3D Path-finding in a voxelized model of indoor environments

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Current work

- Trying to find a model representation or method suitable for
  - different sized actors (width & height) with
  - different mode of locomotion (walk, drive, fly)

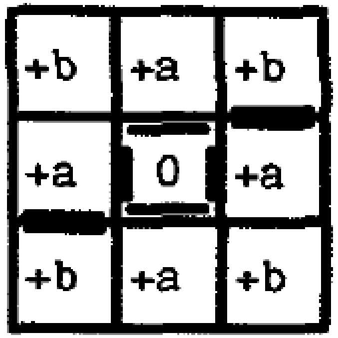
- Utilizing distance maps

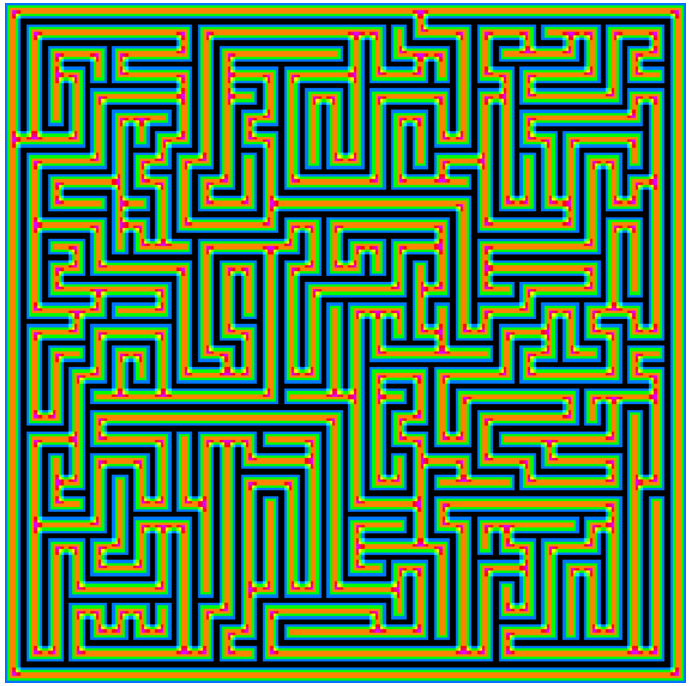
Topics

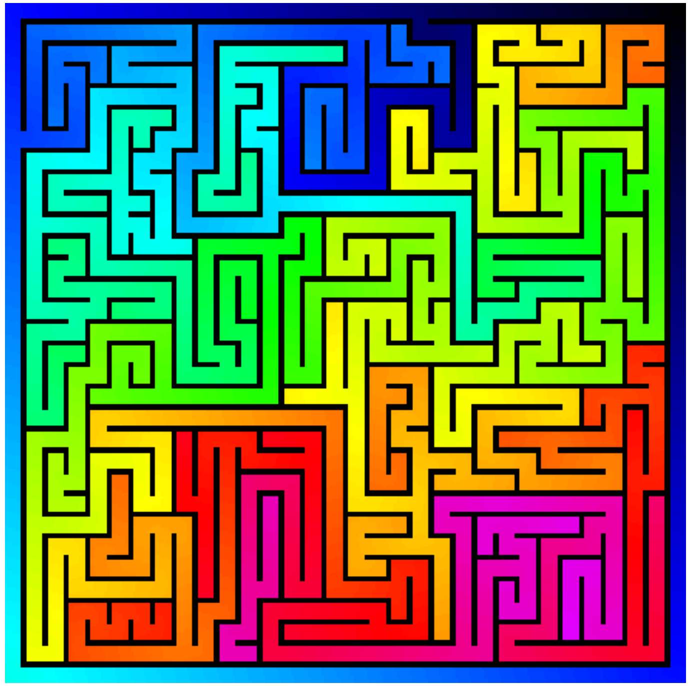
- Distance transform
- Path-finding with distance transform
- Slope estimation of ground voxels

Distance transform

- Flood Fill
- Borgefors
  - 2 passes
    - Forward pass
    - Backward pass
  - Similar to convolution filter
  - Propagation of the distance value (recursive)
- Dorst
  - Towards one point
  - More than 2 passes

