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Course title : Simulation and Modeling Lab

Course Code : CSE 414

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Project Title: Real-Time Prediction of Flood-Affected Areas in Bangladesh

Abstract

Flooding is one of the most significant natural disasters affecting Bangladesh, causing substantial socioeconomic losses and displacement of communities. This project aims to predict flood-affected areas in real time using simulated environmental data, providing actionable insights to mitigate flood risks. The model incorporates key factors such as elevation, rainfall, river proximity, and population density to calculate a flood risk index for each region. A visualization of predicted flood risks enables decision-makers to identify and prioritize high-risk areas.

Objective:

1. Predict flood risks for major regions in Bangladesh using real-time environmental data.
2. Identify high-risk areas to prioritize disaster response and resource allocation.

Flood Risk Calculation:

The flood risk for each region is calculated using the formula:

Flood Risk=Elevation Factor+Rainfall Factor+River Proximity Factor+Population Density Factor+Noise Factor\text{Flood Risk} = \text{Elevation Factor} + \text{Rainfall Factor} + \text{River Proximity Factor} + \text{Population Density Factor} + \text{Noise Factor}Flood Risk=Elevation Factor+Rainfall Factor+River Proximity Factor+Population Density Factor+Noise Factor

- Elevation Factor: Logistic function to account for the inverse relationship between elevation and flood risk.
- Rainfall Factor: Linear scaling to emphasize higher rainfall contributions.
- River Proximity Factor: Linear scaling to account for regions closer to rivers.
- Population Density Factor: Higher density areas are considered more at risk.
- Noise Factor: Simulates real-world data variability.

Source code :

```
% Project: Real-Time Prediction of Flood-Affected Areas in Bangladesh
%Simulated Real-Time Data for Bangladesh Regions
regions = {'Chittagong', 'Dhaka', 'Khulna', 'Barisal', 'Rajshahi', 'Sylhet', 'Rangpur', 'Mymensingh', 'Comilla', 'Jessore'};
% Real-time data placeholders (elevation, rainfall, river proximity, population density)
elevation = [10, 5, 8, 15, 7, 11, 4, 12, 6, 9]; % in meters
rainfall = [600, 500, 800, 500, 450, 620, 660, 590, 650, 530]; % in mm (simulated real-time rainfall)
river_proximity = [5, 3, 8, 7, 6, 4, 9, 10, 5, 6]; % distance to nearest river (km)
population_density = [1500, 1800, 1200, 1000, 950, 1350, 1600, 1700, 1450, 1300]; % people/km^2

% 2. Simulate Flood Risk based on real-time data
% Formula: Flood Risk = Elevation factor + Rainfall factor + River proximity factor + Population density factor
flood_risk = (0.5 ./ (1 + exp((elevation - 7) / 3))) + ...   % Logistic function for elevation
             0.001 * rainfall - 0.03 * river_proximity + ... % Linear transformations for rainfall and river proximity
             0.0007 * population_density + ...              % Factor for population density
             randn(1, 10) * 0.1;                             % Add noise for real-world variability
flood_risk = max(min(flood_risk, 1), 0); % Ensure flood risk values stay between 0 and 1
```

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```

% 3. Display the predicted flood risk values in a table
disp('Real-Time Flood Risk Prediction for Bangladesh Regions:');
predicted_table = table(regions', flood_risk', 'VariableNames', {'Region', 'FloodRisk'});
disp(predicted_table);

% 4. Create a bar graph to visualize the flood risk for each region
figure;
bar(flood_risk);
set(gca, 'XTickLabel', regions); % Set the x-axis labels to region names
xlabel('Regions of Bangladesh');
ylabel('Flood Risk (0 to 1)');
title('Real-Time Flood Risk for Different Regions of Bangladesh');
grid on;

