Monrovia E2E Drone - fAIr - FMTM Pilot

We are using fAIr to digitize an area in Monrovia, Liberia in collaboration with the local Liberian team and WNAH, from drone imagery that we're acquiring immediately in advance of a household enumeration project using the HOT Field Mapping Tasking Manager by a partner, Slum Dwellers International.

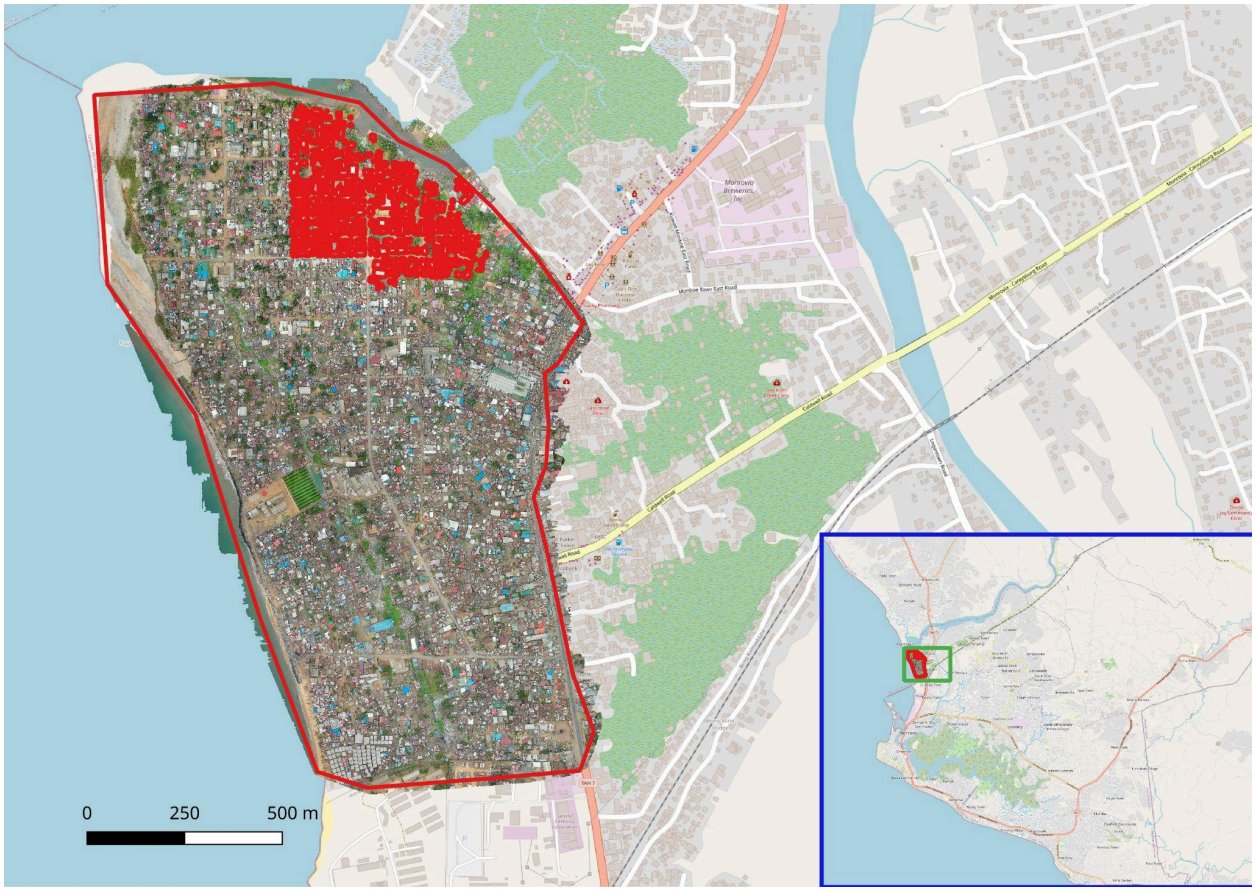
This is a key example of the End-to-End (E2E) community mapping process in which all aspects of the mapping are done by the community using locally-accessible tools.

Context

Slum Dwellers International is doing a large (60 people in the field for 3 months) funded (World Bank) project doing house-to-house enumeration surveys in a key context for the HOT West and North Africa Hub (informal settlements in Monrovia). We have *not one but two* sets of 5 cm resolution drone imagery, dating from 2019 and 2024 (February 27-29, done with a local Mavic 2), quite well georeferenced to one another.

Two sets of 5 cm resolution drone imagery in the same location, five years apart

The area is 1.5km², and contains roughly 6,000 buildings (we initially digitized 650 buildings in a sub-area of 0.17km², so by extrapolation the whole area should contain about 6k buildings).



