Processing Updated Imagery for Use in Dismounted Mission Planning on NETT Warrior

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Abstract: Small unit leaders need real time images to aid in planning missions and making decisions. Currently, this ability partially exists through the use of short range Unmanned Aerial Vehicles (UAV) like Raven and Shadow, which provide unprocessed imagery. There is a limited capability to gather imagery for a large area, process it into a useable format, and deliver the product to the small unit leader. Android-based platforms like Nett Warrior currently use older, primarily satellite, imagery to depict the battle space. We are creating a process that takes up to date satellite and UAV imagery in a format that is available as an offline map and use the Nett Warrior platform to deliver this imagery to small unit leaders. This enhanced imagery will allow leaders to plan missions in a more effective manner due to the updated imagery and the benefits mobile maps provide.

Keywords: Nett Warrior, Route Planning, Android, Map Tiles, GeoTIFFs, UAV, Mission Planning

1. Introduction

There are many mission planning tools already available to leaders in the field. Short range UAVs such as the Raven and Shadow are now fully integrated in tactical units, however they are limited in the sense that they only provide full motion video imagery. Additionally, the geo-referencing capability of these UAVs is not mature enough to allow for the precision geo-referencing required to readily generate map products. Another tool available to leaders is Nett Warrior (NW), an Android based mission planning and execution tool. This system, a program of record under constant feature enhancement, currently uses raster imagery and digital elevation data, coupled with user input to provide useable information to the war fighter.

1.1. UAVs

Most small unit short range UAV platforms simply provide full motion video (FMV) to the war fighter. While this FMV imagery is generally helpful and is more beneficial than no imagery at all, FMV is difficult to process and use for terrain and situational awareness updates beyond the “real time” viewing of the video feeds provided. To process this FMV imagery into a product usable for most map formats, we must take periodic stills of the FMV imagery and utilize a complex work flow to geo-reference each image and account for factors including view angle. These images are then overlayed on a map and stitched together into a single image that can be used for map generation.

1.2. Nett Warrior

Smart phones on commercial networks have the capability to view their current location and a tremendous amount of map data for the surrounding area including roads, locations such as businesses and public areas, imagery, photos, routes, traffic, and other information. That level of information availability is because smart phones on commercial networks can access online servers and actively download information as needed. As Erin Connors, a lead developer for Nett Warrior

Future Initiatives (NWFI), noted in her briefing *Offline Mapping*, users in a tactical environment must be able to access maps offline because reliable high bandwidth connections are not always readily available in the field. In other words, maps must be pre-loaded and available prior to the mission.

Nett Warrior is an Android based program that provides users with enhanced situational awareness and understanding of the battle space. It is an interface that incorporates map and terrain data from satellites with tactical information to provide a usable illustration of the operating environment. It is also capable of connecting with other Android phones and loading video from external sources.

Nett Warrior, like other Android based mission planning tools, has the ability to load additional map packages. These packages can include new map sets to extend the preexisting terrain data currently loaded. There are also several different formats of map data used to augment the information provided by geo-referenced raster imagery. NWFI is working to incorporate Digital Terrain Elevation Data (DTED) into NW while RDECOM STTC sponsored work has produced a Layered Terrain Format (LTF). LTF essentially adds additional layers of terrain information over the existing map data.

1.3. Problem Statement

Small unit leaders lack the ability to readily access updated and comprehensive imagery on the Nett Warrior end-user device (EUD) in a tactical environment. The current Nett Warrior map generation workflow does not provide the ability to easily fill this capability gap. We must develop solutions to allow small unit leaders to access this updated information on the Nett Warrior platform using current ISR assets, GIS tools, and image processing commands. This updated imagery can come from either UAV or satellite sources and our goal is to create a process that allows us to incorporate that updated imagery into Nett Warrior. We will know we are successful when we provide our stakeholders with a workflow to generate updated imagery and a set of alternatives to improve the Nett Warrior platform.

2. Literature Review

Prior to exploring the workflow as a whole, it is beneficial to research some of the individual processes and components that allow this entire system to work. The majority of this benefit comes from thoroughly understanding the source and nature of the system inputs. In this case, that input is a geo-referenced image (GeoTIFF), somewhat constrained by the capabilities and availability of UAVs.

2.1. GeoTIFFs

Imagery from satellites, long range, and short range UAVs can be compiled into a single image formatted as a TIFF, JPEG, etc. The TIFF file extension stands for Tagged Image File Format. The first version of this specification was published in 1986. The TIFF file structure consists of 3 components, the file header, one or more image file directories, and other data. GeoTIFF is a file format that ties specific georeferencing information of an image to a TIFF file. GeoTIFF's are common in digital satellite imagery, aerial photos, and scanned maps. Normal images are tagged with certain reference points, most commonly the longitude and latitude of each corner and center of the image (“GeoTIFF”, 2015). Most open-source geospatial interface programs support the GeoTIFF format. It is slowly emerging as the standard file format for GIS and image processing packages due to its flexibility of storing different types of data and the scope of applications.

