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M.Sc (21th Batch) Computer Science

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IMPLEMENTATION OF AN AUTOMATED DYNAMIC WEAPON RANGE VISUALIZATION AND ENGAGAEMENT PLANNING FOR MILITARY TACTICAL SUPPORT SYSTEM USING GEOSPATIAL DATA

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- Aim of Thesis
- Objectives of Thesis
- Problem Statement
- Background Theories
- Conclusion

Abstract

- The system automates the process of mapping current and target locations, measuring distances, and visualizing weapon ranges based on their power and specifications.
- The system integrates various APIs to retrieve real-time geolocation data and converts geographic coordinates to the Military Grid Reference System (MGRS) for accurate positioning.
- The system calculates the distance from the current location to the desired target, visualizes the effective firing ranges on interactive maps, and identifies the optimal troops and weapons for engagement based on proximity and ammunition requirements.

Introduction

- In the realm of modern warfare, the precision and efficiency of tactical operations are paramount to mission success.
- Traditional methods of planning and executing tactical operations are often time-consuming and prone to human error, necessitating the development of automated systems that can enhance decision-making processes.
- The system supports the ability to quickly and accurately determine the positioning of forces, calculate engagement ranges, and optimize resource allocation can significantly impact the outcome of military engagements.

Aim of my thesis

The primary aim of this thesis is to develop an automated system that supports military tactical planning by dynamically visualizing weapon firing ranges and optimizing engagement strategies using real-time geospatial data. This system is designed to improve the efficiency and accuracy of military operations, ultimately contributing to mission success.

Objectives

- To integrate APIs for retrieving real-time geolocation data
- To implement algorithms that accurately measure distances between current and target locations
- To develop a visualization module based on weapon specifications.
- To create algorithms that identify optimal troops and weapons
- To design an intuitive user interface
- To conduct extensive testing with simulated and real-world data to ensure the system's accuracy, reliability, and practical utility.

Problem Statement

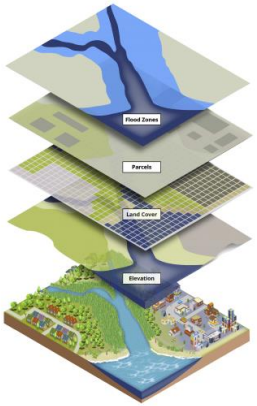
- In modern military, effective tactical planning and resource allocation are critical for mission success and minimizing collateral damage.
- The current methods of tactical planning are time-consuming, prone to human error, and lack the agility required for real-time decision-making.
- This thesis aims to develop an Automated TDSS that integrates real-time geospatial data, advanced algorithms, and intuitive visualizations to enhance tactical planning.

Background Theory

- Flutter
- Web API
- Hyper Text Transfer Protocol (HTTP)
- Personal Home Page or Hypertext Preprocessor (PHP)
- Relational Database Management System (RDBMS)
- MySQL Database Server
- GIS
- Tactical Decision Support System (TDSS)
- Military Grid Reference System (MGRS)
- Algorithm for LatLng to MGRS Conversion

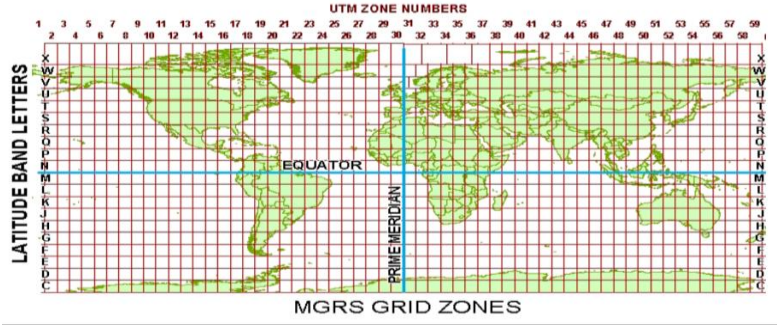
Geospatial Information Systems (GIS)

Geospatial Information Systems (GIS) represent a pivotal technology in the realm of spatial data management and analysis. GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. This technology has become indispensable across various disciplines, including urban planning, environmental management, logistics, epidemiology, natural resource management, and of course, military operations.