Area overview showing the extent of 2014 drone imagery and initial manual digitization

We don't often have good, extremely recent (a few days old) drone imagery, exactly where a field team is working on a project for which digitization is a key requirement. It's an unusual and exciting opportunity.

Digitization by the local Liberian team at 1:800 scale (above) and 1:300 scale (below)

Need for digitization

The Liberian team is doing household enumeration surveys, and have been trained using the FMTM to locate each precise building on the map, select it, and complete a detailed form that resembles a long-form census. There is a lot of value in the addition of the building selection; it ties the data to a specific structure, vastly reduces (practically to the point of elimination) duplication and missed structures, and creates a powerful advocacy tool for the local residents seeking better recognition and services for their community.

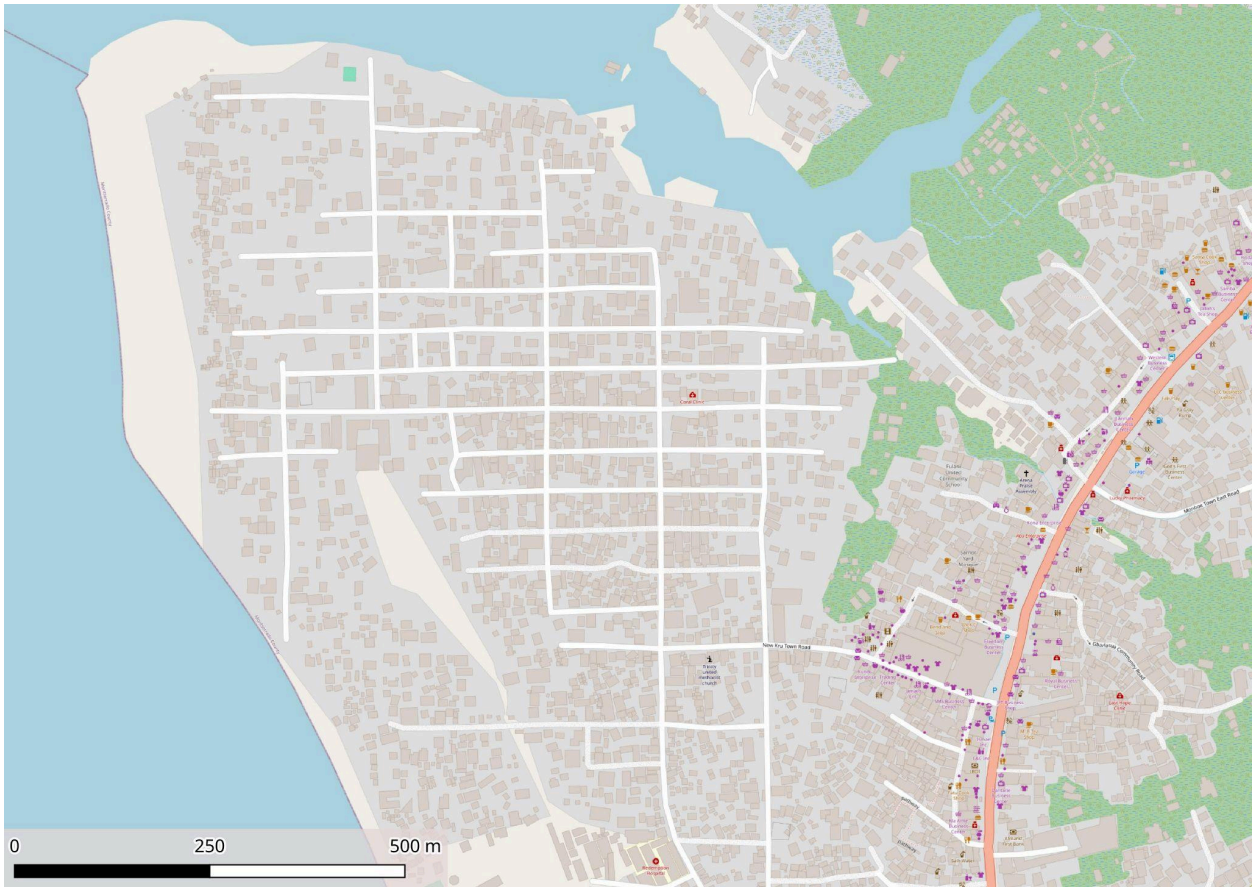
Selecting a discrete building from typical OSM digitization is difficult; most of the time there's not a great 1:1 correspondence between building footprints and actual structures. With the digitization seen above, the local mappers are—for the most part—easily and accurately locating and selecting the appropriate buildings.

However, there's a lot more area still to be covered, and this is a great opportunity to use fAIr in collaboration with a local community.

