

WWW.MWFTR.COM Charles Kim

UAV Navigation by Cellular Automata Approach

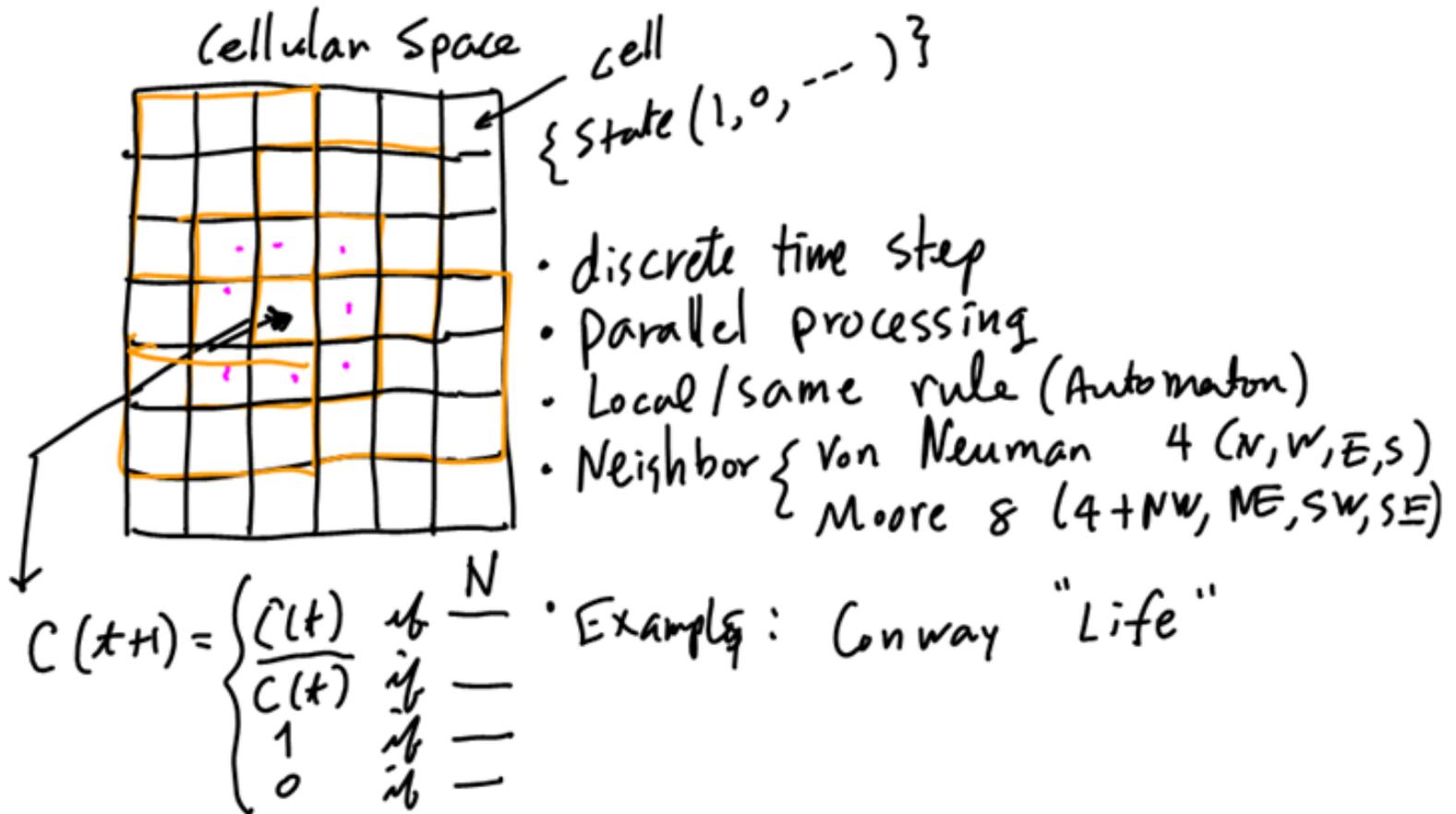
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Cellular Automata

Cellular Automata.



