

A Web-based Andhra University Spatial Information System (AUSIS) and a Building Information Extraction Model using WebGIS & Image Recognition Technique

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Abstract: A university campus is an intricate infrastructure. Especially new students, who are thereon for the first time, have a tough time orienting themselves and finding places. The campus of Andhra University occupies more than 422 acres (170.7 hectares). The campus has many different buildings. Every year, thousands of new students join the university. These students either take a campus commuter or walk around to get familiar with the campus compound. Visitors to Andhra University might have a hard time searching for a particular location on the campus. Every day, uncountable numbers of students, staff, and visitors move around the campus compound to perform tasks by walking, cycling, driving, or riding campus commuters. Even if there are maps at various points on the campus premises, users do not have continuous help to reach their destination. On these static maps, they can try to figure out a way to get to their target, but as soon as they start walking in the target direction, they have no help anymore. The main objective of this study is to develop a Spatial Information System for Andhra University (a Progressive Web App). Which provides several features like a voice-enabled optimal navigation solution, shows nearby places within campus premises, and a geo-tagged university (Geo-tagging of all entities within campus premises). To make the web application more operative, the application is appended with more features. For instance, a map shows statistical data with pie charts visualization (statistical data like monthly attendance), machine learning's image recognition model for extracting the building information from the digital or captured images.

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Keywords: WebGIS, Spatial Information System, Navigation System, Progressive web app, Geo-Visualization, Image recognition.

1. INTRODUCTION

Geospatial Technology is an emerging field of study that includes Geographic Information System (GIS), Global Positioning System (GPS), and Remote Sensing (RS). Geospatial technology enables us to obtain data referenced to the Earth and use it for analysis, modeling, simulations, and visualization of spatial data [21]. Geospatial technology allows us to construct informed decisions based on the significance and priority of resources, most of which are limited in nature [5].

An information system that can be implemented to collect, store, analyze, and disseminate spatial information about given areas is often categorized as a spatial information system [22]. Generally, a commercial geographic information system requires sophisticated and well-trained technicians to run the system as easily as it should be. The cost of commercial GIS software isn't modest. A cheap and user-friendly spatial information system is very desirable [26].

WebGIS, the union of Web and geographic information systems (GIS), is a new and promising field. It has widened the power of GIS from local servers to the cloud, putting online maps and geospatial intelligence in the offices of millions and the hands of billions [17]. WebGIS should not be added with Internet GIS as there is a slight difference between the two. The Internet supports many services. The Web is one of the services supported by the Internet. If an Internet GIS uses more Internet services as opposed to being singularly Web-based, it is called Internet GIS [24]. WebGIS is also sometimes known as the geospatial Web or the GeoWeb.

2. OBJECTIVES

- To design and develop voice-enabled navigation information system-aided with Chatbot assistance, which shows optimized routes from one location to another within campus premises for easy movement of the users.
- Geo-tagging of every entity (like Buildings, Bore wells, Road network, dustbins, amenities, and

etc.) using GIS technology within campus premises to display it on a map with brief details.

- To create a web map which shows statistical data like monthly attendance of every department on Pie chart, which displays on a marker of each department.
- Building information Extraction model using Machine learning's image recognition technique shows the details of a particular building or department (details like Head of the department, Department name, Spatial coordinates, website link for more information about the department). It can be done by taking or uploading a particular building image through any mobile device.

3. STUDY AREA

The university is a campus included with 121 buildings for academic, administrative, and support services, with an area of about 422 acres (170.7 hectares). The university campus is scenic, with the Kailasagiri hill range on one side of it and the Bay of Bengal on the other side.

The university contains two segments, the south and north campus. The south campus included the Arts, Humanities, and Sciences departments along with the administrative and examination blocks. The north campus of Andhra University (established in 1962) comprises the Engineering College.

A GIS-based web Spatial Information System is developed in this study area.