Undigitized area at 1:300 scale; most of the AOI looks a lot like this and needs digitization

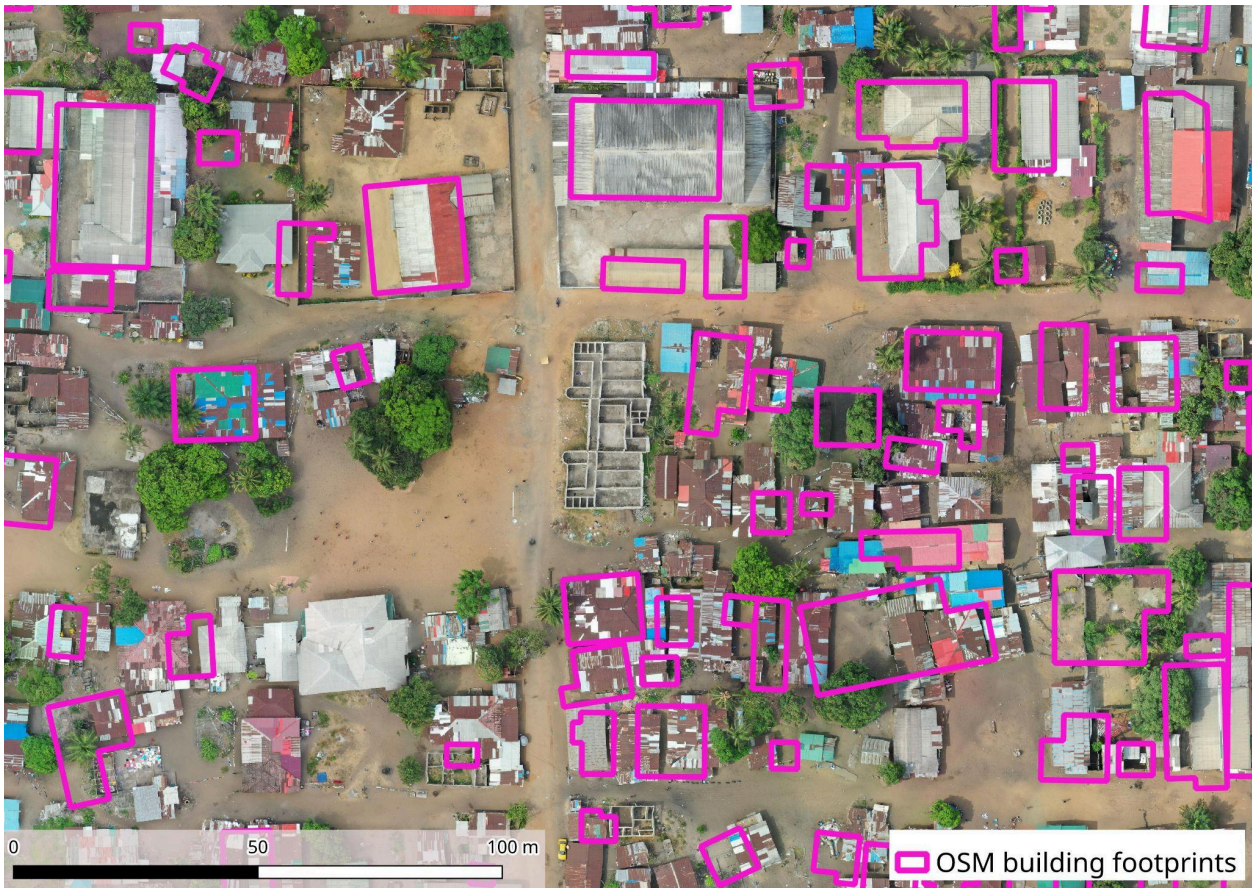
OSM building digitization is not fit for field mapping purposes

The existing digitization in OpenStreetMap doesn't actually match the buildings on the ground very well. This is fairly typical; building footprints in OSM often don't match the individual structures on the ground in a 1-to-1 correspondence, particularly in informal settlements which change rapidly, are densely packed, and often aren't covered with high-resolution imagery.



A cursory glance at the OSM coverage for this part of Monrovia (New Kru Town) would seem to indicate that it's "complete," at least in the sense that the area is full of digitized building footprints. Unfortunately, a closer look reveals that it's not as good as it may seem.

Buildings are quite visible and clear in the drone imagery. When we overlay the OSM digitized building footprints, we immediately see that many buildings are missed, and the footprints that do exist don't match the visible buildings very well. For field mapping purposes, a mapper needs to arrive at a building in the real world, identify its corresponding footprint, select it, and proceed with their survey. When the footprints don't match the buildings, this is impossible. A few mismatches are tolerable; a missed building here, a group of buildings digitized as a single structure there, or an offset footprint that's near but not precisely aligned with the actual structure are OK. But in the case of New Kru Town—and the majority of informal settlements around the world—the correspondence between buildings and OSM digitized footprints isn't better than 50%. We need to do better to support selection of buildings for addition of local information attributes in the field using mobile data collection.