Military Grid Reference System (MGRS)

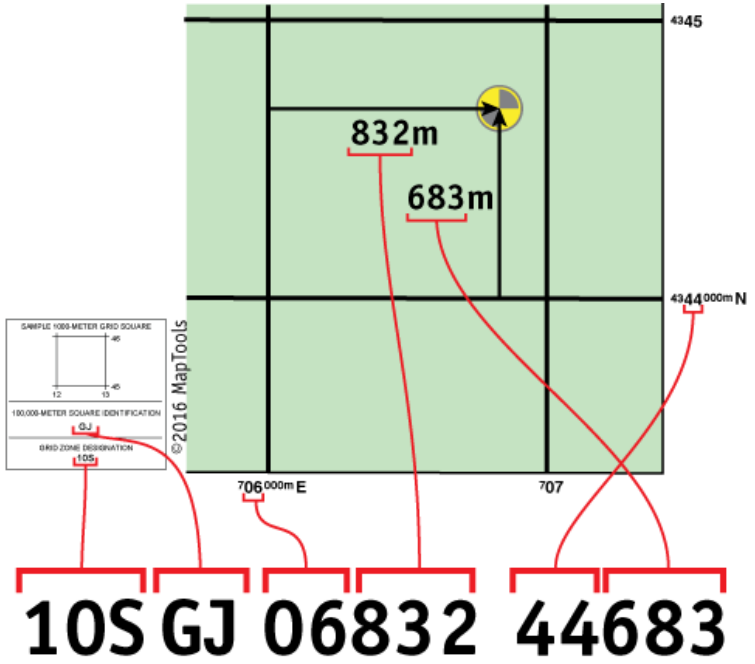
The Military Grid Reference System (MGRS) is a geographic coordinate system used extensively by military forces worldwide for locating points on the Earth's surface. It is based on the Universal Transverse Mercator (UTM) coordinate system but provides a more concise and standardized method of representing geographic coordinates. MGRS divides the Earth's surface into a grid of zones, each identified by a unique combination of zone number, zone letter, grid square identifier, and numerical location identifier.



LatLng to MGRS Conversion

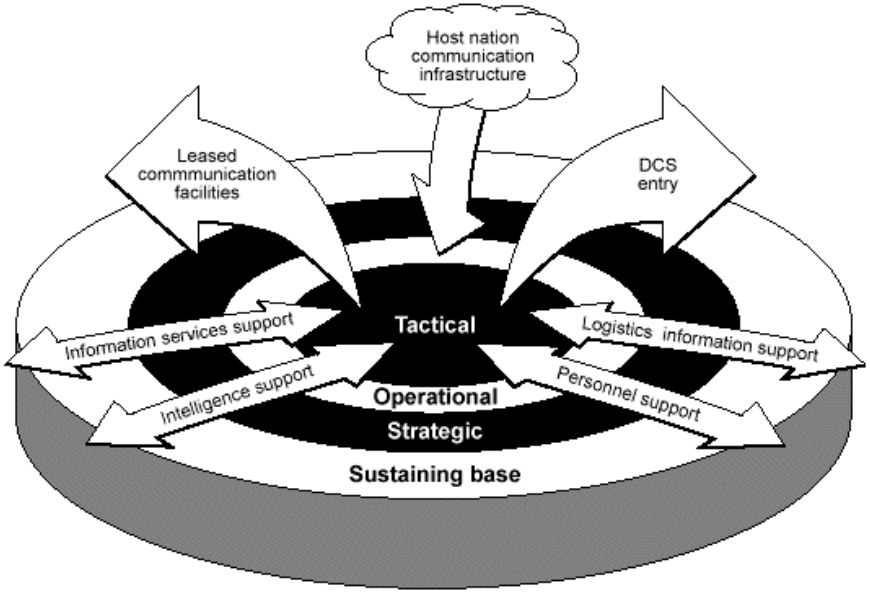
The conversion from LatLng (latitude, longitude) to MGRS involves several steps, including:

- Convert LatLng to UTM (Universal Transverse Mercator) coordinates
- Determine the UTM zone
- Convert UTM to MGRS



