Block structured mesh using a system of coordinated reflex agents

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Summary

Today, there is no algorithm to generate a hexahedral block structure for any 3D Ω geometric domain. Engineers building such meshes can spend several days creating the desired structures using interactive software.

In this work, we propose to follow a different approach than the state of the art. Considering that an engineer knows what the block structure should be locally at a part of the Ω domain, we implement a system of reflexive agents mimicking this knowledge and coordinating to provide a globally valid block structure. In this poster, we illustrate our approach in 2D dimension.

Goal: Block structure improvement

We consider that we have as input a non-optimal block structure, derived from a Polycube algorithm [1]. The goal is to improve this structure in order to satisfy **alignment constraints** at the edge. We will take into account the **valence** of the vertices and their **criticality**.

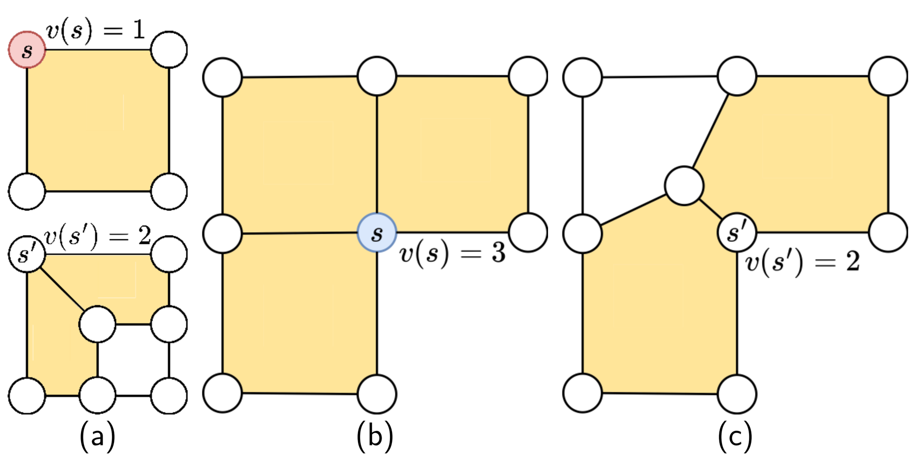


Figure 1

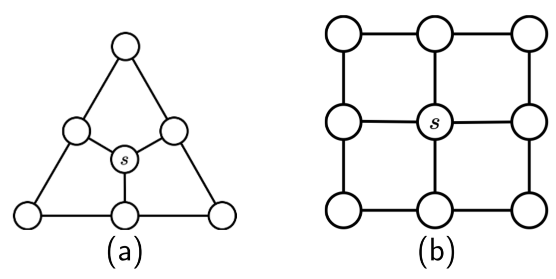
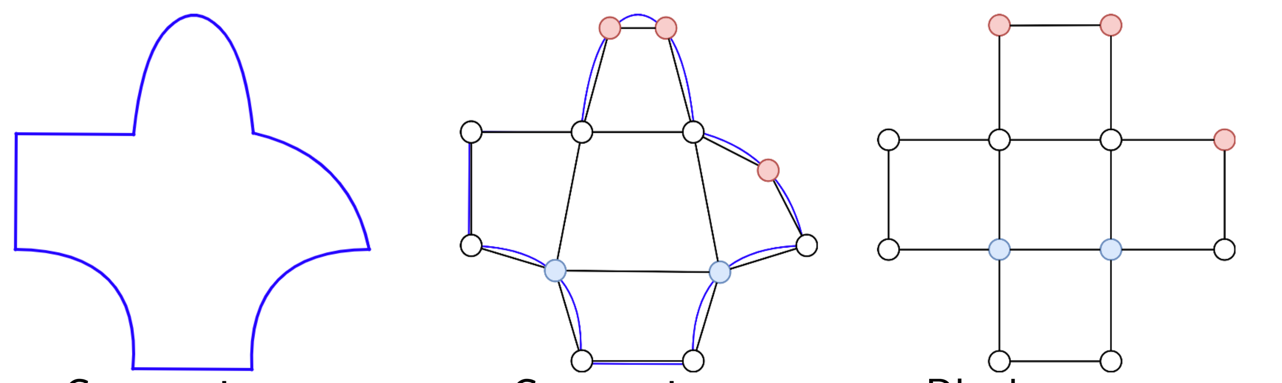
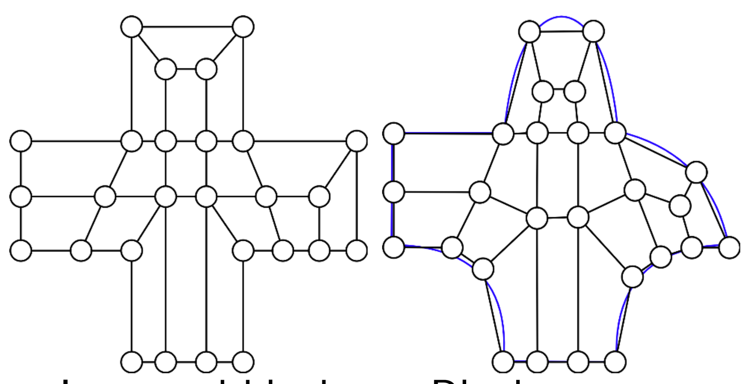