The existing digitization of Monrovia's informal areas in OpenStreetMap is not fit for purpose for field mapping. The correspondence between structures and polygons is not close enough.

There's a great deal of change in 5 years. In this typical small area of New Kru Town in Monrovia, six structures have been demolished, five have been newly constructed, and most have changed some or all of their roofing material.

We do not often have sets of similarly-georeferenced, high-resolution imagery from different times in exactly the same location. Urban changesets are a product in massive demand from many data users (not to mention donors) and we have very few practical opportunities to generate them at this high a resolution and quality level (note that the 2014 imagery was acquired using a cheap DJI Mavic 2 belonging to a local person, not with an expensive mapping-specific drone, but it was done using the best practices from HOT's experience gather local drone imagery with inexpensive devices).

Once a model is trained from the more recent 2024 imagery, it can almost certainly be run again to generate building footprints on the 2019 imagery with no modifications at all (it's literally mostly the same buildings), giving us what will likely be one of the first practical uses of AI to quantify change in informal urban areas.

Roles

Team roles

- The fAIr team (Omran and Kshitij) to take the lead in creating a model from the existing digitization and determine what more is needed (there are probably still areas that need more work before the predictions are good across the entire area)
- The WNAH to allocate some staff/volunteer time to supporting digitization where the fAIr team indicate it's needed
- The FMTM team (Ivan, Sam, Susmina) ensure the results are used in the field in FMTM
- Special Project Advisor (Pete) to ensure the partner orgs and community understand what is happening and that the work supports their goals

Challenges

Time sensitivity

We need this done quite quickly, since a major FMTM deployment depends on having good digitization.

To be clear, we could get this all done manually, but that would be a lost opportunity to showcase operational value from fAIr as well as the time-series changeset

OSM integration of digitization

The digitization so far has not been done in OSM (no time to workout how fAIr integration affects organized editing guideline compliance, and the integration of OAM/TM/fAIr/FMTM is not ready, ongoing development work), so for now we need to work from GeoJSON digitization that's been done in QGIS. The current plan is to do conflation after the digitization and field work is done.

Overlapping buildings

There are a lot of overlapping buildings. By which we don't mean bad digitization, we mean *the buildings actually overlap*; many smaller buildings are partially beneath the overhanging roofs of adjacent buildings. We have no idea how that affects fAIr, nor do we know how to deal with the OSM quality checks that often consider overlapping buildings to be digitization errors rather than reflections of the reality of informal settlements.

Overlapping roofs in a close-up view of a cluster of shelters

Resources

Imagery

Here's the new drone imagery from February 27-29, 2024 on OpenAerialMap (direct link):
https://map.openaerialmap.org/#/-10.78984022140503,6.373284641328655,15/user/6268de8f59de8f00070b32aa/65e4bb85e6f8d4000128235b.tif?_k=ot54j8
And here's the TMS:
https://tiles.openaerialmap.org/65e4bb85e6f8d4000128235a/0/65e4bb85e6f8d4000128235b/{z}/{x}/{y}

Here's the old drone imagery from sometime in 2019 on OpenAerialMap (direct link):
https://map.openaerialmap.org/#/-10.794764757156372,6.3746707682978965,16/square/033330220323021211/5dee77e79c3b1700059a3593?_k=7opt9q
And here's the TMS:
https://tiles.openaerialmap.org/5dee66e89c3b1700059a3590/0/5dee66e89c3b1700059a3591/{z}/{x}/{y}

Manual digitization footprints

Here's a GeoJSON of the digitization done so far (GDrive link with permissions set to "anyone with the link can comment"):
https://drive.google.com/file/d/1osXfi5Gpn763agNqzmn5NzzafX66yvjm/view?usp=drive_link

AOI

Here's a GeoJSON of the Area of Interest covered by the new drone imagery. The old drone imagery covers a much larger area, in fact nearly the entire city of Monrovia, but the key area here is the bit with both old and new imagery (Gdrive link with the permissions set to "anyone with the link can comment"):
https://drive.google.com/file/d/1_KWntQI3wEsL0oBnLI036CVA0_BEeJaV/view?usp=sharing

Data Collection Form

Here's the OpenDataKit survey form (in FMTM format with a Select from Map question and some special sauce that makes an ODK form work with FMTM), primarily designed by SDI International but modified by the local Liberian team with support from HOT (only in terms of architecture, not content; the actual data is the same but the flow of questions is optimized for effective field work).
https://docs.google.com/spreadsheets/d/1l3OfIjt9gLbe0QcSrmdnldNZPKQ8GHILCja3fqDY3xo/edit?usp=sharing

Note: this is a remarkably well-designed data collection form, likely useful to other communities.