User’s Guide for TerrCtrl QGIS Plugin

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This document introduces the QGIS plugin “TerrCtrl”, short for territorial control, which calculates the location and extent of territory controlled by warring parties during civil wars after each combat. It relies on data measuring the occurrence and location of violent events to identify the degree to which a warring party exercises control. The territory is calculated as a drive-time buffer from the conflict location to estimate the region where the warring party can project military power within a specified time window. The size and shape of the territory is determined by both on-road and off-road movements on a hybrid transportation network with both existing road/railway data and hexagon-fishnet-based artificial road data. This design guarantees its applicability to countries or regions with inferior transportation infrastructure where off-road movement of the military is common. The results can be used to reflect a quasi-real-time status of territorial controls of a specific region on the map. They can also serve as the input of further scientific analysis.

1. Installation

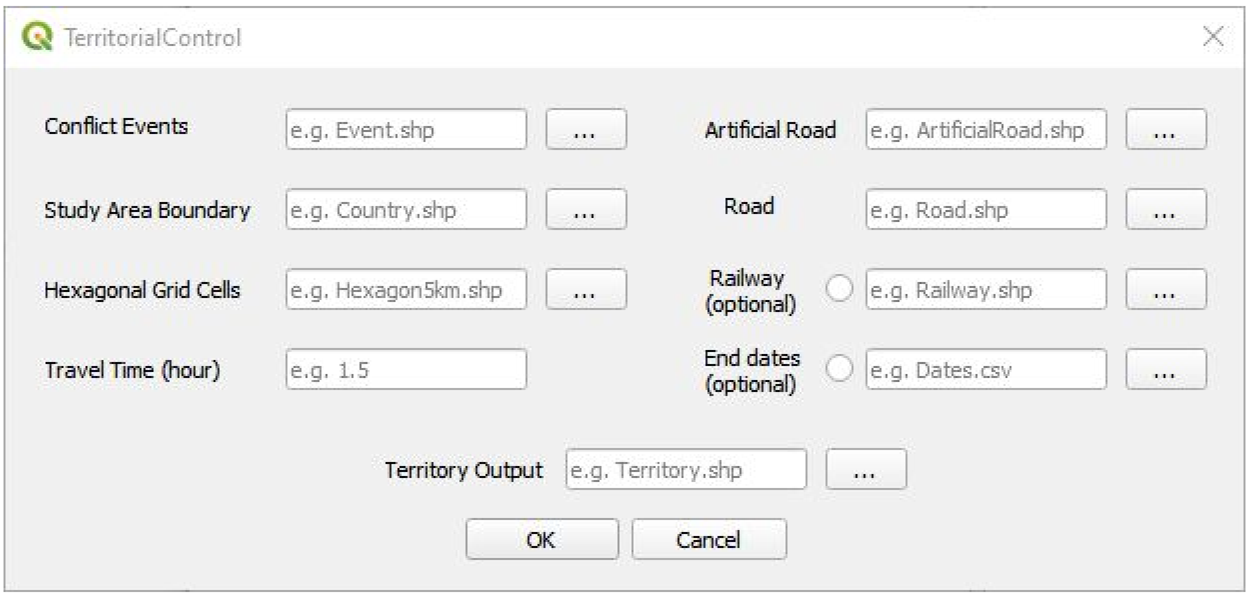
- **Install QGIS 3**
  The tool is a plugin for the QGIS open source geographical information system program. To download and install the latest version of QGIS for your operation system, please go to https://qgis.org/en/site/forusers/download.html. This instruction is demonstrated using the QGIS version 3.12.2 (64bit) on Windows 10. (Note: please run the QGIS Desktop 3.X.X with GRASS 7.X.X similar as below, since the plugin uses GRASS GIS functions).
  

- **Install TerritorialControl plugin**
  Option 1. Manual installation. Place the unzipped folder of source codes (download) named *territorial_control* in the following directory:
  C:/Users/username/AppData/Roaming/QGIS/QGIS3/profiles/default/python/plugins

  Option 2. Download from official repository. Open QGIS and start a new Project, on the menu find “Plugins” → “Manage and Install Plugins...” Search for the plugin “TerrCtrl” and install it by checking the box in front of it,

After installation, the plugin icon will appear on the QGIS menu. The meaning behind the icon is twofold: first, the hexagonal shape corresponds to the hexagonal grid cells used for modeling territorial control; second, the Yinyang pattern expresses our sincere wish through this old Chinese philosophy: although conflicts and violence always exist, harmony and peace can be eventually achieved.

