Using Open Source Web GIS for Analysis of Transnational Illicit Trafficking

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Background

- Illicit trafficking is a serious transnational crime
Background

- Illicit trafficking
  - Causes negative socio-economic effects
    - Loss of human life and properties, etc.

https://www.whitehouse.gov/blog/2015/02/02/historic-requests-treatment-and-prevention-president-obama-s-2016-budget
Background

- **Illicit trafficking**
  - Constitutes criminal funds promoting various transnational criminal activities (TCAs)
Background

- To detect and prevent TCAs
  - Identify transnational criminal organizations (TCOs)
  - Analyze high-risk routes for smuggling

http://www.wired.com/2011/01/ff_orgchart_crime
Background

- Problems
  - Hard to find available global network data of multiple transportation modes
  - Hard to find readily available GIS applications supporting analysis of trafficking pathways
Objectives

- Identify and analyze TCOs and its networks
- Identify and analyze potential routes of trafficking of radiological/nuclear (RN) materials considering different transportation modes
- Access high-risk routes and transportation modes for RN smuggling in the regions of interest
Tasks

- Four Main Tasks
  - Subtask 1
    • Group Identification and Theoretical Background
  - Subtask 2
    • Organizational Profiling and Threat Assessment
  - Subtask 3
    • Case Studies of illicit trafficking
  - Subtask 4
    • Development of a web-based GIS application for TransIT (transnational illicit trafficking) analysis
Tasks

- **Subtask 4**
  - Develop a web-based GIS application for TransIT (transnational illicit trafficking) analysis
    - Build transportation networks of multiple transportation modes
    - Geocoding and visualizing of operation areas, friends and enemies of TCOs
    - Analyze trafficking routes of different transportation modes
Web-based GIS App

- Develop a web-based GIS app integrating FOSS

**Software Components**
- Web Server (HTTP) Server
  - Apache Web Server
- Application Server
  - PHP Server
- Database Server
  - PostgreSQL, PostGIS, pgRouting
- Geospatial Server : GeoServer
- OpenLayer3
Architecture

- **Overview**

Client

- Standard Web Request
- OpenLayers
- WMS Request

Server

- Apache Web Server
- PHP Server
- GeoServer
- PostgreSQL/PostGIS/pgRouting
- Database
Software Components

- Apache Web Server
  - A program that stores HTTP pages, listens HTTP requests, and delivers web pages to web browsers

- PHP Application Server
  - Support the construction of dynamic web pages
  - Handle connections to the database on one side, and connections to the web client on the other
Software Components

- **PostgreSQL**
  - An object-relational database system
    - Object-relational mapping defines structural relationships between object-oriented and relational representations of data
    - Enable the use of complex objects, with methods, that can be used in a Relational Context (SQL)

- **PostGIS**
  - Spatial database extension for PostgreSQL
  - Store, query, and manipulate geographic objects
Software Components

- pgRouting
  - Geospatial routing extension for PostgreSQL/ PostGIS
  - Provide functions for shortest path algorithms
    - Dijkstra shortest path
    - Shortest path A*
    - K-Dijkstra, One to Many Shortest Path, etc.
  - Functions operate with direct SQL commands
  - The “cost” parameter can be dynamically calculated from multiple fields through SQL
Software Components

- GeoServer
  - A server for sharing and editing geospatial data
  - Publish data from any major spatial data source using open standards
    - Web Map Service (WMS)
    - Web Feature Service (WFS)
    - Web Coverage Service (WCS)
    - Web Processing Service (WPS)
  - Include a graphical user interface for configuration
Software Components

- **OpenLayers**
  - JavaScript library for displaying map data in web browsers
  - Provide APIs for building web-based geographic applications
  - Support KML, GML, GeoRSS, GeoJSON, etc.
  - Can load data from many sources
    - Google Maps, Yahoo Maps, Virtual Earth
    - Web Map Service or Web Feature Service
  - Makes use of map “tiles”
Data

- **Geographical Data**
  - Global Administrative Areas
    - GADM database ([www.gadm.org](http://www.gadm.org))
    - National governments and/or other organizations
  - Transportation Data
    - Roads (primary, secondary, trails)
    - Railroads, Railroad stops
    - Airline routes, Airports
    - Ferries, Shipping facilities, Ports
  - Transnational Criminal Organizations
    - Operation areas, enemies, and friends
Data

- Building Network Topology
  - Transportation Line Shapefiles imported to PostgreSQL using PostGIS command `shp2pgsql`
  - Create network topology using `pgr_createTopology` function

```
SELECT pgr_createTopology('<table>', float tolerance, '<geometry column', '<gid>')
```