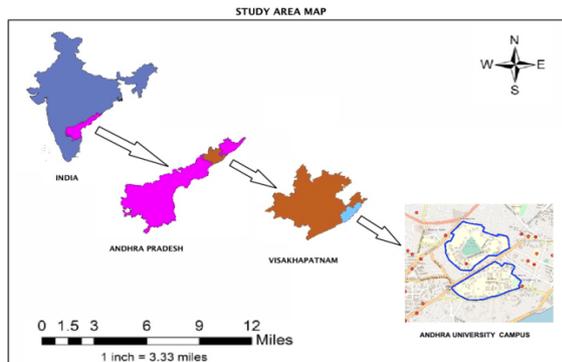


Figure 1. Study Area Map

4. LITERATURE REVIEW

A. Related Literature

The evolution of WebGIS has been steady, progressing with the Internet's growth and the advancement of hardware and software. The Web allows the end-user to interact with the data and make better conclusions from it. The fundamental architecture of a webGIS application is a client-server architecture. This is because the standard of geodata is very specific in the

sense that it requires a map server on top of the web server and a database [2].

In contrast, most other websites do not require these extra technologies to function properly.

Before developing a web application, the first and foremost thing is to convene all necessary web development components and tools. For instance, a suitable framework for displaying maps, JavaScript libraries for responsive user interface, and other third-party APIs which makes the application more functional and dynamic.

B. Getting started with Mapbox GL JS:

Mapbox GL JS is a JavaScript library used for displaying interactive, customizable vector maps on the Web. Mapbox GL JS is a portion of the cross-platform Mapbox GL ecosystem, which includes compatible native SDKs for Android, iOS, Qt, macOS, and React Native. Mapbox GL JS provides building blocks to add location features like maps, search, and navigation into any experience you create.

We have to import the below CDN scripts to use it.

```
<script src="https://api.mapbox.com/mapbox-gl-js/v1.7.0/mapbox-gl.js"></script>
```

```
<link href="https://api.mapbox.com/mapbox-gl-js/v1.7.0/mapbox-gl.css" rel="stylesheet" />
```

C. Geographic Information System:

A Geographic Information System (GIS) is a software system for gathering, storing, checking, and displaying data related to positions on the Earth's surface [15]. By relating seemingly unassociated data, GIS can better understand spatial relationship data and its patterns.

GIS can use any information that comprises locations. The location can be expressed in many discrete ways, such as longitude and latitude, address, or ZIP code [5].

With GIS technology, humans can compare different entities' locations to discover how they correlate with each other.

D. QGIS:

QGIS is a free and open-source cross-platform desktop GIS software enabling the user to visualize, manages, edit, analyze geospatial data, and compose printable maps [23]. QGIS supports both vector and raster layers. Vector data is stored as point, line, or polygon features. And raster data consists of a matrix of pixels organized into rows and columns (or a grid). QGIS supports shapefiles, coverages, personal geodatabases, Dxf, MapInfo, PostGIS, and other formats. Web services, including Web Map Service and Web Feature Service, are also supported to allow the use of data from external sources [23].

E. Progressive Web App:

Progressive Web Apps are web applications that use emerging web browser APIs and features that provide an installable app-like user experience to cross-platform web applications [7]. Progressive web apps are fast and reliable.

F. Turf.js- Advanced Geospatial Analysis :

The spatial analysis includes a variety of techniques and procedures used to understand the patterns and relationships of geographic features. Turf is an advanced geospatial JavaScript open-source library that allows you to do spatial operations in the browser [13]. Turf helps you analyze, aggregate, and transform data to visualize it in new ways and answer advanced questions.