2. Set up & test run



Referring to the graphical user interface (GUI) of this plugin, it takes eight input data or parameters and outputs the territorial control results in the shapefile format. To save users time and to lower the learning curve of using this plugin, we have spent quite some time preparing the input data for many countries in the world, using publicly available data sources such as OpenStreetMap, USGS. Users can download the prepared input data for individual countries via this url: https://drive.google.com/drive/folders/1kdvdLB9WPDfMJ00TFI4J3MMgN3PZuVpf (currently African and Asian countries are available).

Note: the only input data that **we didn't prepare** for all the countries is the conflict event data. Users are expected to prepare it by themselves to serve their needs. Please refer to Section 3 to see how to prepare the conflict event shapefile data. For testing purposes, we prepared a small sample dataset named "*LiberiaGov_MODEL_ConflictEvents.shp*" to try the plugin using the example of conflicts between the Liberian government and the Movement for Democracy in Liberia (MODEL).

We provide a set of sample data looks shown in Fig.1. The country of Liberia is the study area. The five conflict events are the UCDP-GED https://ucdp.uu.se/downloads/ records between the

Liberian government and MODEL in 2003. The labels show the conflict event dates. The road and railway data are from OSM.

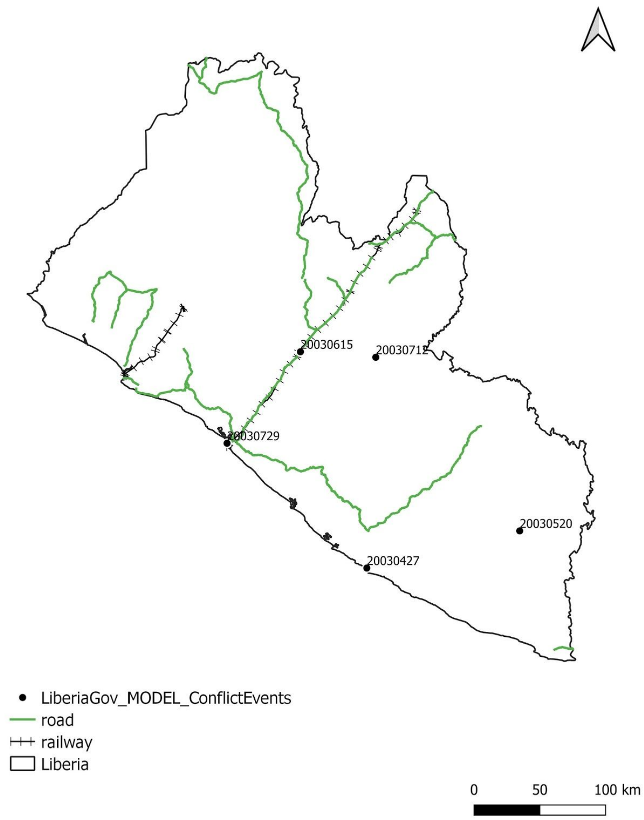


Figure 1. Liberia Government vs MODEL in 2003

Click on the icon to run the plugin. Set up the GUI like Fi.g 2 with sample data and have a test run. The detailed description of each input parameter can be found in Section 3.

