STUDY ON THE DEVELOPMENT OF A GIS-BASED MONITORING SYSTEM FOR PREVENTING COASTAL EROSION ALONG THE KOREAN COAST

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ABSTRACT: Coastal erosion causes not only sand loss but also socio-economic damages along coastal zones. Although multiple facilities such as seawalls and breakwaters were built along the coasts of Korea, they did not help much in preventing coastal erosion. Preventing coastal erosion in Korea is intensely challenging due to the region's complex topographic characteristics. The utilization of one-type or imitated solutions worsened coastal erosion along the coasts of Korea. In this research, a GIS-based monitoring system for preventing coastal erosion along the Korean coast was developed using the digital twin and artificial intelligence techniques with 3D spatial information datasets. The standardized GIS database of the coastal dunes, the drone LiDAR data with LAS format, the high-resolution satellite imagery and the other datasets with the DWG, XLS and XYZ formats were designed and built. Consequently, the simulation function for showing the coastal erosion process with the multiple steps was also designed and developed based on the database. The system also provided the decision-making process including the recognition of current status, judgment of disaster-reactions and the establishment of a disaster prevention plan. Such disaster prevention plan is essential for the coastal disaster management agencies of Korea in establishing significant programs for preventing coastal erosion and protecting Korea's coastal properties.

Introduction

Globally, coastal spaces are increasingly being utilized at an intense scale due to socio-economic development and expansion of urban functions, including the expansion of industries, ports, and residential complexes. For this reason, coastal spaces are undergoing serious changes in terms of the coastal natural environment with changes in the coastline unlike before, and a typical example of such change is coastal erosion.
The outermost beaches in coastal areas are not only valuable assets for tourism and economic resources but also serve as crucial safeguards for the coastal line against natural disasters such as typhoons, storm, and tsunami, while also maintaining the natural environment of the coastal areas. Therefore, the protection of these beaches is of paramount importance from both economic and industrial standpoints. In this regard, this research studied a coastal erosion monitoring system that captures real-time 3D terrain data and various coastal physical phenomena, utilizing fourth industrial revolution technologies, including AI, big data, and digital twin technology.

Discussions

The flowchart of the system is presented Figure 1 below.

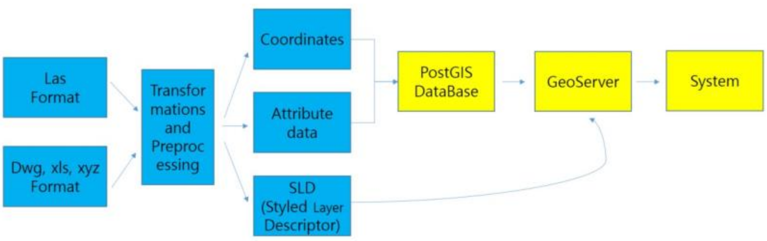

Figure 1. Flowchart of the system

LAS format LiDAR point cloud data is transformed into a raster dataset with an m*n matrix using interpolation methods (Linear, Kriging, Cubic, IDW, etc.) This process determines the spatial resolution to create a Digital Elevation Model (DEM), and the resulting DEM data is saved with a ".tif" extension.

The created TIF file was subsequently stored using GIS-specific databases like PostgreSQL. Then, a WebGIS system visualized the DEM based on the raster data using GIS servers like GeoServer and libraries such as OpenLayers.

When dealing with data in formats such as AutoCAD DWG, XLS, and XYZ, GIS-specific software such as QGIS was used to convert the data into the standard vector-based GIS data format, Shapefile (SHP).

The converted SHP files were stored in PostgreSQL, and they were visualized in a WebGIS system using GeoServer. When visualizing the data in the WebGIS system, the values associated with each dataset were linked to specific styles, and these styles were saved as SLD (Styled Layer Descriptor) files.

For example, the wave vector diagram consists of text data with a 4-column XYZ extension. The default style for the wave vector diagram is represented by arrows. When examining the data, the x and y columns representing coordinates are used for mapping onto the diagram. The third value represents wave height, which is applied to the size of the arrows specified in the default style. A higher value results in larger arrows, while a lower value results in smaller arrows, making it visually intuitive. The fourth value represents the angle, indicating the direction of the wave in degrees. The direction of the arrows is visualized according to this angle value.

As a result, it is much easier and faster to understand the data because it is visualized by applying a style to the relevant location rather than text data.

In the case of sedimentary data, it is presented as three-column text data with the DAT extension. The basic style used circular points. When examining the data, the x and y columns represent coordinates, just like the wave vector diagram. The z column is a value that represents the degree of sedimentation, and the color of the circular point is changed based on the legend to make it easier to understand.

The base map of the WebGIS system used the V-World API. To prepare for situations where data may not be intuitively understood because the color for each data is similar to that of the base map, several types of base maps are provided. Road maps, aerial photos, hybrid maps with cycles on aerial photos, blank maps, and night maps are among the map types provided.

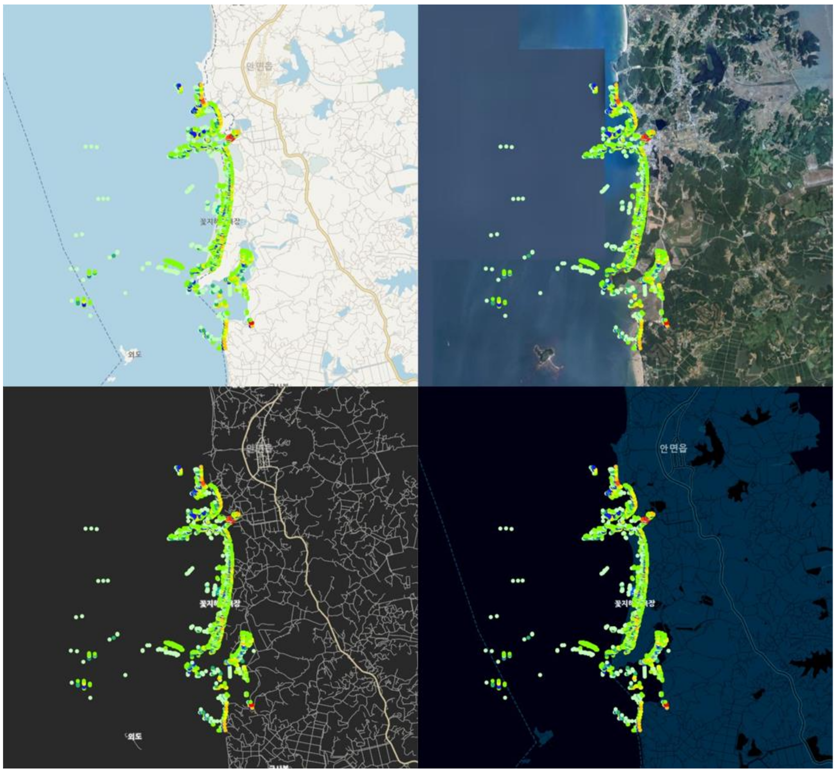

Figure 2. Several types of base maps

Conclusion

By converting survey data into GIS data and creating a database, it is easy to compare and analyze the values of each set of visualized data. It is intuitive and efficient because multiple data can be viewed at once by overlapping data. This is expected to make management of monitoring, evaluation, prediction, and response feasible to create a safe and comfortable coastal environment for users. The more data related to coastal erosion is collected, the greater the impact it will have.

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