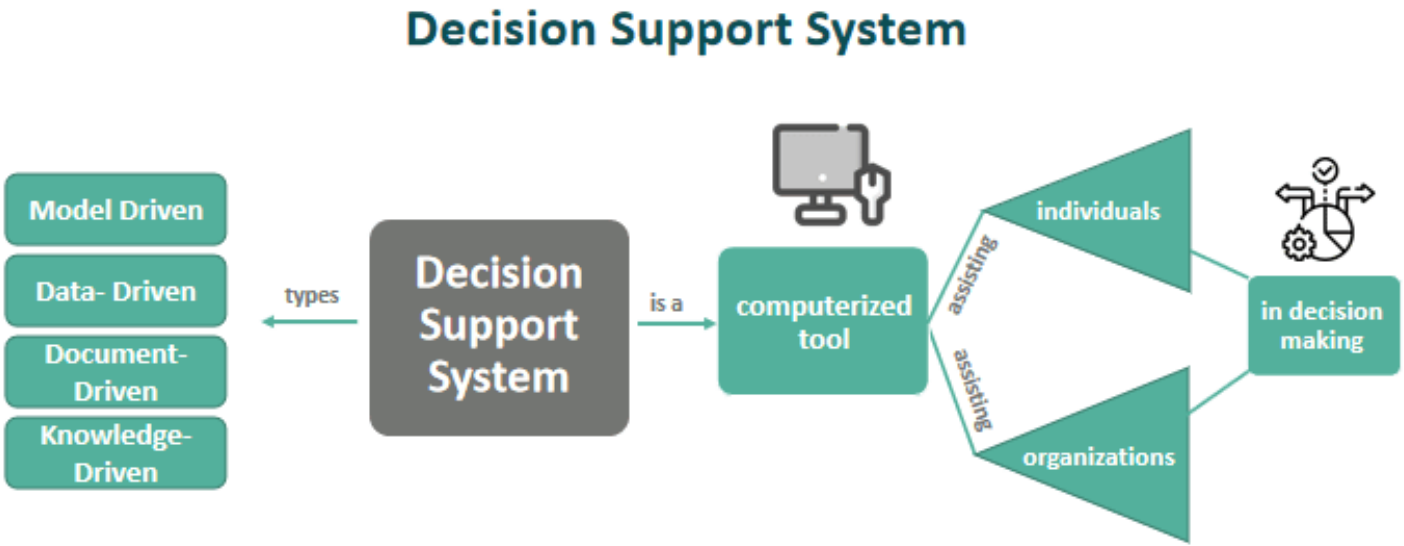
Tactical Decision Support System (TDSS)

A Tactical Decision Support System (TDSS) is a specialized software application designed to assist military commanders and decision-makers in making informed decisions during tactical operations. It integrates various data sources, analytical tools, and visualization techniques to provide real-time situational awareness and actionable insights.



General Equations and Algorithms Used in TDSS

- Distance Calculation
- Route Planning
- Weapon Firing Solutions
- Spatial Analysis



General Equations and Algorithms Used in TDSS

- Distance Calculation: Here use Haversine Formula to calculate distance.

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1) \cdot \cos(\phi_2) \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)$$

$$c = 2 \cdot \operatorname{atan2}\left(\sqrt{a}, \sqrt{1-a}\right)$$

$$d = R \cdot c$$

Where:

- $\phi 1, \phi 2$: Latitudes of the two points
- $\Delta\phi$, $\Delta\lambda$: Differences in latitude and longitude between the points
- R: Radius of the Earth (mean radius = 6,371 km)
- d is the distance between the two points along the surface of the sphere.

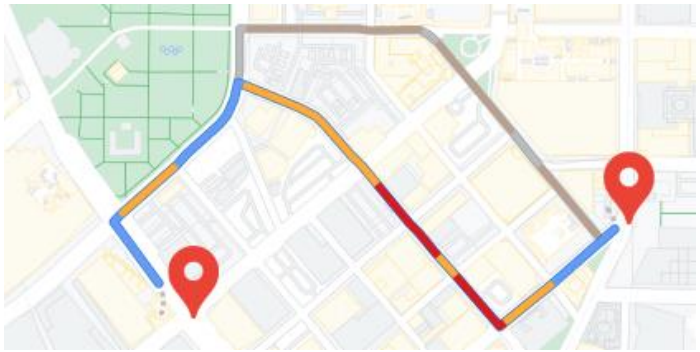
General Equations and Algorithms Used in TDSS

- Route Planning : Here use A Algorithm (A-star) to calculate Route Planning.