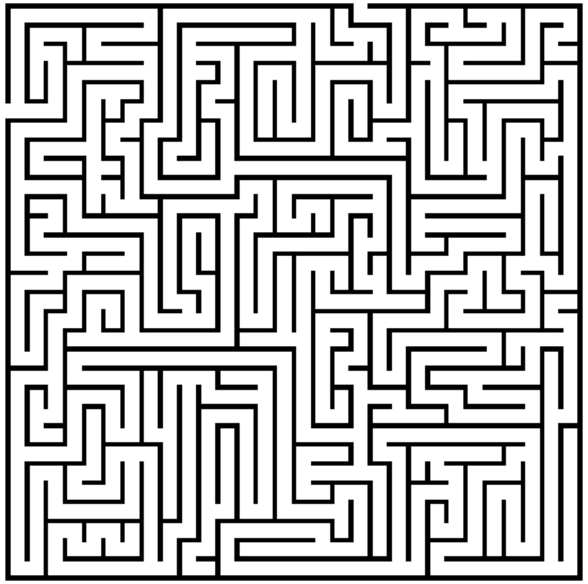




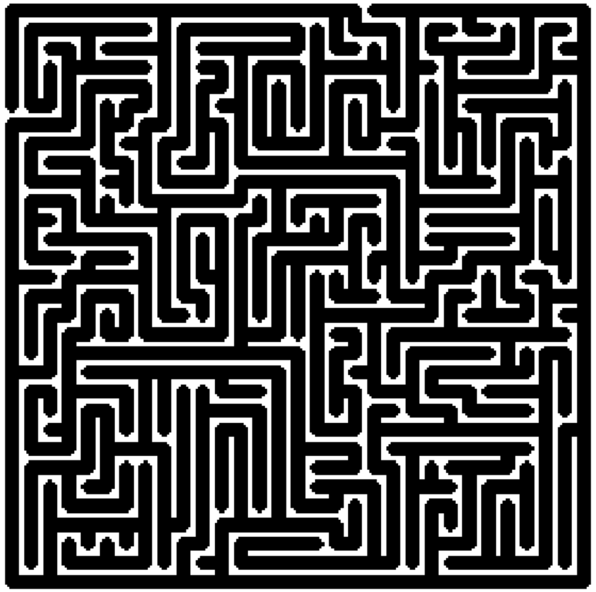


17 passes

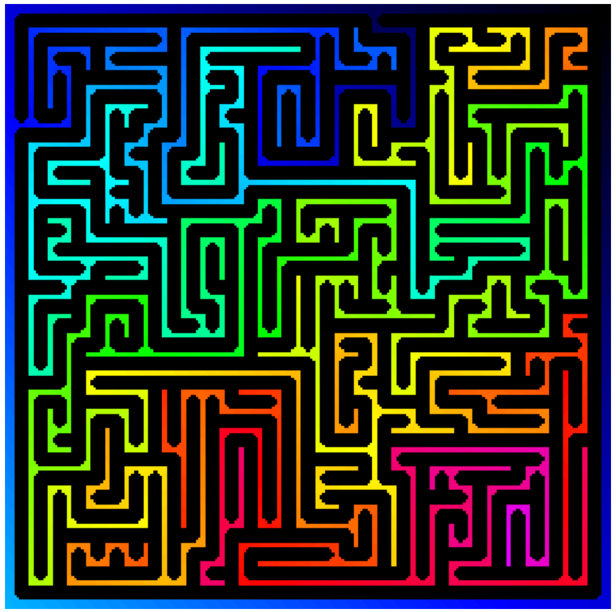
Path-finding with distance transform 2D



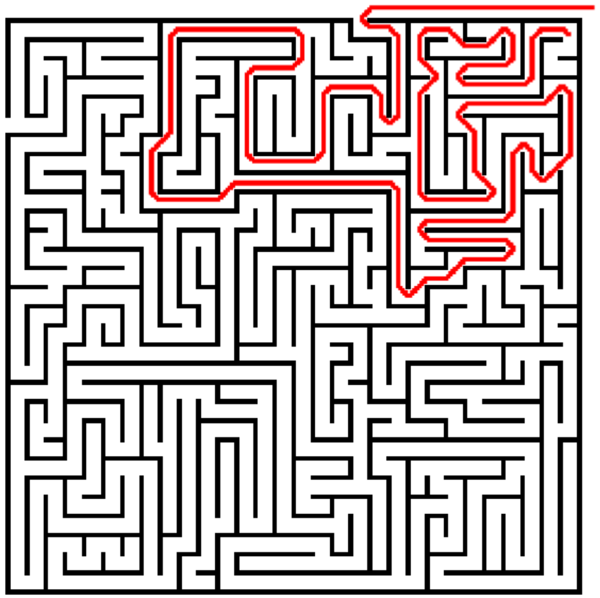
Input
White = Inf
Black = 0



Dilate
radius = 2



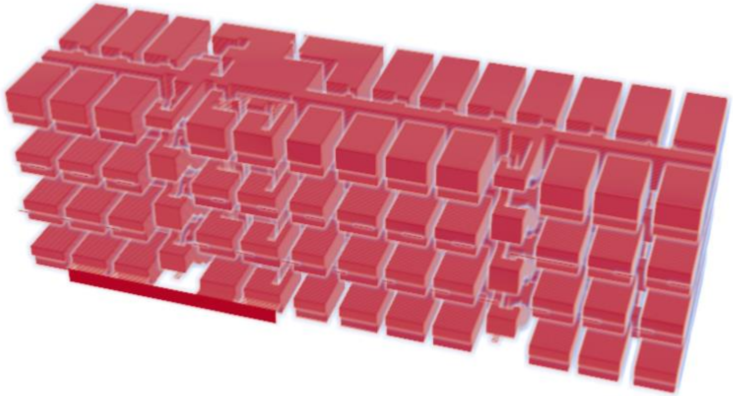
Distance field
Flood fill

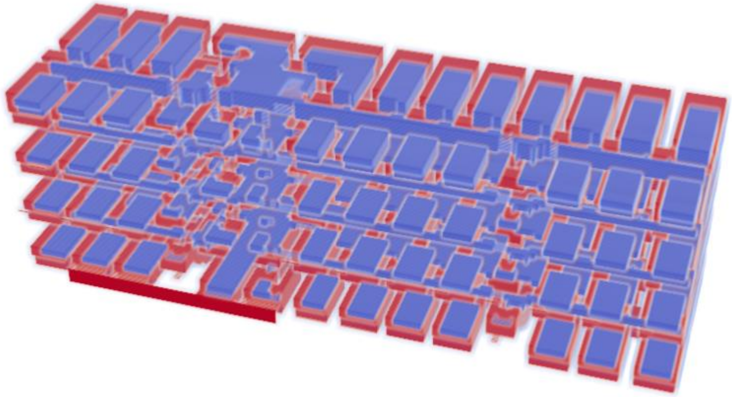


Path
Steepest descent