2.2. UAVs as Intelligence and Surveillance Assets

Unmanned Aerial Vehicles (UAVs) greatly enhance leaders' situation awareness and intelligence gathering capabilities. The demands of the modern battlefield have increased the United States Army's need for more long range UAV's equipped with intelligence, surveillance, and reconnaissance (ISR) data collecting devices. These long range UAVs provide invaluable imagery of the battlefield that not only collect intelligence, but can be used as mission planning tools. The process of collecting, processing, and distributing data to unit leaders is still evolving. Currently there is a capability gap of being able to provide near real time imagery to small unit leaders. There are short range UAVs such as the Raven and Shadow that can feasibly be tasked out to the company or platoon level to collect data before a mission. However, converting this imagery into updated geo-referenced static images required to produce map tiles or other image products that can be rendered on Nett Warrior while incorporating the existing imagery does not currently exist in the fielded version of Nett Warrior. Small non-military “mapping” UAVs such as the eBee have the capability to take images and process them into georeferenced map tiles. These tiles could be processed for use in Nett Warrior, but due to the high expense of this program required to “militarize”

this capability and the resources already devoted to military UAV platforms, this solution is somewhat infeasible given our project scope.

3. Methodology and Models

Our overarching aim is to begin with a pre-mission updated imagery request and existing GeoTIFF imagery, which can be acquired by satellites or UAV platforms, in order to provide an enhanced imagery product to be rendered on the Nett Warrior EUD. This enhanced imagery product will incorporate the updated imagery into the existing map set, possibly further enhanced with photos of the objective and other mission specific intelligence. This is accomplished by processing the GeoTIFF and other imagery into a set of map tiles and then converting the tiles into a MOMAP (mobile offline map) file. These MOMAPs are useable on the EUD and easily transferable.

3.1. Methodology

The current offline map generation tool for Nett Warrior is called Map Warrior, a Mitre developed product which manages and processes raster imagery into map tiles for efficient offline viewing. Once the tiles are created, a Mitre Python Script, momap.py, can be called to convert a directory of tiles into a variant of MBTiles map format referred to as **momap**. "The MBTiles specification is an efficient format for storing millions of tiles in a single SQLite database." ("An Open Platform", 2015).

The Map Warrior software is a local PC web service which makes calls to the free and open source Geospatial Data Abstraction Library, GDAL, distributed by the Open Source Geospatial Foundation (OSGEO) ("GDAL - Geospatial Data Abstraction Library", 2015). In order to take full advantage of all the features of the GDAL open source library with supporting tools, and to potentially streamline the map generation process, we chose to learn to build map products from the Python command line. Command line calls are very useful in prototyping the image conversion process and commands can later be joined together in scripts to perform the same functionality as Map Warrior or to implement new functionality.

We found that running the GDAL command line GDAL2TILES to tile a single GeoTIFF into Tile Map Specification (TMS) format and then import it into a MOMAP format supported by Nett Warrior to be both faster and more user friendly than dealing with Map Warrior and its overhead to create Nett Warrior map products.

Once we had baselined a geo-image command line workflow which could generate Nett Warrior map products utilizing OSGEO's GDAL2Tiles and the momap.py import script, we explored different alternatives which would facilitate streamlined processing of recent images, possibly from a UAV flyover, into imagery products which could then be rendered on Nett Warrior. We learned that it is also possible to separate the GeoTIFF into its imagery component and its geo-reference component.

The OSGEO command **listgeo** provides the ability to list and capture the geo attributes of a GeoTiff images while **geotifcp** can be used to apply geo-referenced metadata to a standard (non-geo referenced) TIFF ("GeoTIFF", 2015). These commands enable us to modify the original base imagery itself prior to processing it into tiles and MOMAPs. The main advantage of doing this is the ability to add additional information using standard editing tools such as Photoshop or GIMP to the GeoTIFF imagery or to include other images on top of the existing imagery.

Once the baseline imagery is edited with this recent imagery and supporting metadata, the original geo-referencing can be re-applied to this newly enhanced composite image as long as the original image's pixel width and height geometries are unchanged from the original GeoTIFF. For example, if we have ground-level photos or recent UAV photos of a target area, we can place those photos on the original imagery and re-apply geo-referencing using listgeo/geotifcp. The end result of creating these Enhanced Mission Planning (EMP) Imagery products is to see the entire objective on the EUD and then zoom in one layer and see additional photos of the objective from different angles and perspectives similar to a Google "street view". This new EMP GeoTIFF is then tiled and converted to a MOMAP in the same process as a non-modified GeoTIFF.