Cellular Automata Applications

Uses of Cellular Automata

2

- ① Biological Modeling & Simulation
(ex) Conway's Life
- ② physical process modeling (Non-Linear Behavior)
 - gas diffusion
 - Molecular Behavior
- Image Processing (low level)
 - Image Enhancement — Noise cancellation
 - Border detection
- Architectural Lighting Control

Related Works

- Use of Cellular Automata in Air Space for Collision Avoidance and Autonomous Flight. (FAA sponsored Research)

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- Grid — NAS
- cell — space for an autonomous aircraft
- GPS & Transponder for "State" I/O
- SRC → DST (Collision Avoidance)



- Weather Dynamics & No-fly zone Considered

First Approach of Navigation

Use of Cellular Automata in Route Planning & Navigation ④
A. Scaled Down (2-stage) Appr. (ANT)
pheromone

(1) Map \rightarrow Low-level Image Processing

\rightarrow Binary Map as Cellular Space of (100×100)

(2) Scaled Down Map (by 5) $\rightarrow (20 \times 20)$

(3) Route Finding

① general Direction
by $\frac{DST}{SRC}$

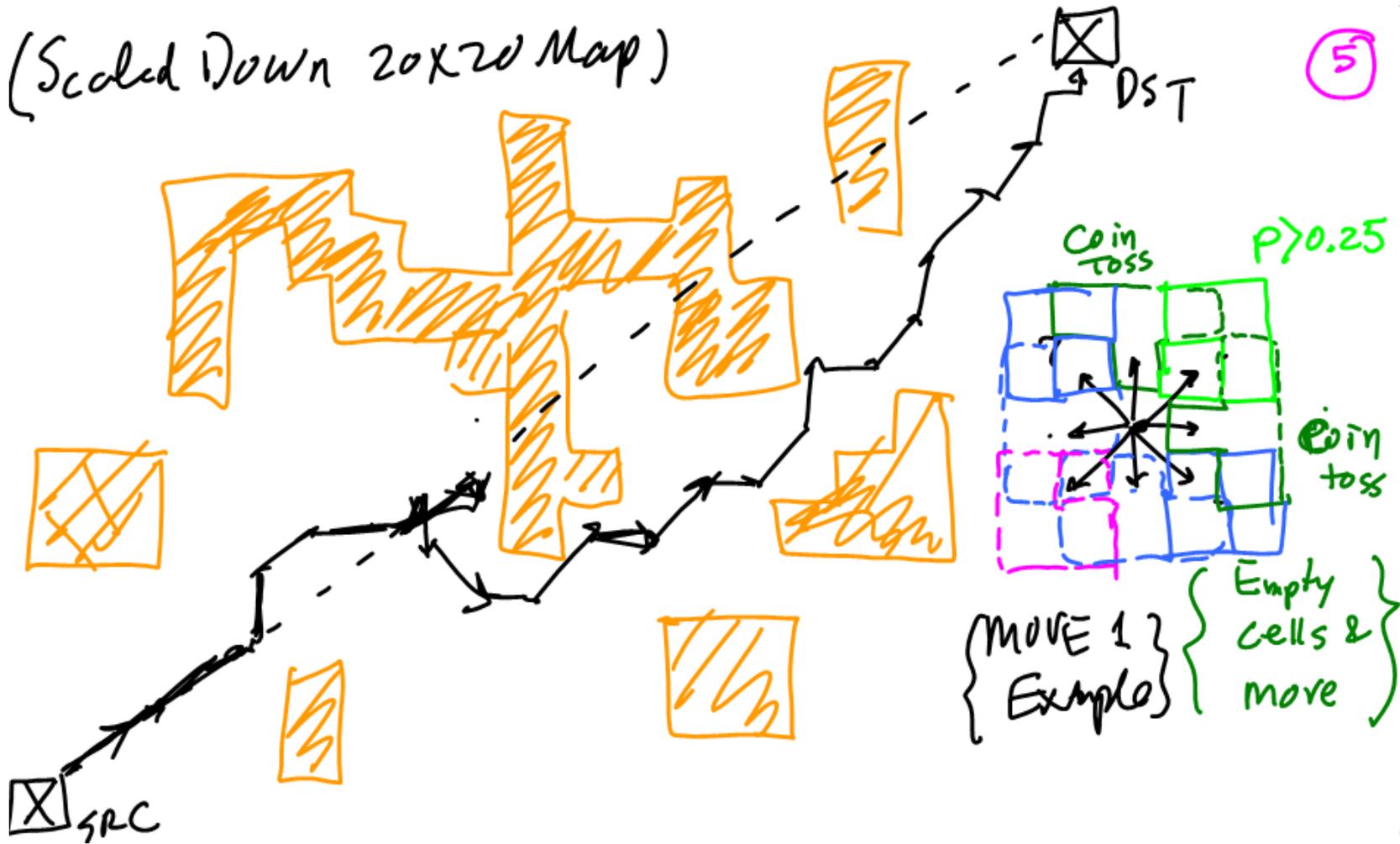
② Move (Occupation)

