A* Flood Routing System

Malolos, Bulacan, Philippines

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SYSTEM OVERVIEW

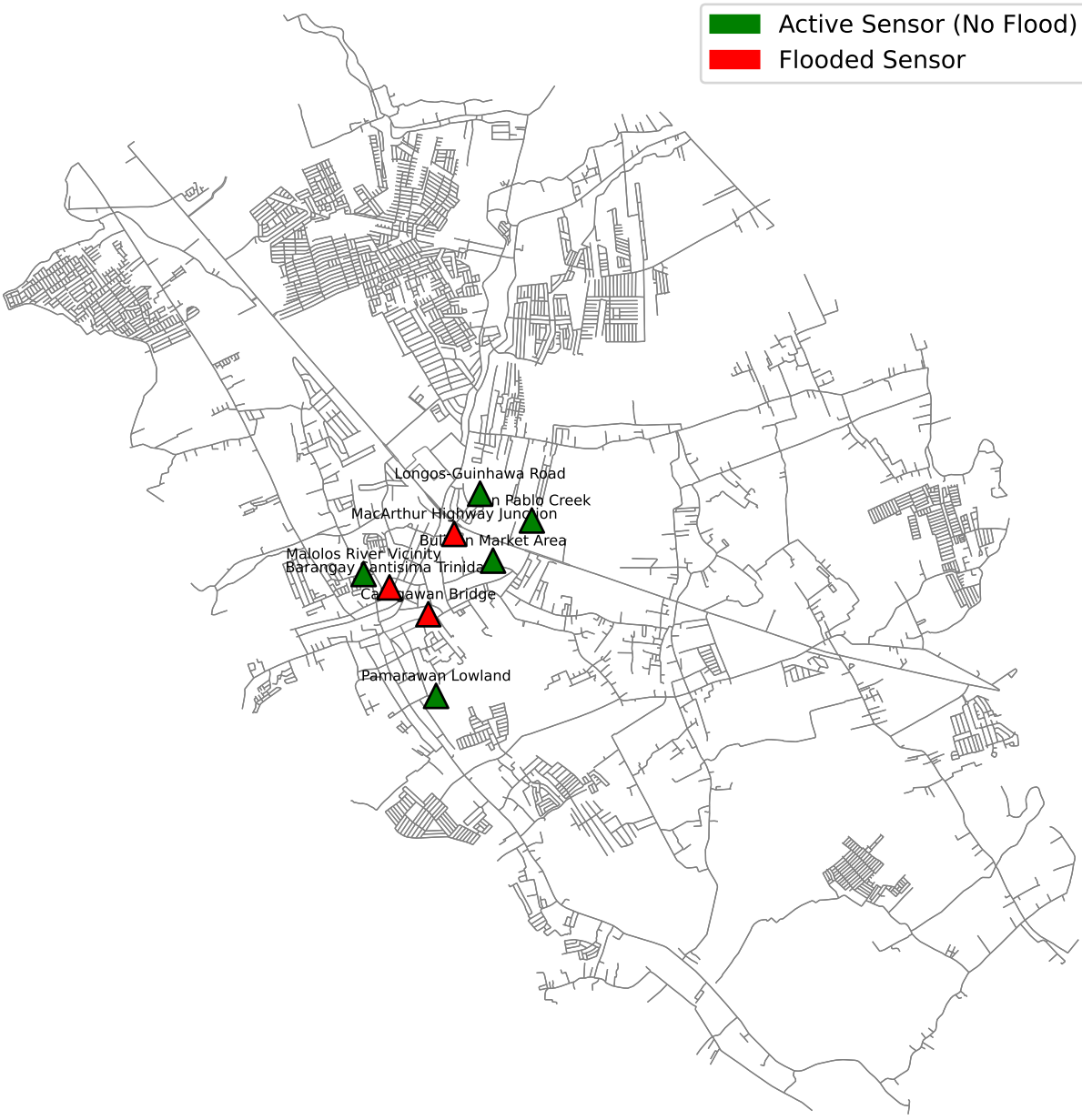
This A* Pathfinding System uses real OpenStreetMap data to find optimal routes while avoiding flood-affected areas. The system:

