Forecasting forced displacement through agent-based simulation

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Background

Question: How accurately can we forecast forced displacement volume and geographic distribution using an agent-based modelling environment?

Response:

The FLEE environment appears to forecast forced displacement volume and geographic distribution with moderate accuracy.

Motivation: Accurate predictions would enable humanitarian organizations to better prepare

Recent Work: agent-based modelling framework FLEE Suleimenova et al (2017)

Contributions:

1) Establishing benchmarks for simulation parameters by optimization.
2) Extension of FLEE from initial to protracted displacement.

Data Sources

Case study: Iraq 2017-01 to 2018-04

International Organization for Migration Displacement Tracking Matrix Reports

- Twice monthly census of displaced people
- Rounds 84 to 91 (2017-01-05 - 2018-04-30)
- Training on rounds: 84-89
- Testing on rounds: 90-91

Armed Conflict Location and Event Database

- Reports of violent incidents
- 2017-01-01 to 2018-04

Geodata from the UN Office for the Coordination of Humanitarian Affairs

- Settled locations, districts

Methods

Modelling Environment:

- FLEE agent-based modelling environment

Locations: centroids of 18 regions

Distance: Euclidean distance between centroids

Initial Population: Existing IDP population as of 2017-01

Parameter optimization:

- Basinhopper
- Basic minimizer
- Heuristic optimization as in Suleimenova et al (2017)

Objective Function:

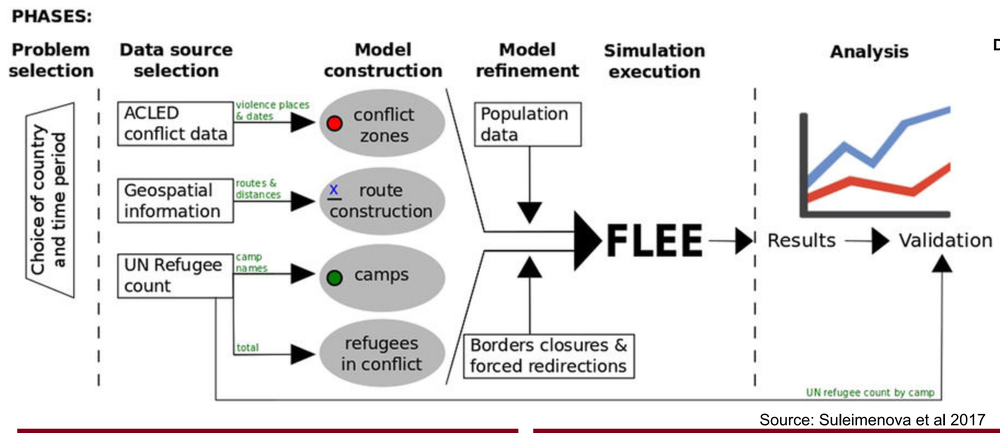
- Simulate 5 rounds (2.5 months)
- Return: Mean Absolute Scaled Error (MASE), averaged across regions

$$MASE = \frac{1}{T}\sum_{t}^{T}\frac{|pred_t - real_t|}{\frac{1}{n}\sum(|real_t - real_{t-1}|)}$$

Testing:

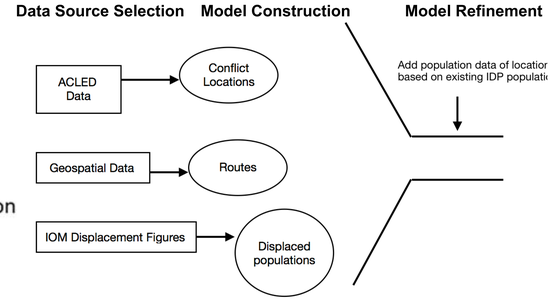
- Simulate rounds 90-91 with optimized parameters
- Calculate Mean Absolute Scaled Error

Original FLEE Environment

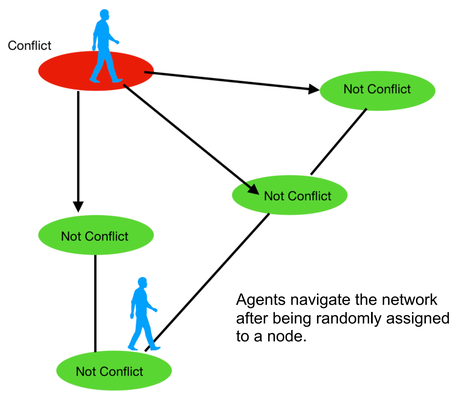


Source: Suleimenova et al 2017

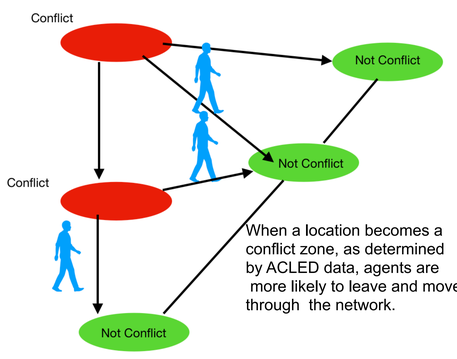
Modifications



Simulation Step, time = t



Simulation Step, time = t + 1



Results

MASE of approximately 0.6 across all optimization methods.

- 40 % improvement over assumption population stays the same
- Compare to ~25% in Suleimenova et al (2017).

Heuristic Optimization offers comparable performance to algorithmic optimization.

Conclusion

1) Parameter optimization does not offer substantial improvement over simple heuristic optimization.
2) The FLEE environment is moderately robust across initial and protracted displacement scenarios.

Limitations

Missing Data: Counts for the test data were missing for some governorates. Baseline figures from the initial training round (84) were used as replacements in testing.

Distance Metric: Implemented using euclidean distance, whereas Suleimenova et al (2017) implemented using estimated travel times via Bing Maps.

Next Steps

- Simplify and diversify the modelling environment's decision rules (currently based on the gravity model).
- Validate against alternatives such as random walks and Markov models.

References

Suleimenova, Diana, David Bell, and Derek Groen. 2017. "A Generalized Simu- lation Development Approach for Predicting Refugee Destinations." *Scientific Reports* 7 (1). Nature Publishing Group:13377.