☒ SRC

☒ DST

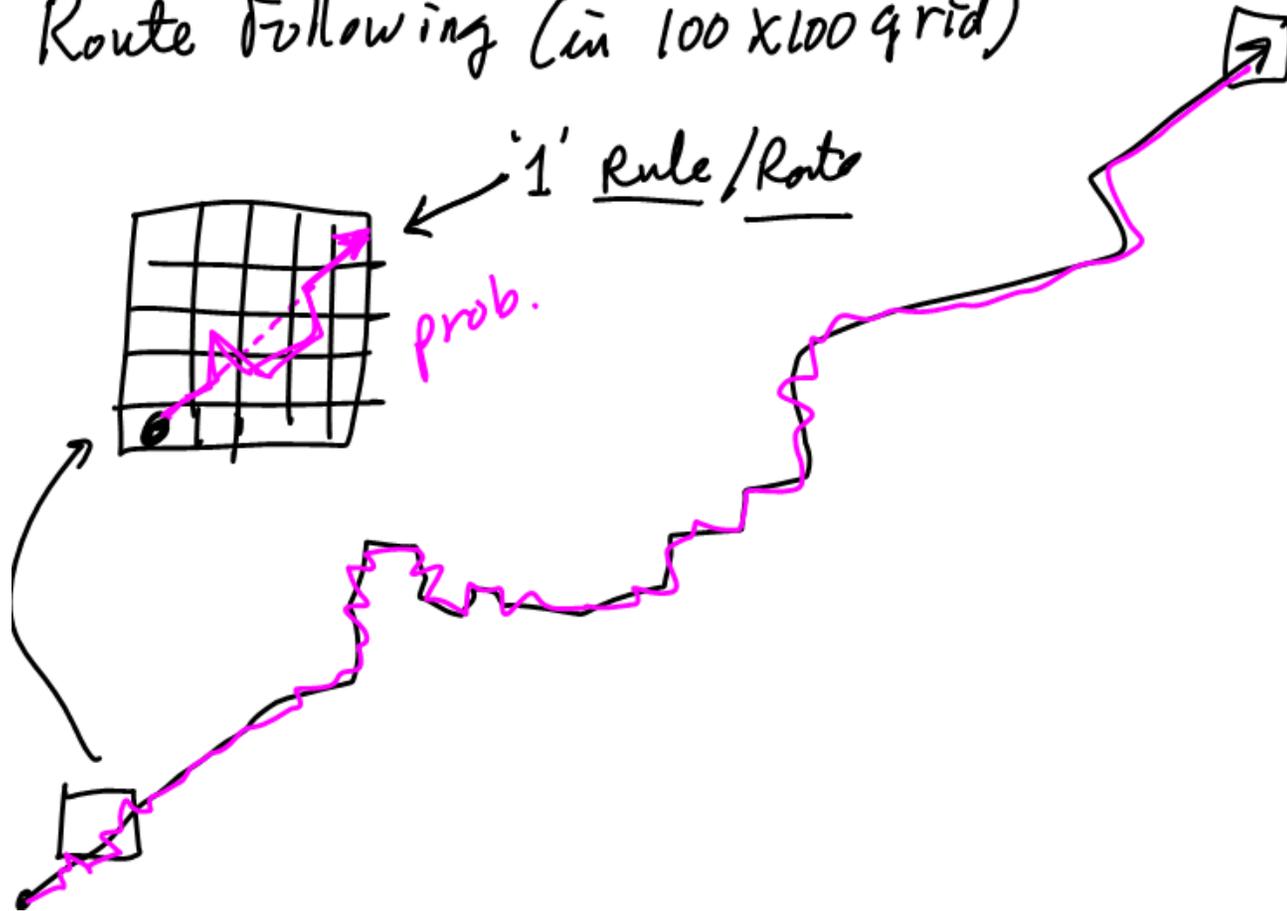
UAV Movement Example

(Scaled Down 20x20 Map)