- Uses real road network data from OpenStreetMap
- Respects one-way streets and road restrictions
- Considers road types and speed limits for travel time estimation
- Simulates flood sensors at strategic flood-prone locations
- Implements A* algorithm with flood avoidance capability
- Provides alternative routes when primary routes are flooded

STUDY AREA: Malolos, Bulacan

Malolos is the capital city of Bulacan province in the Philippines.
It is known for having flood-prone areas, especially during monsoon season.

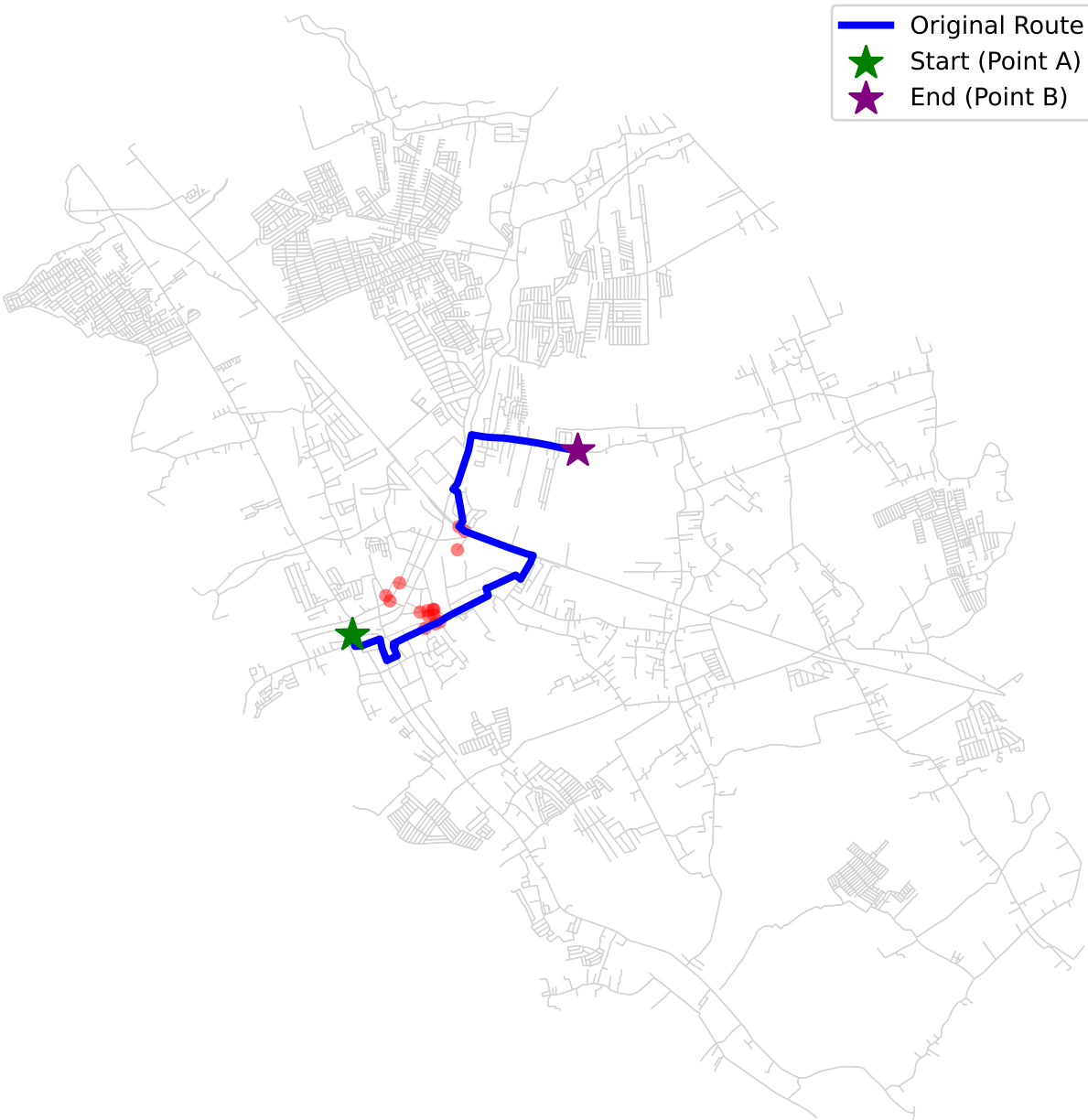
Road Network of Malolos, Bulacan (OpenStreetMap Data)