The below script tag should be included for the use of advanced geospatial analysis tools.

```
<script
src='https://npmcdn.com/@turf/turf@5.1.6/turf.min.js'>
</script>
```

G. Charts.js :

Chart.js is a free, open-source JavaScript library for data visualization, which supports eight chart types: bar, line, area, pie (doughnut), bubble, radar, polar, and scatter [13]. Chart.js renders in HTML5 canvas and is widely covered as one of the best data visualization libraries.

```
<script
src='https://cdnjs.cloudflare.com/ajax/libs/Chart.js/1.0.1/Chart.min.js'> </script>
```

H. Firebase Realtime Database:

Firebase provides a real-time database and backend as a service. The service provides an API that allows application data to be synchronized across clients and stored on Firebase's cloud. The company provides client libraries that enable integration with Android, iOS, Java, JavaScript, Swift, Objective-C, and Node.js applications. Developers using the real-time database can secure their data by using the company's server-side-enforced security rules.

```
<script
src='https://www.gstatic.com/firebasejs/7.8.2/firebase-database.js'> </script>
```

I. Tensorflow.js:

TensorFlow.js is an open-source JavaScript library that can add machine learning capabilities to any web application. With TensorFlow.js, we can develop machine learning scenarios from scratch [25]. It is used to define, train, and run machine-learning models entirely in the browser, using JavaScript and high-level API.

```
<script
src='https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@1.3.2/dist/tf.min.js'></script>
```

J. Microsoft Custom Vision:

Azure Custom Vision is a cognitive service that lets you build, deploy, and improve your image classifiers. An image classifier is an AI assistance that applies labels (which represent classes) to images according to their visual characteristics [11]. Unlike the Computer Vision service, Custom Vision permits us to specify the labels to apply.

5. DATA AND METHODOLOGY

A. Types of Data used:

1. KML:

Keyhole Markup Language (KML) is an XML notation for expressing geographic annotation and visualization within two-dimensional maps and three-dimensional Earth browsers. KML is an official Open Geospatial Consortium (OGC) standard. It is a common format for sharing geographic data with non-GIS users as it can be easily delivered on the Internet. KML files are either with .kml or .kmz file extension.

2. Shapefile:

The Shapefile (known here as the ESRI Shapefile format) stores non-topological geometry and attribute information for the spatial features in a data set. A shapefile consists nominal of the main file, an index file, and a dBASE table. The shapefile format spatially describes geometries as either 'points,' 'polylines,' or 'polygons.'

3. GeoJSON:

GeoJSON is an open standard format designed for representing simple geographical features, along with their non-spatial attributes. It is based on JavaScript Object Notation (JSON). The features include points, line strings, polygons, and multi-part collections of these types.

B. Methodology:

Methods followed in the study comprise problem identification, Literature Review, Data collection, and data representation on web maps.

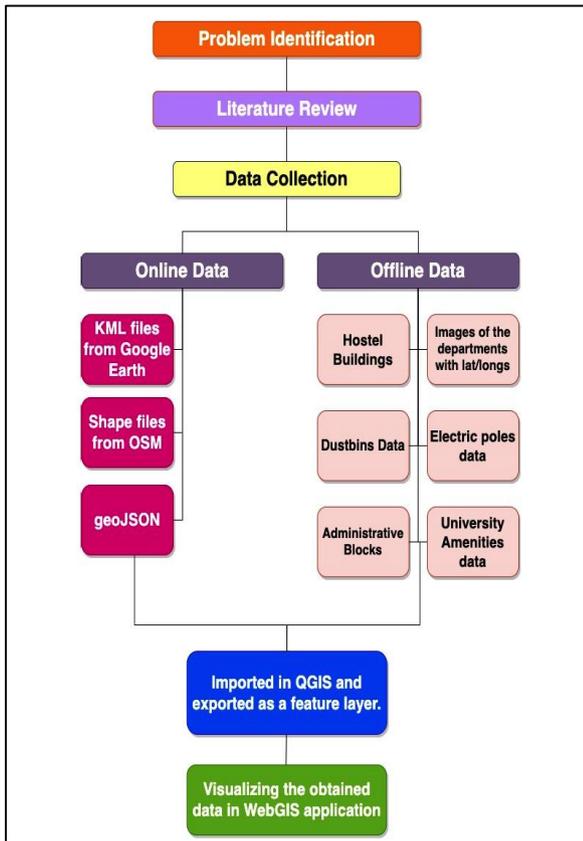


Figure 2. Methodology Flow chart

The first thing we have to look into prior developing any WebGIS application is how we represent the geospatial data on map. It can be done in several ways using different libraries and frameworks. In this application we are using a geoJSON data format to visualize a spatial data on web map.