This is an entirely new capability which we have prototyped and propose for Nett Warrior. In all cases, the MOMAP is uploaded on the EUD through either a hardwire connection or a SD card as map sets are currently loaded now. This EMP GeoTIFF approach allows the user to selectable access to both the original mission execution map sets and utilize the updated and/or modified imagery on their Nett Warrior platform with mission specific information including "street view" or aerial perspectives of the objective for example.

3.2. Models

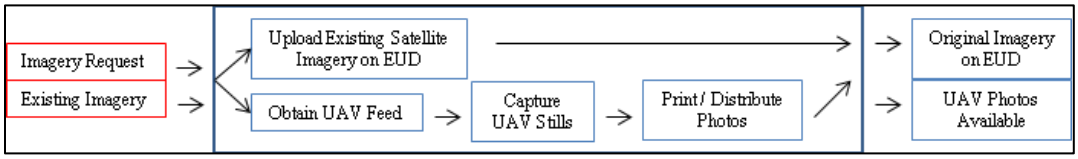

Figure 1. Baseline System Boundary Diagram

The system described in Figure 1 above is what already exists. When a leader is planning a mission, they can request imagery and might receive it if available. The imagery they may receive consists of the original satellite imagery for use on the EUD and still aerial view photographs taken from a UAV.

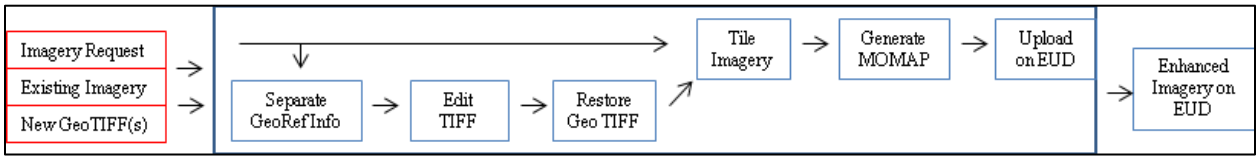

Figure 2. New System Boundary Diagram

The system we have created is described in Figure 2 above. Now, a new GeoTIFF is developed by processing UAV photographs. This GeoTIFF is used to update the existing satellite imagery. Additionally, we can modify the photo itself to contain additional photo thumbnails or to mark it up with additional information. The final enhanced imagery will be a composite of satellite and UAV imagery with modifications made by the user. An expanded view of this system, to include the generation of the input imagery and the distribution of the output MOMAP is described by the operational view (OV-1) below.

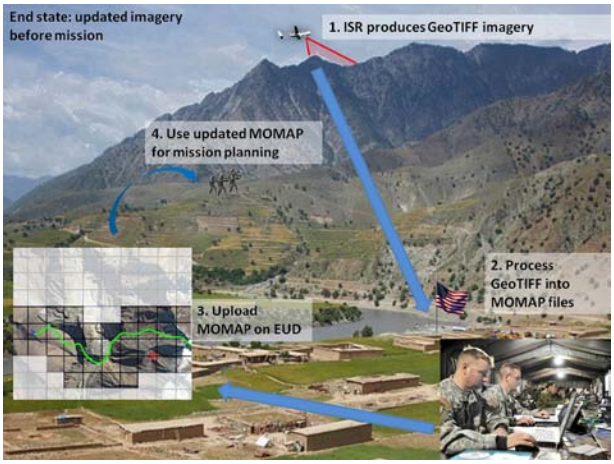

Figure 3: Operational View – 1

In practice, a small unit leader, upon receipt of a mission, would request updated imagery for his objective. That request, assuming resources are available, would cause a short range UAV to be deployed to capture images of the objective area. These images would have to be geo-referenced and processed to minimize distortion. If a UAV is not available, the most recent imagery captured could be used. In either case, the imagery is then converted into map tiles for the various zoom

levels (typically 8-18) through either MapWarrior or a command line process. Then, the tiles are compiled into a MOMAP for transfer to the EUD (Offline Mapping, 2012).

The guidelines used to judge the success for our Capstone were whether we were able to create a system that allows small unit leader's with better capabilities to view the terrain pertaining to their mission routes and objectives. In order to provide these small unit leaders with better imagery, we recognized that map tiles were better sources of visual aid rather than plain aerial imagery that UAV's provide.

Therefore, we wanted to find a way to take UAV imagery and create map tiles in a quick and efficient manner, so small unit leaders could receive a mission, send out a UAV, and have map tiles of the terrain pertaining to their mission within hours. We set the accomplishment of this task as the basic guideline that we needed to achieve in order to grant success for our Capstone. Fortunately, we were able to take aerial imagery and convert it into a map tile in a timely manner, so were able to accomplish our baseline guideline for success.