Flood Sensor Locations

ID	Name	Coordinates	Status
0	Barangay Santisima Trinidad	(14.8470, 120.8120)	FLOODED
1	MacArthur Highway Junction	(14.8510, 120.8170)	FLOODED
2	Bulihan Market Area	(14.8490, 120.8200)	Normal
3	Pamarawan Lowland	(14.8389, 120.8156)	Normal
4	San Pablo Creek	(14.8520, 120.8230)	Normal
5	Caliligawan Bridge	(14.8450, 120.8150)	FLOODED
6	Longos-Guinhawa Road	(14.8540, 120.8190)	Normal
7	Malolos River Vicinity	(14.8480, 120.8100)	Normal

Original Route (Without Flood Consideration)

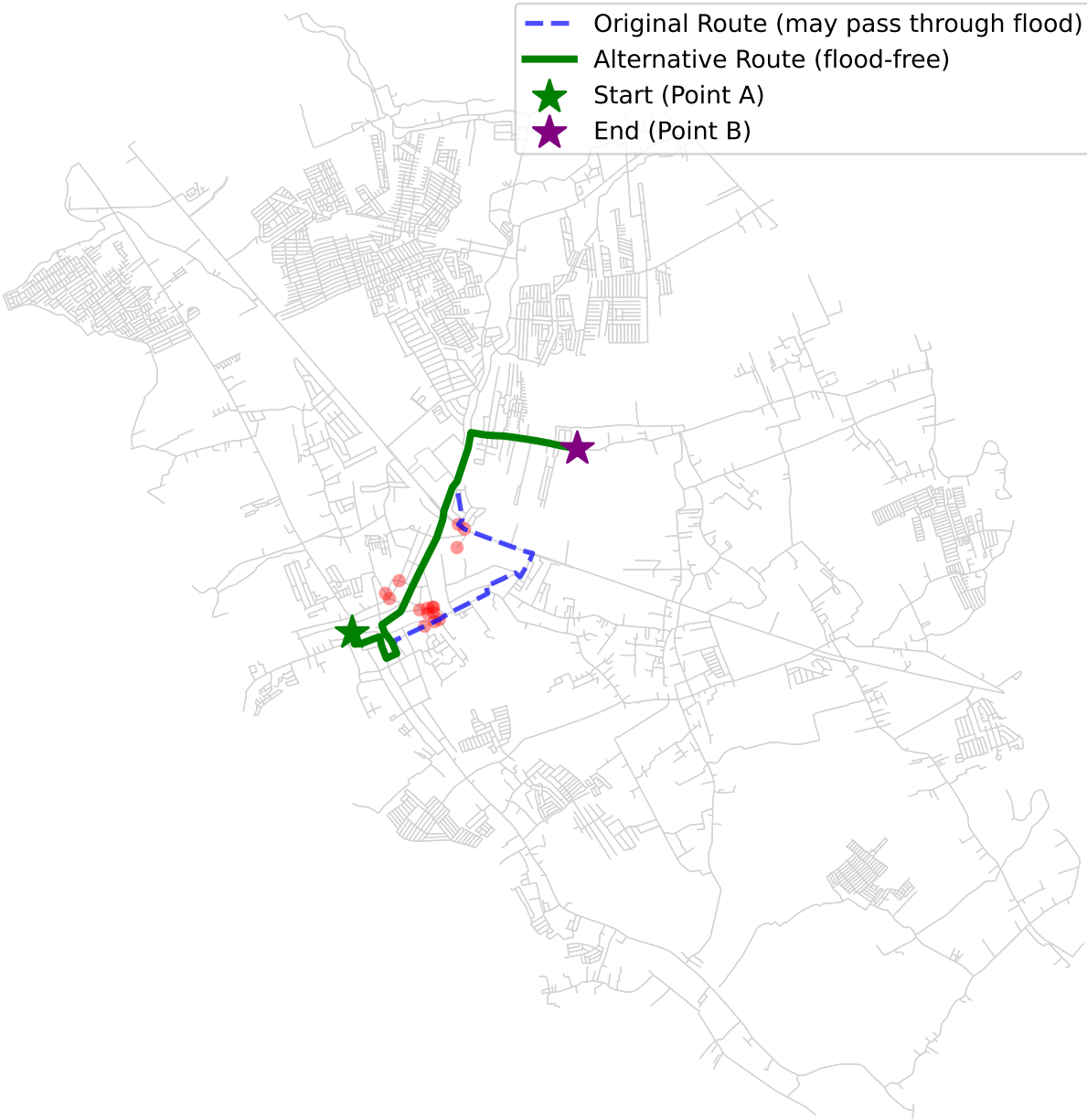


Distance: 4.64 km | Travel Time: 8.0 minutes

Alternative Route (Avoiding Flood Areas)

Distance: 3.56 km | Travel Time: 4.7 minutes

Route Comparison: Original vs Alternative



Route Analysis Summary

ROUTE COMPARISON
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ORIGINAL ROUTE (May pass through flooded areas):
• Distance: 4.64 km
• Estimated Travel Time: 8.0 minutes
• Status: BLOCKED BY FLOOD

ALTERNATIVE ROUTE (Avoiding all flood zones):
• Distance: 3.56 km if alt_dist < float('inf') else 'N/A'
• Estimated Travel Time: 4.7 minutes if alt_time < float('inf') else 'N/A'
• Status: Available

FLOOD IMPACT ANALYSIS:
• Number of flooded nodes: 15
• Number of blocked road segments: 56
• Active flood sensors: 3

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RECOMMENDATION:

Take the ALTERNATIVE ROUTE to avoid flood-affected areas.
• Additional distance: -1.08 km (-23.2% longer)
• Additional travel time: -3.3 minutes

This route ensures safe passage avoiding all detected flood zones.

A* Algorithm Implementation Details

A* PATHFINDING ALGORITHM
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The A* algorithm finds the shortest path between two points using:

f(n) = g(n) + h(n)

Where:
• f(n) = Total estimated cost of path through node n
• g(n) = Actual cost from start to node n
• h(n) = Heuristic estimate from n to goal (Haversine distance)

IMPLEMENTATION FEATURES:

1. REAL ROAD DATA
   - Uses OpenStreetMap road network
   - Respects one-way streets
   - Considers road types (highway, primary, residential, etc.)

2. TRAVEL TIME ESTIMATION
   - Uses road type-based speed limits
   - Accounts for road length and conditions

3. FLOOD AVOIDANCE
   - Sensors detect flood at specific coordinates
   - Nodes within flood radius are marked as blocked
   - A* algorithm excludes flooded nodes from path

4. HEURISTIC FUNCTION
   - Haversine distance (great-circle distance)
   - Admissible and consistent heuristic
   - Guarantees optimal path when possible

DATA SOURCES:
- Road Network: OpenStreetMap (© OpenStreetMap contributors)
- Coordinates: WGS84 (EPSG:4326)
- Network Analysis: OSMnx library