Route Following

Route Following (in 100x100 grid)



6

Another Approach

B. 1-Stage Approach (100 x 100 grid)

⑦

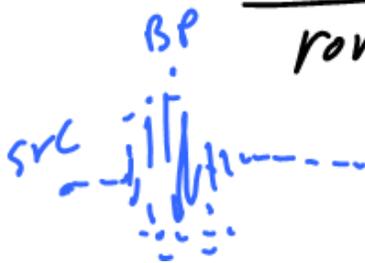
1. Cellular Space (src, dst, & obstacles)

2. From Src → "Base Camp" location
by "breeder", "gun shot", or
"diffusion" Cellular Automaton



why?

Change of the Start location determines the route finding success/failure.



Why Base Camp

3. Find ⁹Complete Routes by the
Base Camp Points as different starting points.

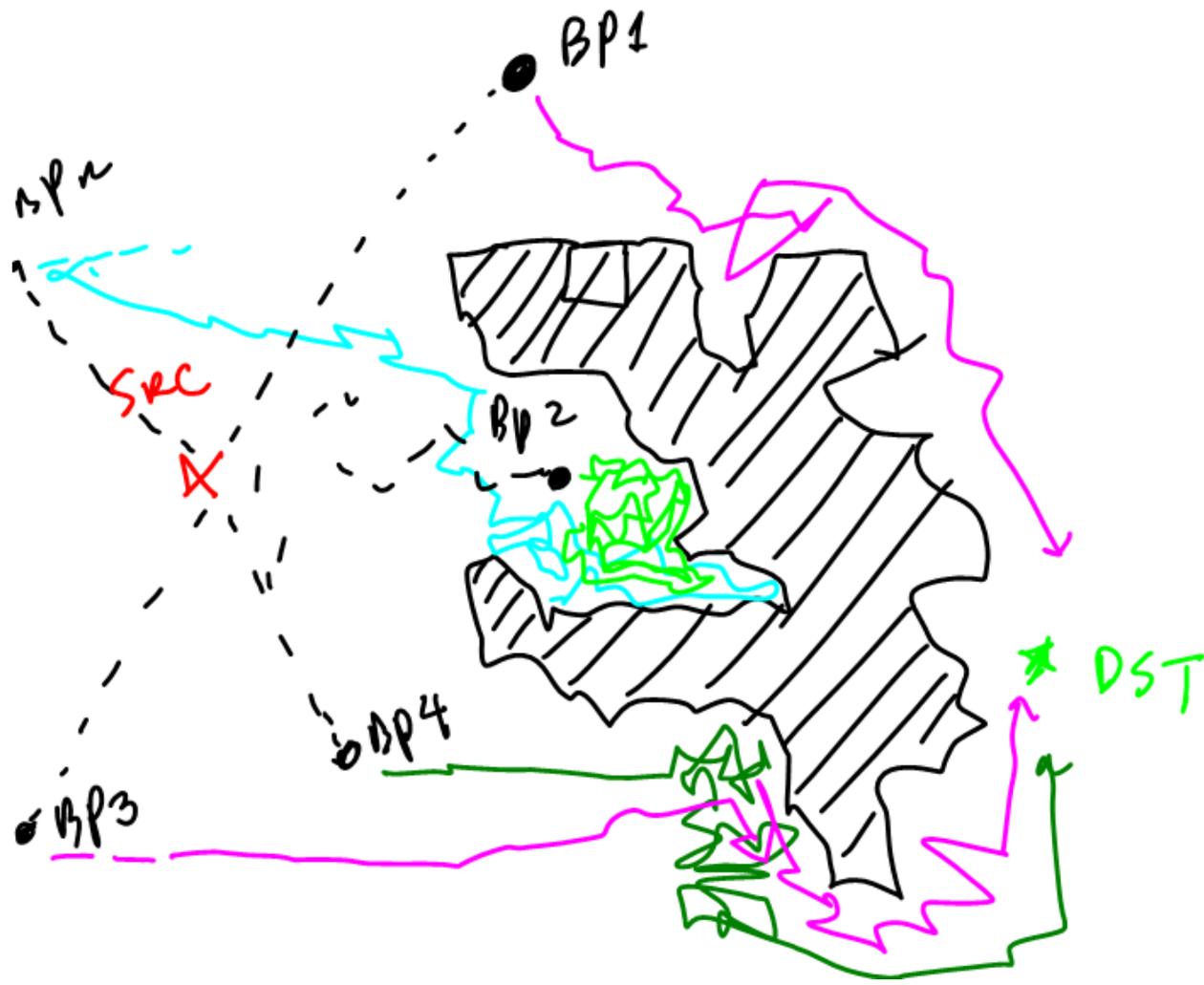
8

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Effect of Base Camp

9



Completion of Route

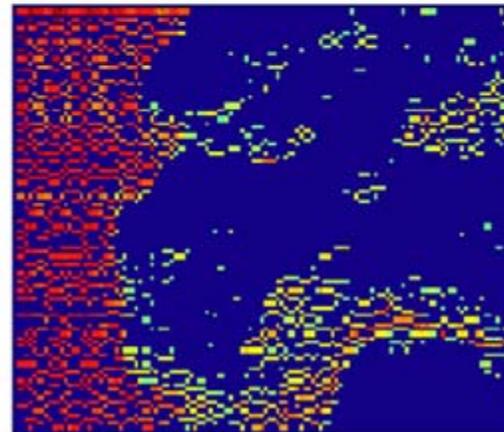
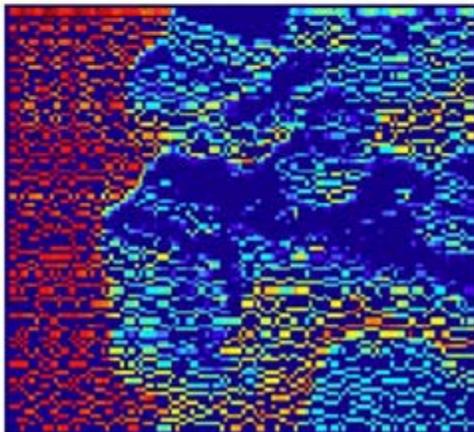
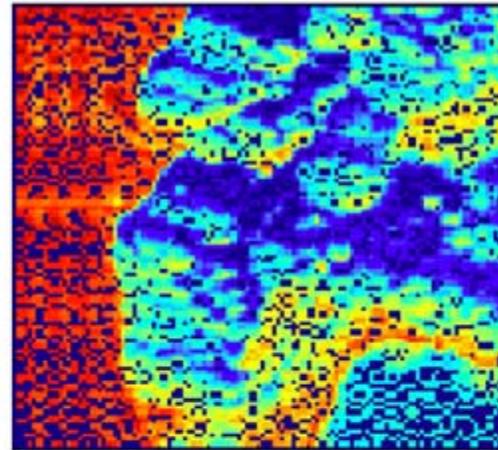
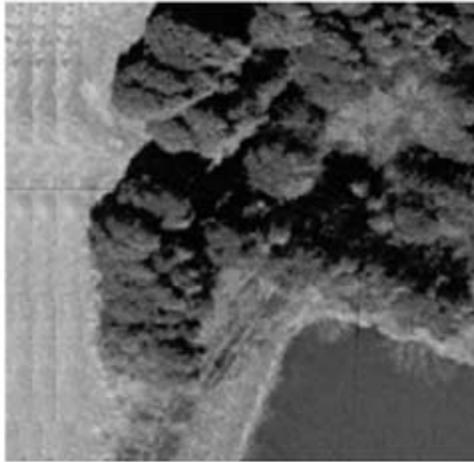
3. From a complete route,
→ Construct a Route