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

Where:

- f(n): Estimated total cost of path through node n
- g(n): Cost to reach node n
- h(n): Estimated cost from n to the goal based on heuristic



General Equations and Algorithms Used in TDSS

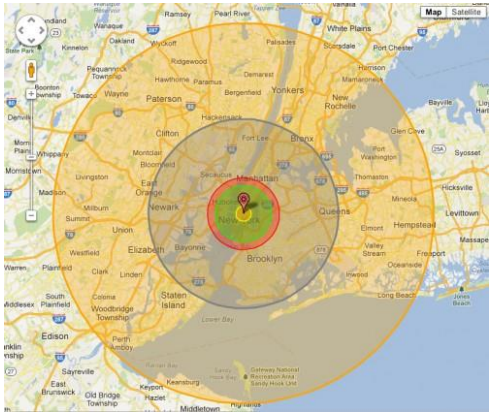
- Weapon Firing Solutions : Here use Ballistic Equations to calculate Weapon Firing Solutions.

$$y(t) = y_0 + v_0 \sin(\theta) \cdot t - \frac{1}{2} g t^2$$

$$x(t) = x_0 + v_0 \cos(\theta) \cdot t$$

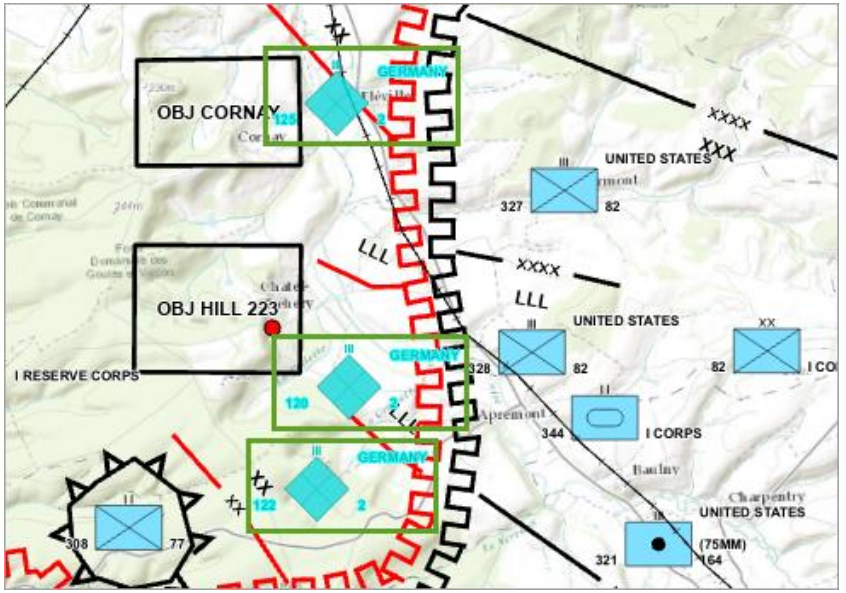
Where:

- (x_0, y_0): Initial coordinates of the projectile
- v_0: Initial velocity of the projectile
- θ: Launch angle
- g: Acceleration due to gravity



General Equations and Algorithms Used in TDSS

- Spatial Analysis :
  - Overlay Operations: Used to analyze spatial relationships between different layers or datasets on a map. Operations include intersection, union, difference, and buffering to determine areas of overlap, containment, or proximity between spatial features.



Proposed System Design

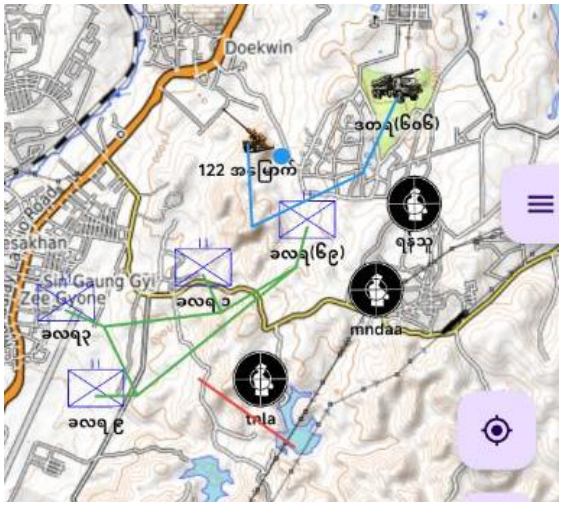
Geospatial Data

Real-Time Location Data

Weapon Range Specification

Dynamic Visualization Engine(Real-Time Map On Android or IOS)

Engagement Planning & TDSS Interface



Real-time Data Processing

Feedbacks & Adjustment Loop

Conclusion

- This system supports an Automated Military Tactical Support System, designed to leverage advancements in Geospatial Information Systems (GIS) and algorithmic optimization to provide dynamic visualizations of weapon firing ranges and comprehensive engagement planning.
- It also supports to automate the process of retrieving location data, measuring distances, visualizing weapon ranges, and calculating optimal engagement strategies, thereby providing military personnel with a robust tool for more precise and effective decision-making.

Any Suggestions?

Thank You

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