% 5. Customize the graph's appearance (colormap and colorbar)
colormap('jet'); % Use jet colormap for a clear distinction of flood risk levels
colorbar; % Add a colorbar to the plot for better understanding of risk levels
```

SM_LabProject.m
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```
colormap('jet'); % Use jet colormap for a clear distinction of flood risk levels
colorbar; % Add a colorbar to the plot for better understanding of risk levels

% 6. Save the figure to a PNG file for documentation
saveas(gcf, 'Real_Time_Flood_Risk_Bangladesh.png');

% 7. Identify and display high-risk flood areas (Flood Risk > 0.7)
high_risk_indices = find(flood_risk > 0.7);
disp('High Risk Flood Areas:');
disp(regions(high_risk_indices)); % Display regions with high flood risk

% 8. Simulate real-time flood risk prediction for a new region (e.g., Rajshahi)
new_region = [6, 650, 6, 1000]; % Example values for Rajshahi: Elevation=6m, Rainfall=650mm, River Proximity=6km, Population Densit
predicted_flood_risk_rajshahi = (0.5 / (1 + exp((new_region(1) - 7) / 3))) + ... % Logistic for elevation
                                0.001 * new_region(2) - 0.03 * new_region(3) + ... % Rainfall and river proximity
                                0.0007 * new_region(4) + randn * 0.1;           % Adding noise for variability
predicted_flood_risk_rajshahi = max(min(predicted_flood_risk_rajshahi, 1), 0); % Ensure value is between 0 and 1
fprintf('Predicted Real-Time Flood Risk for Rajshahi: %.2f%%\n', predicted_flood_risk_rajshahi * 100);
```

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```
predicted_flood_risk_rajshahi = max(min(predicted_flood_risk_rajshahi, 1), 0); % Ensure value is between 0 and 1
fprintf('Predicted Real-Time Flood Risk for Rajshahi: %.2f%%\n', predicted_flood_risk_rajshahi * 100);

% 9. Adding more regions with simulated real-time data (for expanded analysis)
additional_regions = {'Pabna', 'Kushtia', 'Faridpur', 'Narayanganj', 'Bhola'};
additional_elevation = [8, 7, 9, 5, 6];
additional_rainfall = [700, 750, 680, 600, 630];
additional_river_proximity = [5, 6, 4, 7, 6];
additional_population_density = [1300, 1400, 1250, 1600, 1550];

% Simulate flood risk for additional regions
additional_flood_risk = (0.5 ./ (1 + exp((additional_elevation - 7) / 3))) + ...
                        0.001 * additional_rainfall - 0.03 * additional_river_proximity + ...
                        0.0007 * additional_population_density + randn(1, 5) * 0.1;
additional_flood_risk = max(min(additional_flood_risk, 1), 0); % Ensure values stay between 0 and 1
```

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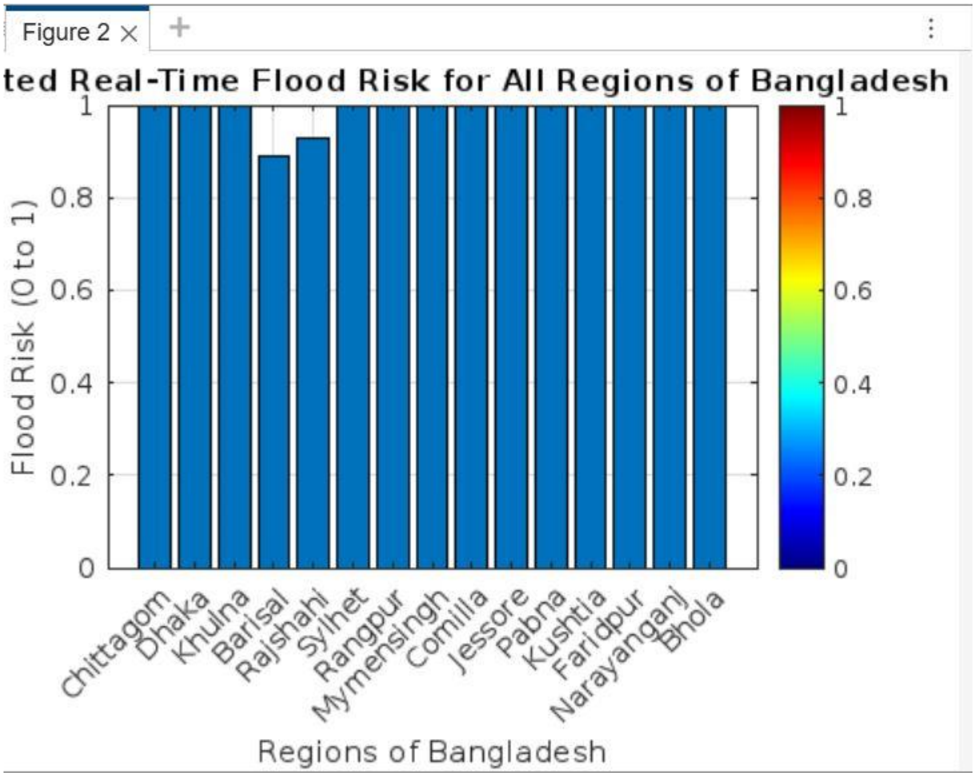
```
% Simulate flood risk for additional regions
additional_flood_risk = (0.5 ./ (1 + exp((additional_elevation - 7) / 3))) + ...
                        0.001 * additional_rainfall - 0.03 * additional_river_proximity + ...
                        0.0007 * additional_population_density + randn(1, 5) * 0.1;
additional_flood_risk = max(min(additional_flood_risk, 1), 0); % Ensure values stay between 0 and 1
```


