**
 - **Computer Vision:** Deep learning models (e.g., CNNs, Vision Transformers) for object detection, tracking, and classification of marine species in challenging low-light, high-pressure conditions.
 - **Unsupervised & Few-Shot Learning:** To classify unknown or rare species with limited training data.
 - **Data Fusion:** To correlate species observations with environmental data.
 - **Collaborative AI:** A human-in-the-loop system that allows researchers to verify and correct AI-generated labels, continuously improving the models.
- **Research Context:** While AI is used for biodiversity monitoring in terrestrial environments (e.g., wildlife cameras), its application to the deep sea is still in its early stages. This project extends deep learning applications to a new and challenging domain, innovating with unsupervised and few-shot learning for the discovery of new species. It moves beyond manual analysis of deep-sea footage to an automated, scalable, and collaborative platform for ocean exploration and conservation.

- **Technical Requirements:**

- **Data Ingestion:** Handling large volumes of video data from underwater vehicles.
- **Backend:** High-performance backend for video processing and AI model serving.
- **Database:** For storing species observations, environmental data, and video metadata.
- **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning models.
- **Cloud Platform:** For large-scale data storage and computation.
- **Frontend:** Web-based portal (React/Vue.js) with video annotation tools and interactive maps.

- **Non-Technical Requirements:**

- **Collaboration with Marine Biologists:** Essential for data access, species identification, and model validation.
- **Data Scarcity:** Developing strategies to train models with limited data for rare or unknown species.
- **Ethical Considerations:** Responsible use of AI in scientific discovery and conservation.

14. Social Good: Combating Misinformation in Low-Literacy Populations

- **Unsolved Problem:** Misinformation and disinformation spread rapidly in low-literacy populations, often through audio and visual media (e.g., voice notes, manipulated images, deepfake videos). This can fuel social unrest, public health crises, and political instability. Existing fact-checking tools are predominantly text-based and not accessible to individuals who cannot read or have limited literacy skills.
- **Innovative Software Solution:** An AI-powered voice assistant and mobile app designed to combat misinformation in low-literacy populations. The system would allow users to submit audio clips, images, or videos for verification. The AI would use speech-to-text to transcribe audio, computer vision to analyze images and videos (e.g., for signs of manipulation), and NLP to understand the claims being made. It would then query a knowledge graph of verified facts and known misinformation to assess the content's veracity. The key innovation is the delivery of results through simplified, synthesized audio explanations in local languages, making the information accessible to non-readers. The system would also provide

context and links to reliable sources (if applicable). A web backend would allow journalists and fact-checkers to update the knowledge graph and review AI-flagged content.

- **AI Integration:**

- **Speech-to-Text & NLP:** To transcribe and understand spoken claims.
- **Computer Vision:** To analyze images and videos for manipulation (e.g., deepfake detection).
- **Knowledge Graph:** AI-powered knowledge base for fact-checking.
- **Text-to-Speech:** To deliver audio explanations in local languages.
- **Human-in-the-Loop:** A system for journalists and fact-checkers to verify and update the knowledge graph.

- **Research Context:** While fact-checking is a well-established field, and AI is used to detect text-based misinformation, there is a significant gap in accessible, audio-centric solutions for low-literacy populations. This project innovates by hybridizing AI-powered fact-checking with voice interfaces, extending research from text-based misinformation detection to a new and critical domain. It addresses a major social good challenge by making information verification accessible to all.

- **Technical Requirements:**

- **Mobile Development:** Mobile app (React Native/Flutter) for audio, image, and video submission.
- **Backend:** Python (FastAPI/Django) for AI model serving and knowledge graph management.
- **Database:** Graph database (e.g., Neo4j) for the knowledge graph.
- **AI/ML Frameworks:** Hugging Face Transformers for NLP, TensorFlow/PyTorch for computer vision and speech models.
- **Cloud Platform:** For scalable AI model serving and data storage.

- **Non-Technical Requirements:**

- **Collaboration with Fact-Checking Organizations:** Working with journalists and fact-checkers for knowledge graph population and verification.
- **Cultural & Linguistic Expertise:** Ensuring the system is culturally sensitive and supports local languages and dialects.
- **User Trust:** Building trust in the accuracy and impartiality of the fact-checking service.
- **Ethical Considerations:** Addressing the potential for misuse and ensuring the system is used to empower, not censor.

15. Extraterrestrial Resource Mapping for Mars Colonization

- **Unsolved Problem:** The long-term goal of establishing a sustainable human presence on Mars is critically dependent on identifying and utilizing in-situ resources (e.g., water ice, minerals). However, our knowledge of the distribution and accessibility of these resources is still incomplete, based on limited data from rovers and orbiters. This hinders mission planning and the development of viable colonization strategies.
- **Innovative Software Solution:** An AI-powered simulation and mapping tool that processes and integrates diverse Martian data to create probabilistic resource maps. The system would ingest data from various sources, including rover imagery (e.g., from Perseverance, Curiosity), spectral data from orbiters (e.g., Mars Reconnaissance Orbiter), and geological maps. The AI core would use Bayesian networks and other probabilistic models to infer the likelihood of finding specific resources (e.g., water ice, iron ore, silicates) in un-surveyed areas, based on the geological context of known resource locations. A key innovation would be the integration of a generative AI component that allows mission planners to run virtual explorations, simulating rover traverses and drilling operations to assess the viability of different landing sites and resource extraction strategies. The platform would provide an interactive 3D visualization of Mars, with layers for resource probability, geological features, and simulated exploration paths.
- **AI Integration:**
 - **Probabilistic Modeling:** Bayesian networks to map resources and quantify uncertainty.
 - **Data Fusion:** Algorithms to integrate imagery, spectral data, and geological maps.
 - **Generative AI & Simulation:** To create virtual exploration scenarios and predict outcomes.
 - **Computer Vision:** To analyze rover and orbiter imagery for geological features indicative of resources.
- **Research Context:** While NASA and other space agencies have sophisticated tools for analyzing Martian data, a publicly accessible, AI-driven platform that integrates diverse datasets for probabilistic resource mapping and virtual exploration is a novel concept. This project extends the application of AI in geology and remote sensing to an extraterrestrial context, innovating with Bayesian uncertainty models and generative simulation to support the ambitious goal of Mars colonization. It

moves beyond static resource maps to a dynamic, predictive, and interactive exploration tool.

- **Technical Requirements:**

- **Data Ingestion:** Access to public Martian datasets from NASA PDS (Planetary Data System) and other sources.
- **Backend:** High-performance backend for data processing and simulation.
- **Database:** Geospatial database for Martian data.
- **AI/ML Frameworks:** TensorFlow/PyTorch for deep learning and probabilistic models.
- **Cloud Platform:** For large-scale data storage and computation.
- **Frontend:** Web-based 3D visualization interface (e.g., CesiumJS, Three.js).

- **Non-Technical Requirements:**

- **Collaboration with Planetary Scientists:** Essential for data interpretation, model validation, and ensuring scientific accuracy.
- **Domain Expertise:** Consultation with geologists and astrobiologists.
- **Computational Resources:** The project may require significant computational power for data processing and simulation.