The application is split up into several fragments.

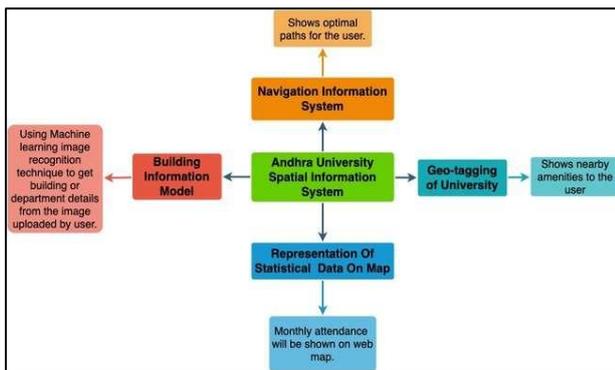


Figure 3. Flowchart of the web application

The below image shows what type of technologies and tools are being used to develop this web application.

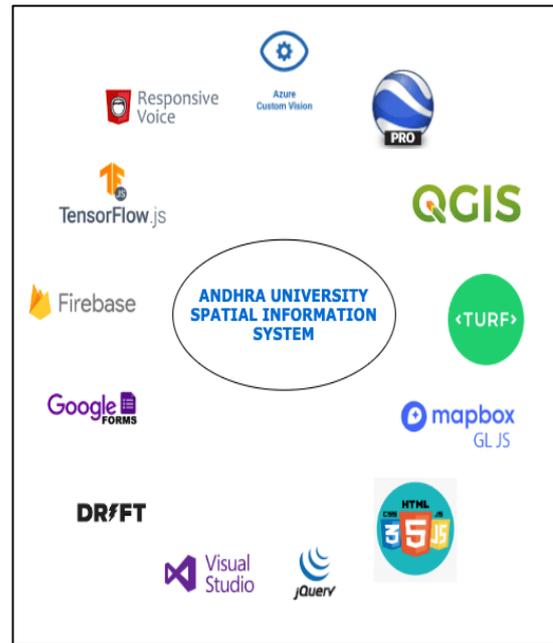


Figure 4: Technologies and Frameworks used in Web Application

1. Navigation Information System:

The technologies and frameworks used in Navigation Information System are:

- Mapbox GL JS
- Open Route Service
- Responsive Voice API
- Web Speech API
- Turf.js

Mapbox GL JS for rendering of base maps on web pages. The below code snippet should be included with the access token.

```

<script> mapboxgl.accessToken =
'YOUR ACCESS TOKEN';

var map = new mapboxgl.Map({
  container: 'map',
  style: 'mapbox://styles/navjothbn/ck8hg1f4f02kz1ioh92ffvpeq',
  center: [83.319903, 17.728981],
  zoom: 15,
  scrollZoom: true,
}) </script>
  
```

For showing the shortest route from one point of interest to another point of interest, we have used an API called Openrouteservice. Using this API, we can send an HttpRequest, and in response to the sent request, we will

get GeoJSON data, which represents the shortest path between the two given coordinates.

To enable voice assistance in the Navigation system, we've used Responsive Voice API for Text to speech conversion. The below script tag should be included to use this functionality.

```
<script
src="https://code.responsivevoice.org/responsivevoice.js?
key=vQA98UAN"></script>
```

Turf.js is used to calculate the shortest distance between two coordinates. turf.length() method with two parameters is used for the calculation of distance.

```
<script
src='https://npmcdn.com/@turf/turf@5.1.6/turf.min.js'><
/script>
```

example:

```
var length = turf.length(Geo_to_principal_block,
{units: 'kilometers'})
```

For users, convenience, the current location feature is also added so that they can move from their current location to another place. The below code will provide the user current location details.

```
map.addControl( new mapboxgl.GeolocateControl({
positionOptions: {
enableHighAccuracy: true
}, trackUserLocation: true }

```

2. Geo tagging of University Objects:

In this, the University Buildings, Hostels, Canteens, Borewell locations, Electric poles locations, etc., are geo-tagged by taking photographs of each with spatial data. For the collection of spatial data from each location, we have used a mobile application, namely Open Camera, to get more accurate latitude/longitude values.