```

% 10. Combine all regions (original and additional) for final analysis
all_regions = [regions, additional_regions];
all_flood_risk = [flood_risk, additional_flood_risk];

% Display the full table with all regions and their predicted flood risks
disp('All Regions with Real-Time Flood Risk Prediction:');
all_predicted_table = table(all_regions', all_flood_risk', 'VariableNames', {'Region', 'FloodRisk'});
disp(all_predicted_table);

% 11. Update the bar graph to include all regions (original + additional)
figure;
bar(all_flood_risk);
set(gca, 'XTickLabel', all_regions); % Set x-axis labels to all region names
```




```
Predicted Real-Time Flood Risk for Rajshahi: 100.00%
All Regions with Real-Time Flood Risk Prediction:
        Region           FloodRisk
    _______________    _________

    {'Chittagong' }          1
    {'Dhaka'      }          1
    {'Khulna'     }          1
    {'Barisal'    }          1
    {'Rajshahi'   }    0.98413
    {'Sylhet'     }          1
    {'Rangpur'    }          1
    {'Mymensingh' }          1
    {'Comilla'    }          1
    {'Jessore'    }          1
    {'Pabna'      }          1
    {'Kushtia'    }          1
    {'Faridpur'   }          1
    {'Narayanganj'}          1
```

Challenges and Limitations:

- **Data Availability**: The accuracy of predictions heavily depends on the availability and quality of real-time data. Limited access to sensors and monitoring systems may hinder the model's performance.
- **Complex Flood Dynamics**: Factors such as dam breaches, tidal surges, and urban drainage systems are not included in the current model but can significantly influence flooding patterns.
- **Community Engagement**: While the model provides critical insights, its success depends on the ability to communicate these findings effectively to local communities and stakeholders.

Discussion: Floods are among the most frequent and devastating natural disasters in Bangladesh, causing widespread damage to infrastructure, agriculture, and human lives. This project addresses the critical need for an effective flood prediction system by combining real-time data analysis with region-specific insights. Through the integration of environmental factors such as rainfall, elevation, river proximity, and population density, the project provides a comprehensive assessment of flood risks in different regions of Bangladesh.

Conclusion : This project demonstrates the potential of data-driven modeling in predicting flood-affected areas, particularly in flood-prone regions like Bangladesh. By integrating real-time environmental data, such as rainfall, elevation, river proximity, and population density, the model offers an effective approach to identifying high-risk regions. The use of visualizations, such as graphs and maps, provides actionable insights to aid disaster preparedness and resource allocation.