- Assigns a source and a target ID to each link
- Creates `[table]_vertices_pgr` table containing a list of all network nodes
Design

- Functionality
  - Visualization
    - Display and control maps
  - TCOs Analysis
    - Search a TCO
    - Visualize operation areas, friends, and enemies
  - Route Analysis
    - Multiple transportation modes
    - Social behavior constraints
OpenLayers
- Used to display and control maps
- Include a default OpenLayers 3 CSS file and JavaScript library file in your HTML page

```html
<link rel="stylesheet" href="lib/ol3/ol.css" />
<script type="text/javascript" src="lib/ol3/ol.js"></script>
```
Visualization

- OpenLayers
  - Map
  - View
  - LayerGroup
    - A collection of layers
  - Layer
    - Tiled Layer
    - Vector Layer
    - Image Layer
  - Map controls
Visualization

- OpenLayers
  - Create a Map

```javascript
var map = new ol.Map(
    target: container,  //HTML DOM element
    layers: [
        new ol.layer.Group({
            title: "Base Maps",
            layers: [mqLayer, osmLayer, mqOSMLayer]
        }),  //add more layer groups
        new ol.layer.Group({
            title: "Overlay"
        , layers: [
                w_countries, groups,  //add more layers
                afRailSta, afShipPorts, afAirports
            ]
        }
    ]
    ,
    view: v,
    controls: ol.control.defaults()
    .extend([slCtrl, mpCtrl, zeCtrl, fsCtrl])
});
```
Visualization

- OpenLayers 3
  - Create a View

```javascript
var v = new ol.View({
    center: ol.proj.transform([-44.9285, 25.1304], "EPSG:4326", "EPSG:3857"),
    zoom: 3,
    minZoom: 3,
    maxZoom: 16
});
```
Visualization

- OpenLayers
  - Create a Tiled Layer

```javascript
var osmLayer = new ol.layer.Tile(
    {
        title: "Open Street Map",
        type: 'base',
        visible: false,
        source: new ol.source.OSM()
    });
```
Visualization

- OpenLayers
  - Create a Vector Layer

```javascript
var afAirports = new ol.layer.Vector({
  id: "afApt",
  title: "African Airports",
  visible: true,
  source: new ol.source.Cluster({
    distance: 20,
    source: new ol.source.GeoJSON({
      projection: "EPSG:3857",
      url: "data/af_airports.geojson"
    })
  }),
  style: function(feature, res) {
    return pointStyles(feature, res, 'afa');
  }
});
```
Visualization

- OpenLayers 3
  - Create an Image Layer

```javascript
var roadLayer = new ol.layer.Image({
  title: "World Roads",
  visible: true,
  source: new ol.source.ImageWMS({
    url: 'http://gis.start.umd.edu:8080/geoserver/PIT/wms',
    params: {LAYERS: 'PIT:worldroads', VERSION: '1.1.1'}
  })
});
```
Visualization

- OpenLayers
  - Create Map Controls

```javascript
var slCtrl = new ol.control.ScaleLine();
var mpCtrl = new ol.control.MousePosition({
    coordinateFormat: ol.coordinate.createStringXY(4),
    undefinedHTML: '&nbsp;',
    projection: 'EPSG:4326'
});

var zsCtrl = new ol.control.ZoomSlider();
var zeCtrl = new ol.control.ZoomToExtent();
var fsCtrl = new ol.control.FullScreen();
```
Airports

CODE: DAUT
NAME: TIMIMOUN
COUNTRY: ALGERIA
1 more feature(s).
Zoom in for details.
TCOs Analysis

- Search a TCO by continents and countries
  - Visualize the identified TCOs
    - Operational areas of a TCO
    - Areas of enemies of a TCO
    - Areas of friends of a TCO
Route Analysis

- AJAX request to a server-side PHP script
- PHP scripts
  - Makes a connection to Postgres/PostGIS
  - Runs a customized pgRouting shortest path algorithm

```
SELECT ST_AsGeoJSON(route.geom) FROM ( 
  SELECT geom FROM pgr_fromAtoB('worldtransport', 68468.501, 
  1344459.977, 60549.16937,1221268.359) ORDER BY seq 
) AS route;
```

- Display returned GeoJSON as a route layer using JavaScript and OpenLayers
Conclusion

- Develop routing algorithms considering
  - Different combination of transportation modes
  - Preferred vs. restricted areas
  - Multiple waypoints
- Extend analytical and visual functions to evaluate risk of possible routes
- Open Source software make a cost effective yet feature rich implementation of web GIS applications
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Q/A

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