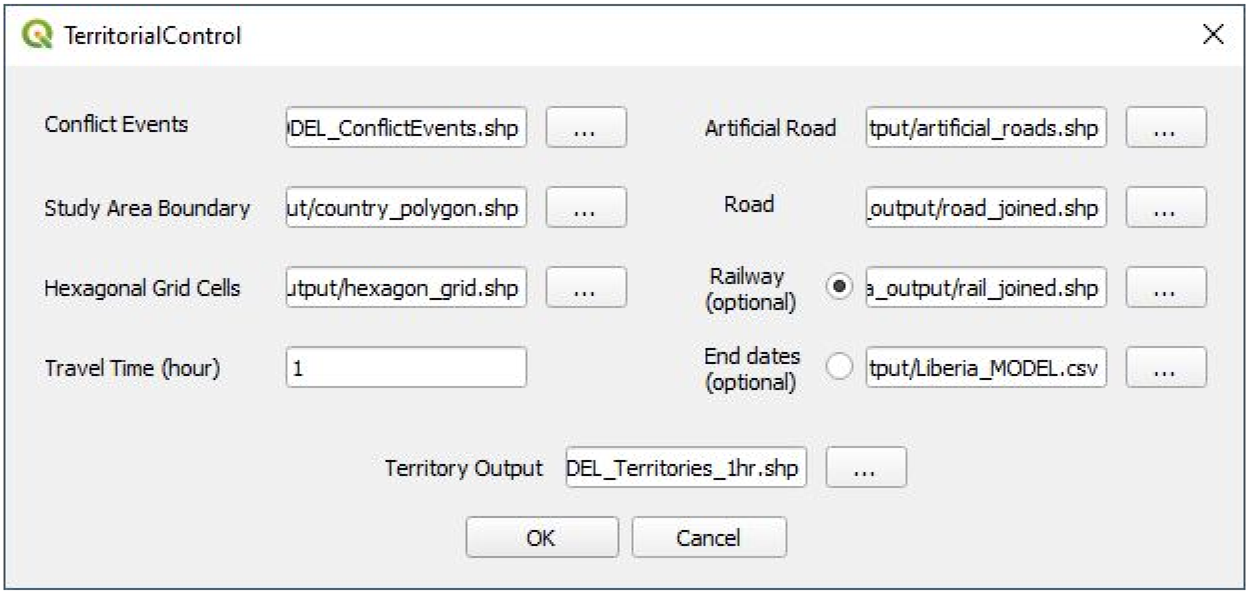


Figure 2. GUI of the plugin with sample data input parameters

The **Territory Output** file name is suggested to include the information of the two warring parties, the travel time, e.g. "*LiberiaGov_MODEL_Territories_1h.shp*". Note that the **End dates (Optional)** is blank, which means this will only generate one result representing the territorial control status by the end of the last event (2013-07-29). Click "OK" to run it. The first-time calculation takes about 5 minutes.

The plugin automatically generates some intermediate results. Most of them are set to be removed after calculation, while the two very useful ones are kept for future repeated calculation. The "*LiberiaGov_MODEL_Territories_1hr_HybridRoads*" is a hybrid road network that combines artificial roads (to simulate the off-road movements), the roads, and the railways (optional). The "*LiberiaGov_MODEL_Territories_1hr_IsoLiones*" is the "Reachable Road Network". It reflects how far the warring party can project its military force along the hybrid transportation network within the given travel time from a certain conflict location. If one or both of the useful intermediate results are detected in the output folder, repeated calculations (e.g. for the same input data except for a different parameter setting such as enabled "*End dates*").

The **Territory Output** is saved in the assigned directory. Figure 3 shows the calculated territories with different travel time. The colors correspond to the warring party who took control after the conflict events. In this test dataset and other UCDP-GED datasets, the variable "*acontrol*" can indicate the conflict results: controlled by side a; controlled by side b; or unclear situation. The travel time parameter decides how far the warring party can project military response from the conflict location. As it increases, the territories expand in space. The ones that are close to existing roads or railways would expand faster. When two territories overlap with each other, the one that happened later would take the overlapped area. And if a later territory covers the location of an earlier conflict event, then the territory based on the earlier event would be completely removed. For instance, the territory in the center of the map is removed in Fig 3d as its base location is engulfed by another later territory.