10



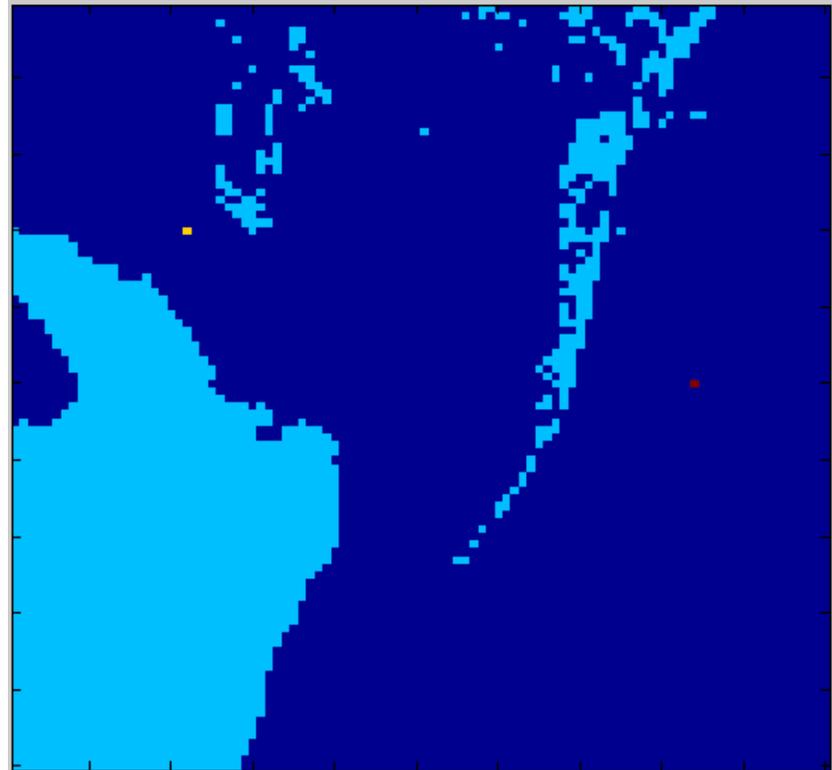
Low-Level Image Processing Example

– CA Approach



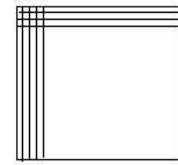
Demonstration

- Simple local rule converts the scene into 2 zones: obstacle & obstacle-free.

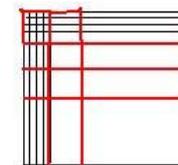


2 Approaches

- Approach 1
 - Meta-grid
 - Path finding on Meta-grid
 - Navigation of the original grid
- Approach 2
 - Path finding on original grid
 - “scouting out” or “base camping” from the SRC
 - Navigation from the Base Camp to the DST



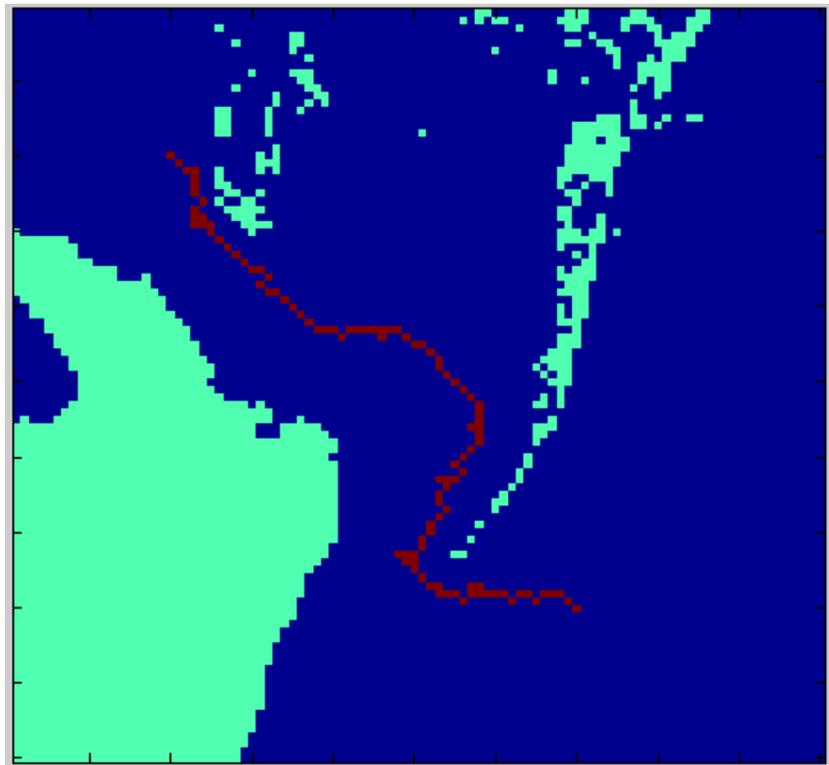
100x100 grid



20x20 grid

Approach 1

- Step 1
 - Best Route on Meta-grid
- Step 2
 - Route following navigation on original grid



Approach 2

- Step 1
 - Base Camping Out from Source
- Step 2
 - Route Finding from Base Camp to Destination