3. Building Information Extraction Model:

Machine learning gives us advanced features like image recognition techniques. In this, we have implemented it using TensorFlow.js and Microsoft Azure's Custom Vision tool. In Custom Vision, we have to upload a number of images of each building/department, so the machine gets trained well using that raw image data. After its perfect training from the uploaded data, a JSON file will be generated that we have to include it in our code.

After completion of the whole process, the outcome of this feature is to recognize the building and display the information about the building (information like Department name, Head of The Department, Courses Available, etc.) if the user takes a photo of the building and upload it.

```
<script>
src="https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@1.3.2/
dist/tf.min.js"></script>
```

The above code snippet is for including the tensorflow.js functions in our web application.

4. Representation of Statistical Data on Map:

In this, the University Buildings, Hostels, Canteens, Borewell locations, Electric poles locations, etc., are geo-tagged by taking photographs of each with spatial data. For the collection of spatial data from each location, we have used a mobile application, namely Open Camera, to get more accurate latitude/longitude values.

Usually, Pie charts, Bar graphs, etc., are used to represent statistical data for better visualization. Using **Charts.js** and **Mapbox GL JS**, we could display monthly attendance data of every department on a map with pie chart visualization. The below script tag is to import charts.js features.

```
<script
src="https://cdn.jsdelivr.net/npm/chart.js@3.0.2/
Chart.min.js"></script>
```

The administration staff of the university will upload the attendance data on monthly basis. The uploaded data will get stored in a firebase real-time database, and that data is retrieved from the database and will be shown on the map.

4. Converting to a Progressive web app:

Before converting any web application or website to a progressive web app, it's necessary to take care of the responsive user interface design to make it compatible with any type of device view (like mobile view, tablet view, desktop view).

To make a responsive design, we have to use the Media Queries. A sample of media query codes is given below.

```
@media (min-width: 576px){
.container{
max-width: 540px;
}}
@media (min-width: 992px){
.container{
max-width: 720px;
}}

```

To make a progressive web app, below are the steps that we have to follow:

- Create an app manifest file.

```

{ "name": "Andhra University Spatial Information System,"
  "short_name": "AUSIS",
  "start_url": "/index.html",
  "display": "standalone",
  "theme_color": "#007bff",
  "background_color": "#FFFFFF",
  "description": "A Spatial Information App.",
  "icons": [
    {
      "src": "logo_512.png",
      "sizes": "512x512",
      "type": "image/png"
    },
    {
      "src": "logo_192.png",
      "sizes": "192x192",
      "type": "image/png"
    }
  ]
}

```

- Add it to your base HTML main page (index.html) using the link tag.

```
<link rel="manifest" href="manifest.webmanifest" />
```

- Deploy your progressive web app
- Use your progressive web app.

6. RESULTS AND DISCUSSIONS:

A web-based GIS application is developed with the help of WebGIS and Machine learning image recognition technique. Functionalities and features included in this application are:

- A Navigation System for optimistic routing solution.
- Geo-visualization of spatial data.
- Geo-tagging of entities within the premises of the university.
- Representation of statistical data on dynamic maps.
- An image recognition technique for getting building/department information.
- Chat bot assistance for user queries is enabled.
- A Progressive web app, which provides a native app-like experience

It is necessary to choose add to home screen option for the website to implement a native mobile app-like experience.

A. Navigation Information System:

The search option of a navigation system enabled with both voice recognition feature and manual text selection from the drop-down menu. The application prompts for permission regarding Location Access and

Micro Phone Access. We have to give permission to enable the feature.