4. Results and Discussion

We found that it is feasible to provide an operational solution to the small unit leader that will enhance the leader's mission planning capability and gain greater situational awareness. This is best achieved through the use of recent imagery obtained through short range UAVs such as the Raven or future improved models. This imagery should then be compiled into a GeoTIFF of the area of interest which can quickly be processed into a MOMAP by two command lines.

4.1. Results

We have developed a set of useable workflows to facilitate the aforementioned process. These provide options to decision makers and stakeholders to best accomplish their objectives. For instance, if a small unit leader just needs updated imagery quickly, they can use the more simple workflow that just creates map tiles and then develops a MOMAP. However, if the client needs to add to the imagery or compile multiple images together, they could use a longer workflow that allows them to edit the TIFF and then tile the images and generate enhanced MOMAP with additional mission critical information. Furthermore, if the desired end state is simply to have additional imagery taken from aerial platforms or the ground, a workflow could be adapted that provides these images in a scroll bar or thumbnail format on the EUD.

To test this process, we collected current satellite imagery of the USMA reservation and used this imagery to update existing Nett Warrior MOMAPs. Furthermore, we edited this updated GeoTIFF by superimposing aerial imagery of a hypothetical objective, the USMA Library. This enhancement can be seen in below. We are now able to efficiently create Nett Warrior map products for the entire USMA reservation and training areas from freely available recent satellite GeoTIFF imagery in a few hours. This process will be utilized to support the map products required for the USMA Cadet Leader Development Training Nett Warrior experiment during the summer of 2015.

We began with the TIFF of the USMA reservation we used to update the existing Nett Warrior MOMAP. This imagery was taken in January 2015. In our case study, we used the USMA Library, Jefferson Hall, as a hypothetical objective. Figure 4 below is this same TIFF as Figure 4, but zoomed in on this hypothetical objective. The Jefferson Hall is easily identified on the enhanced imagery which is now viewable on the current NW platform since the original geo-referencing was "restored" to the enhanced image.

This imagery is more helpful than computer generated imagery or a basic military map, however, if one was planning a raid or other operation on this objective, there is much more information that could be helpful for mission planning. After collecting additional ground or aerial imagery of the objective, we can use photo editing software to enhance the TIFF that can be merged with its original geo-referencing metadata and processed for use in Nett Warrior. This enhanced imagery is shown below in Figure 5. Note both imagery sets (original and enhanced) are still available to the small unit leader as he zooms from a 2D overhead view to an enhanced perspective providing detail of building access points and windows.

Figure 4: Jan2015 Jefferson Hall Objective (un-enhanced)

Figure 5: Enhanced TIFF of Jefferson Hall objective providing detail to entry points and windows.

4.2. Future Opportunities

The enhanced imagery alternative explained above has the photos overlaid on the satellite imagery. This processing is done by changing the imagery itself and converting that imagery into a MOMAP. Another possible way to provide ground or aerial photos of the objective to the user is by showing those photos in a scroll bar on the bottom of the Nett Warrior screen. This is achieved by changing the coding of Nett Warrior, not changing the MOMAP itself. We have not actually coded this yet, but photos of this concept are below.

Figure 6: New Nett Warrior view

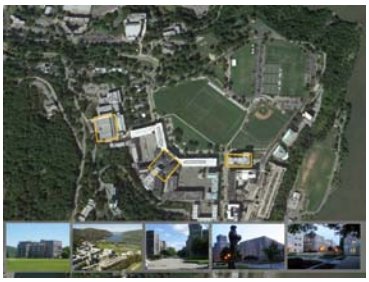

Figure 7: Scroll bar opened

Figure 8: Full size image selected

In Figure 6 above, we see the alternative view. There are gold boxes indicating zones with additional imagery. In this example, these zones are Jefferson Hall, Washington Hall, and Arvin Gym. By clicking on one of these zones, the user would open a scroll bar that contains the additional imagery as shown in Figure 7 below. Then, by selecting an individual image, the user would be able to see the full size image as shown in Figure 8 below.

4.3. Conclusion

A capability gap existed between the current workflow, which only provides the original satellite imagery and separate aerial photographs, and the desired capability to provide users with updated imagery incorporated with the Nett Warrior map set. This EMP imagery will give users increased situational awareness and facilitate improved mission planning. We have developed a process that allows mission planners to update their imagery prior to the mission and make that imagery available on Nett Warrior. Furthermore, we can enhance the product to include ground or aerial imagery, or other similar information on the objective, and make those products also viewable in Nett Warrior. These tools have the potential to support the mission planner prior to the mission and greatly enable the war fighter in the execution of the mission.

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