A Multi-Agent AI Framework for Real-Time Flood Disaster Response Using Satellite Imagery and Geospatial Analysis

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Flood disasters demand rapid situational awareness spanning hazard detection, infrastructure disruption, evacuation planning, and community coordination, yet conventional GIS workflows depend on manual tools and specialist intervention, delaying critical decisions for first responders in resource-constrained emergency environments. This study aimed to design, implement, and evaluate an autonomous multi-agent AI framework that converts satellite imagery and geospatial data into actionable, near-real-time flood-response intelligence usable by non-GIS-expert responders, integrating vision-language modelling, multi-agent orchestration, and geospatial analytics into a single decision-support pipeline. The system employed four specialized agents orchestrated through CrewAI with a Llama 3.2 reasoning backbone. A Qwen2-VL-7B vision-language model was fine-tuned using Low-Rank Adaptation on an AMD Instinct MI300X GPU with the Cyclone Ditwah 2025 Sentinel-1 SAR dataset (50,000 samples; 45,000/5,000 train/validation split) for damage-zone classification and GeoJSON generation, while live precipitation from the Open-Meteo API and OpenStreetMap road networks processed via GeoPandas and NetworkX supported blocked-road detection, shelter identification, and hazard-avoidant routing. Evaluation used 5,000 validation scenes and 50 routing scenarios. The fine-tuned model achieved 83.70% mAP@0.5 (82.51% precision, 86.77% recall) for damage-zone detection, generating valid GeoJSON outputs in under five seconds per image; the pipeline produced complete situational reports in under sixty seconds, and the routing module generated topologically valid evacuation paths in 41 of 50 cases. Supporting modules delivered early warning alerts, seven-day forecasting, geotagged incident reporting, missing-person tracking, SOS dispatch, and offline HTML map export. These results show that combining fine-tuned vision-language models, multi-agent orchestration, and geospatial analytics can consolidate fragmented flood-response workflows into a unified, near-real-time decision-support process suitable for resource-constrained emergency environments.

Keywords: multi-agent ai, flood disaster response, vision-language models, geospatial analytics, emergency decision-support