Path-finding with distance transform 3D

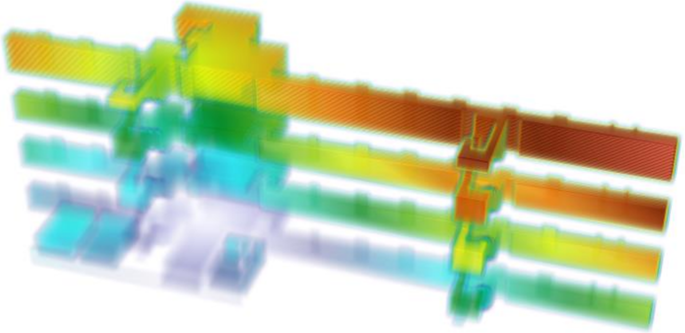
Input
Red = Inf
Transparant = 0

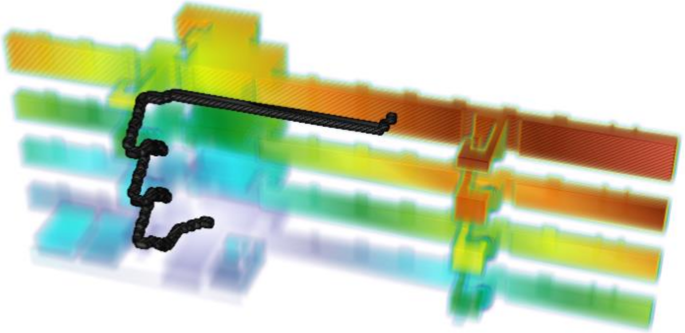




Dilate
Vertical radius = 2
Horizontal radius = 1

Distance field
Dorst
7 passes





Path
Steepest descent

Question

- Can I include the size of the actor in the distance field computation so that it is accounted for in the path-finding?