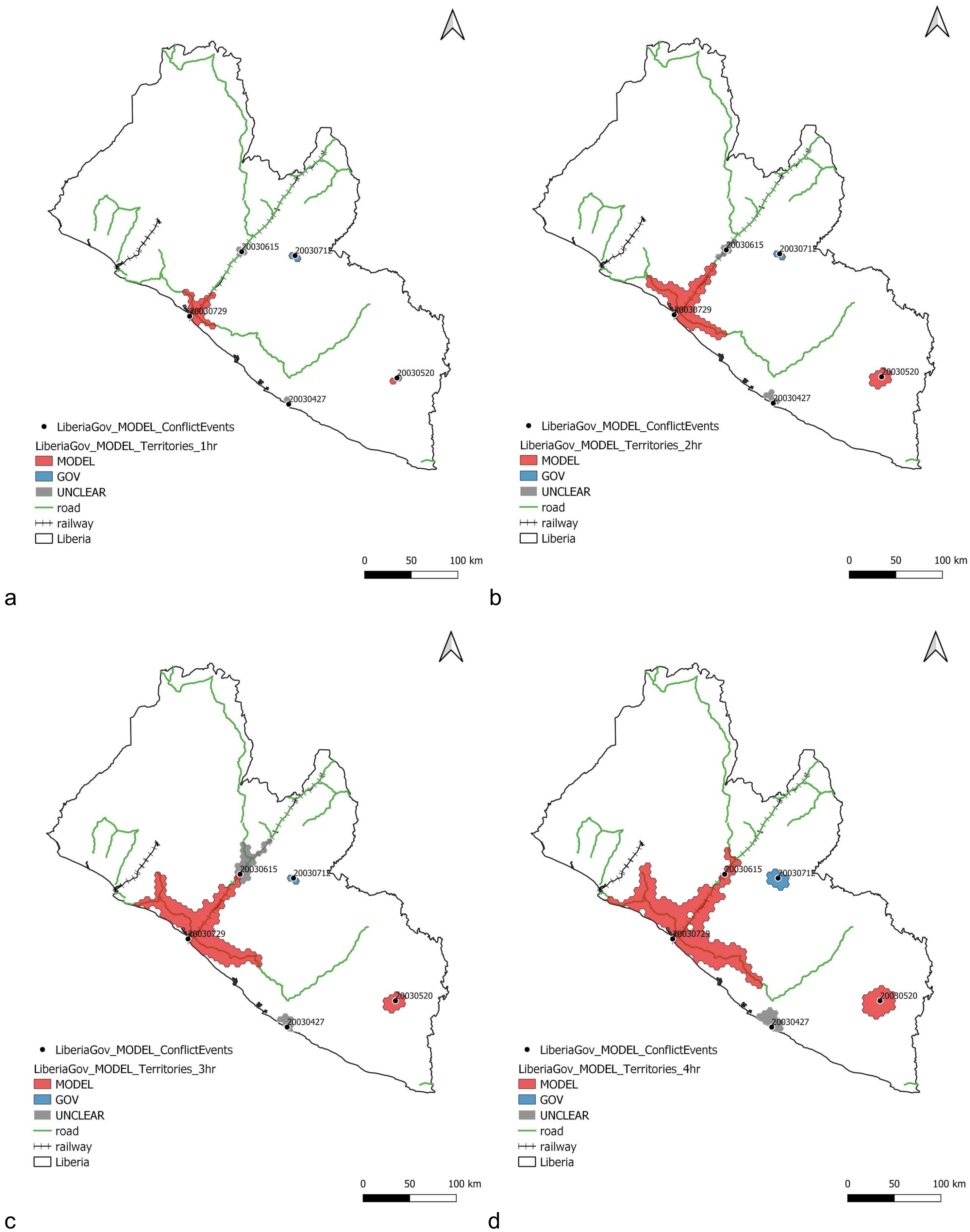


Figure 3. Calculated territories with different travel time: a.1hr; b.2hr; c.3hr; d.4hr

To generate a batch of results, you can enable the option of **End dates** and input a CSV file including the dates you want for each result. The test data file "*Liberia_MODEL_Monthly.csv*" looks like:

20030430
20030531
20030630
20030731

The territorial results will be saved as shapefile in the names like:
"*LiberiaGov_MODEL_Territories_1h_*20030430.shp"
"*LiberiaGov_MODEL_Territories_1h_*20030531.shp"
"*LiberiaGov_MODEL_Territories_1h_*20030630.shp"
"*LiberiaGov_MODEL_Territories_1h_*20030731.shp"

3. Input data detailed descriptions

Here is the checklist of all the inputs data and their preparation instructions:

- **Conflict Events**: This is a shapefile (.shp). Users could begin by preparing a file in tabular format (such as .csv), then convert it to shapefile format in QGIS using the "Add Delimited Text Layer" function. Each row of the table is a conflict event (combat). The file should include a few important columns (or fields in shapefile) for the following variables:
    - Date: The date of the event should be in the format "YYYYMMDD". Name this column "**Date_int**". Sort the data chronologically so that the first row of data is the first event.
    - Event Number: This is a unique identifier for each event. The first event should have 1 as its identifier. Name this column "**TimeID**". Number the earliest event as 1, and then number subsequent events in chronological order.
    - Warring party: This is the name of the warring party that has established control at the location. Suggested name for this column is "side_a". The assumption is that the winner of the combat takes control of that area.
    - Latitude: the latitude of the event.
    - Longitude: The longitude of the event.

  The map projection of the event point layer is recommended to be consistent with all other spatial layers. For example, all the spatial data layers in the sample data for African countries are using the projection system called "Africa Equidistant Conic". Therefore, (re)project your event point layer if needed.

As part of the plugin, we provide sample data for the conflict between the Government of Liberia and the MODEL. These conflict events are drawn from the Georeferenced Event Dataset (GED) [2]. The GED provides information on the identity of the warring parties, the location and time of each event, and other variables. It also includes the original sources (such as media reports) used to generate this list of events. We located these sources and coded the attack and control variables described above, and used these to calculate the level of control for each event.

- **Study Area Boundary**: a shapefile defining the boundaries of the study area, for example, a country experiencing civil war. In the sample data, the boundary of Liberia is provided with filename "*country_polygon.shp*".

- **Hexagonal Grid Cells**: a shapefile of hexagonal cells covering the study area. These cells can be of any size. Note, though, that smaller cells increase the processing time needed to generate the territorial control data.In the sample data we provide hexagonal cells in 5km resolution. The hexagonal grid cells can be easily created in QGIS geoalgorithms => Vector creation tools => Create grid:

- **Travel Time**: The parameter partially decides the size of the territory. We calculate territory as a drive-time buffer from the conflict location as to simulate the region where the warring party can project military response in a timely fashion. So this parameter decides the temporal frame of the military response. A reasonable parameter value often falls in the range from 0.5 hour to 2 hours. Users can choose the value to best fit the context of their study.

- **Artificial Road**: A shapefile of artificial road network with corresponding travel speed. This is an essential part of the analysis. The artificial road is to model off-road movement, which is a commonplace in countries or regions with inferior transportation infrastructure. The artificial road shapefile data is created based on hexagonal grid. The travel speed varies from place to place by considering land cover, slope, and river system. The detailed approach for preparing the artificial road network is elaborated in [1]. In the sample data, the artificial road file is "artificial_roads.shp".

- **Road**: A shapefile of the road network with corresponding travel speed. In the sample data, the road file is "road.shp".

- **Railway (Optional)**: A shapefile of the railway network with corresponding travel speed. Note that this data is optional given some country or region may not have railway. Check the checkbox to enable it. In the sample data, the railway network file is "rail.shp".

- **End dates (Optional)**: This option enables calculating a batch of results simultaneously. If the checkbox is unchecked, the plugin only calculates one result representing the final status after all the events. But if you want some intermediate results, for example the status by the end of each year, you can check the box and input a CSV file that lists in a single column the end-dates for each period you wish to create. For example, to have the result last day of the year in 1989, 1990, and 1991. Your .csv file would look like this:

19891231
19901231
19911231

By enabling this option, the algorithm only takes the events between the earliest event until the designated end time, and calculates the territories for this time window. Note that the dates in this file must be in the format “YYYYMMDD” as it is to compare with the variable “Date_int” you created earlier.

References

[1] Ran Tao, Daniel Strandow, Michael Findley, Jean-Claude Thill, James Walsh. (2016). A Hybrid Approach to Modeling Territorial Control in Violent Armed Conflicts. *Transactions in GIS* 20(3): 413–425.

[2] Sundberg, Ralph, and Erik Melander. (2013). Introducing the UCDP georeferenced event dataset. *Journal of Peace Research* 50(4): 523-532.