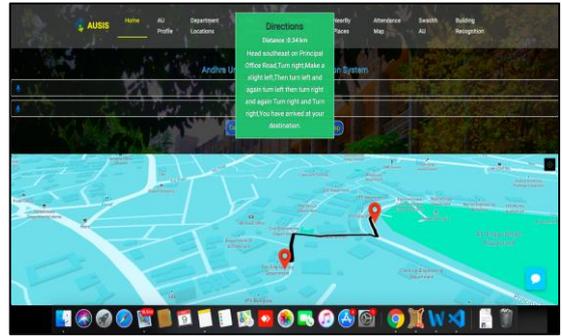


Figure 5: Desktop View of Navigation Information System

B. Geo-tagging of University Entities:

All nearby places will be shown on a dynamic map with their details on each location's marker. Location access is necessary to show the user's current location.



Figure 6: Mobile View of Nearby Places

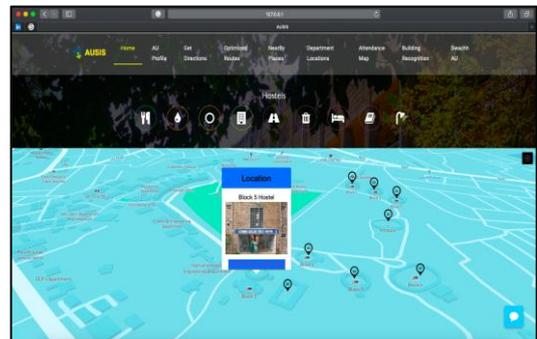


Figure 7: Desktop View of Nearby Places

C. Visualization of statistical data on a map:

Each department's monthly attendance percentage is shown on their respective markers with the help of pie chart visualization. The data is added on a monthly basis by the University Administration team.

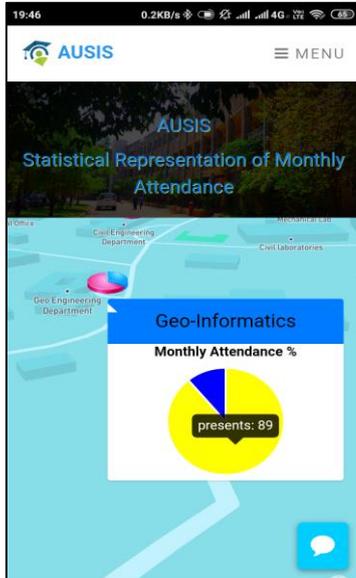


Figure 8: Mobile view of Attendance Map

D. Building Information Extraction Model:

After taking the photo of the building and uploading it through any devices, the user can able to get details of the building. The prediction probability value (ranges from 0 to 1) is also shown in the results to know the accuracy level of the obtained result.

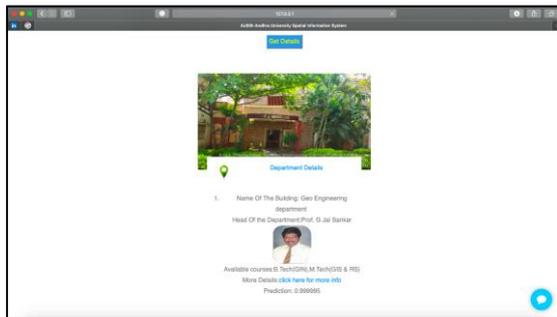


Figure 9: Building Information Extraction Model

7. CONCLUSION AND FUTURE WORK:

A. Conclusion:

The main purpose of the study is to create a web application that helps the individuals on the campus of Andhra University to orient themselves and to get familiar with all the places within campus premises.

The ultimate intention of this GIS-based progressive web application (PWA) is to make a geo-smart university that provides facilities like optimized routes, a voice-enabled navigation system, chatbot for assistance, building information extraction, and moreover a spatial information of the university to the user in and around the Andhra University campus.

B. Future work:

For more consistency and better functioning of the web application, more data sources should be added in the future, which is beneficial for users to get acquainted with different places on campus premises in less time and move effectively.

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