Optimal Area Monitoring: Line-of-Sight Viewsheds in Parallel

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Securing an Area

Fixed towers with sensors can be important assets for monitoring a large land area, but obstructions and terrain can make it hard to calculate and optimize the combined effectiveness of a set of towers before construction. Presented here is a method that uses the line of sight and probability of detection of each tower and yields one number to objectively measure their performance: number of distinct viable paths from a start line to an end line. This number can then be used as a function for optimization of tower placements.

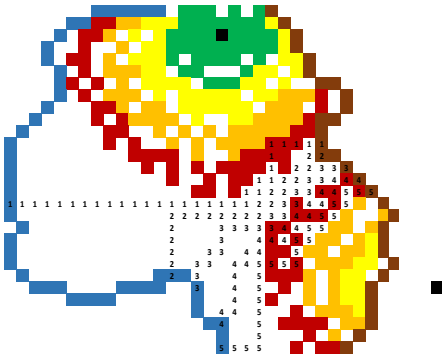
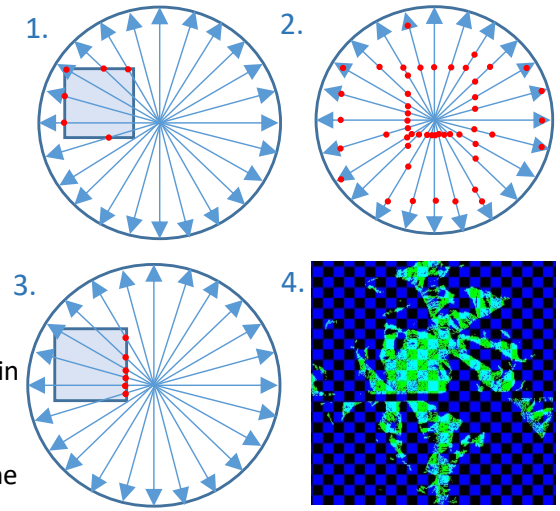


Fig. 1 *Terrain with 5 viable paths from the blue starting line to the brown perimeter. The towers in black have detection probability shown with colors: the highest probability is green.*

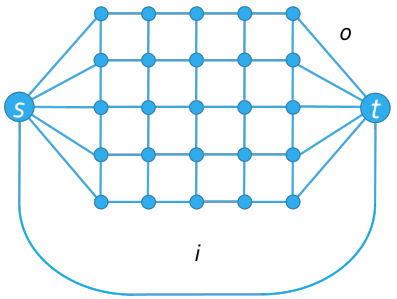
Parallel Line of Sight Calculation on GPUs

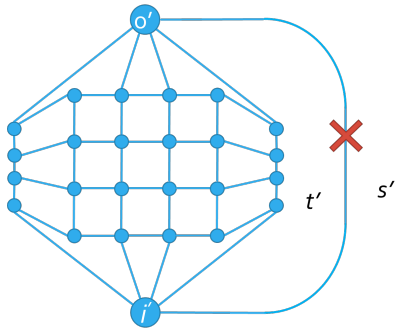
1. Define a set of rays emanating from each observer
2. Split the terrain into rectangular tiles
3. Calculate maximum slopes within every tile for every ray for every observer
4. Assign to all tiles the largest slopes encountered before reaching them.
5. Calculate the line of sight within each tile for all observers and combine them
6. Combine tile results to form the line of sight viewshed



Calculating Distinct Viable Paths

1. Define a movement graph based on the terrain grid
2. Connect start line to start node *s* and end line to end node *t*
3. Assign edge weights based on -log(P_D). Find the shortest distance from *s* to all nodes
4. Assign new edge weights, 1 if a viable path exists from *s* to the node, 0 otherwise
5. Calculate the dual graph
6. Calculate the shortest path from node *o'* to node *t'*. The weight of this path is the number of viable paths





Conclusions and Further Work

Line of sight viewsheds were efficiently calculated for dozens of towers on a terrain with on the order of 10^8 cells. Distinct viable paths were calculated from these. Now the BayesOpt Bayesian optimization library is being used to optimize tower locations.

Optimization of multiple tower locations, heights, and technologies under a budget limit is the overall goal for the future.

References

1. Larsen, M. V., 2015, *FFI*, 01300, 129
2. Osterman, A., et. al., 2014, *IJGIS*, *28*(11), 2304–2327