Slope estimation of ground voxels

- Convolution filter for gradient calculation
- Plane fitting with least squares

Slope estimation: Convolution filter

1. Create local height map (3x3) of ground voxels
2. Apply Prewitt operator
3. Calculate magnitude

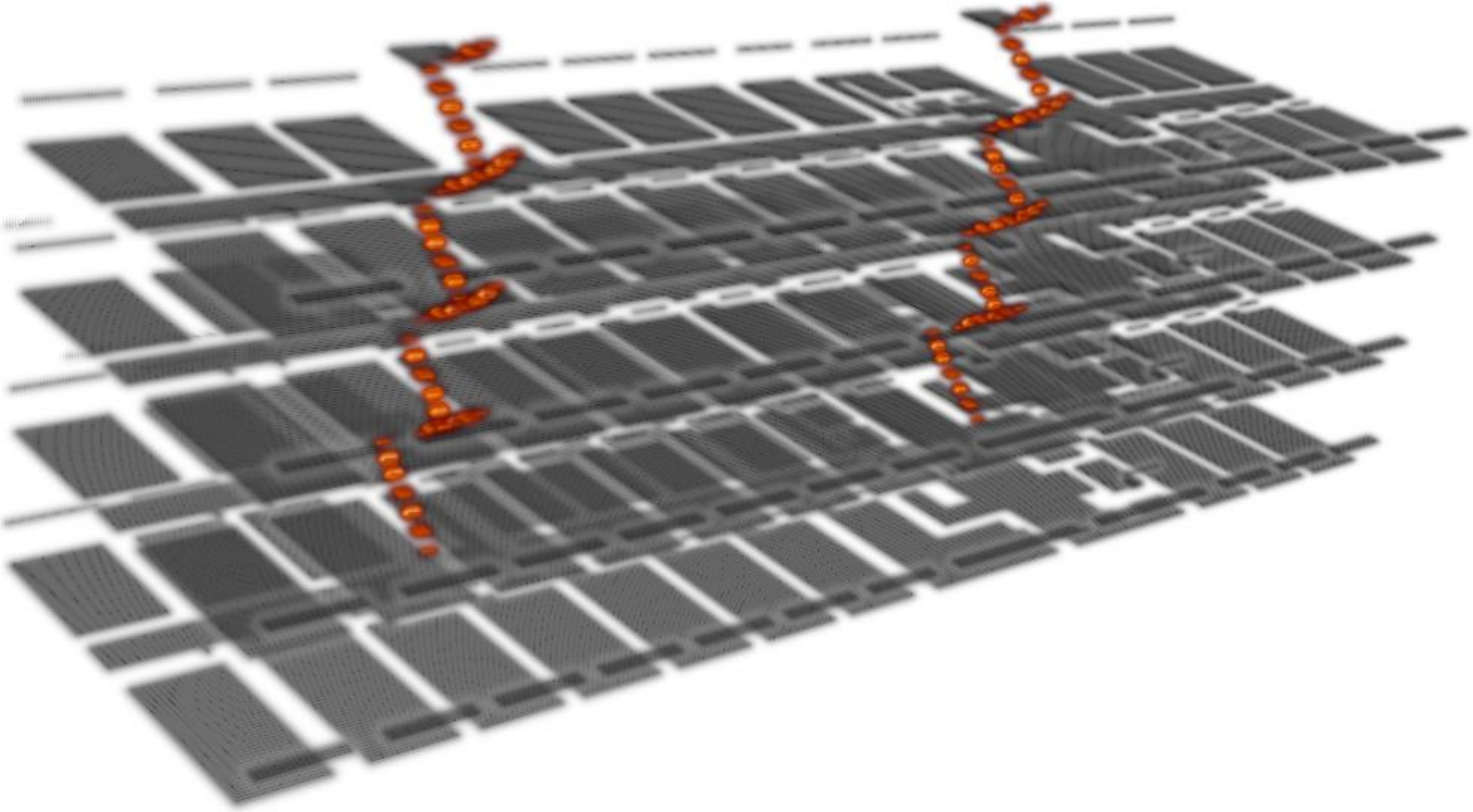
$$\mathbf{G_x} = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A} \quad \text{and} \quad \mathbf{G_y} = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix} * \mathbf{A}$$

$$\mathbf{G} = \sqrt{\mathbf{G}_x{}^2 + \mathbf{G}_y{}^2}$$

Slope estimation: Plane fitting

1. Select neighborhood of ground voxels
2. Fit plane using least squares adjustment
3. Derive normal vector from plane equation
4. Calculate angle between normal vector and up vector

Slope estimation



Interesting papers

Jones, M. W., & Bærentzen, J. A. (2006). **3D Distance Fields : A Survey of Techniques and Applications** 2 Continuous Distance Fields, *12*(4), 581–599.

Grevera, G. J. (2004). **Distance Transform Algorithms and Their Implementation and Evaluation**, (610), 33–60.

Borgefors, G. (1986). **Distance transformations in digital images.** *Cvgip*, *34*(344), 344–371.

Borgefors, G. (1984). **Distance transformations in arbitrary dimensions**. *Computer Vision, Graphics, and Image Processing*, *26*(2), 270. http://doi.org/10.1016/0734-189X(84)90194-4

Zhang, X., Drake, N. A., Wainwright, J., & Mulligan, M. (1999). **Comparison of slope estimates from low resolution dems: Scaling issues and a fractal method for their solution.** *Earth Surface Processes and Landforms*, *24*(9), 763–779. http://doi.org/10.1002/(SICI)1096-9837(199908)24:9<763::AID-ESP9>3.0.CO;2-J

Yuan, W., & Schneider, M. (2011). **3D Indoor Route Planning for Arbitrary-shape Objects**. *Database Systems for Advanced Applications*, 120–131. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.188.2568

Yuan, W., & Schneider, M. (2010). **Supporting 3D Route Planning in Indoor Space Based on the LEGO Representation.** *Proceedings of the 2Nd ACM SIGSPATIAL International Workshop on Indoor Spatial Awareness*, (November), 16–23. http://doi.org/10.1145/1865885.1865890