Figure 2

- Valence d'un sommet $v(s)$ nombre de blocs incident de s
- Positive criticality c^+ Valence increase required
- Negative criticality c^- Valence decrease required



(a) Geometric domain Ω (b) Geometric domain + initial block structure $\Omega + B_H$ (c) Block structure in Cartesian view



(d) Improved block structure (e) Block structure projected to Ω

Modeling by a system of coordinated reflex agents

We model our problem by a multi-agent system (E, AL_i, AC) where: E is the environment made of B_H and of Ω AL_i, with $0 < i < N$, is a set of reflex agents each assigned to a block of the structure. N varies at each iteration. AC is a coordinating agent responsible for the coordination of agents AL_i. Each reflex agent AL_i calculates the transformation priority of its assigned block. Observation here is a function of criticality (4a) and conformity (4b). The coordinator AC selects the reflex agent with the highest priority.

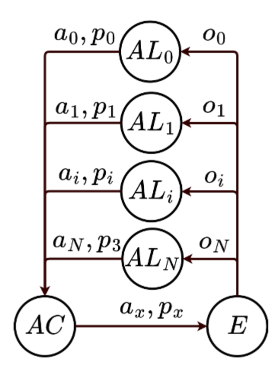
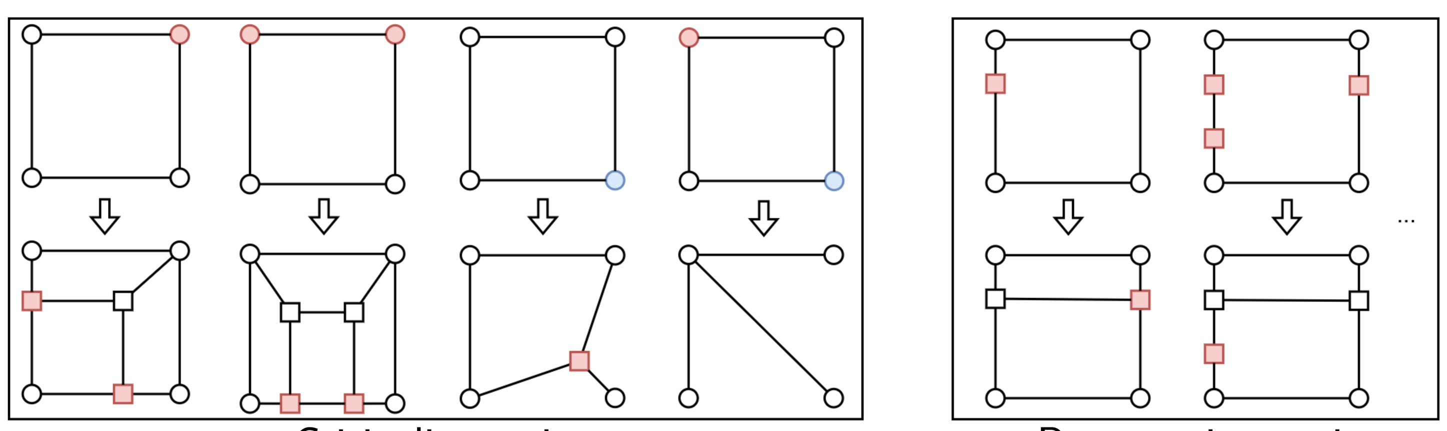


Figure 3. General scheme of the agent system

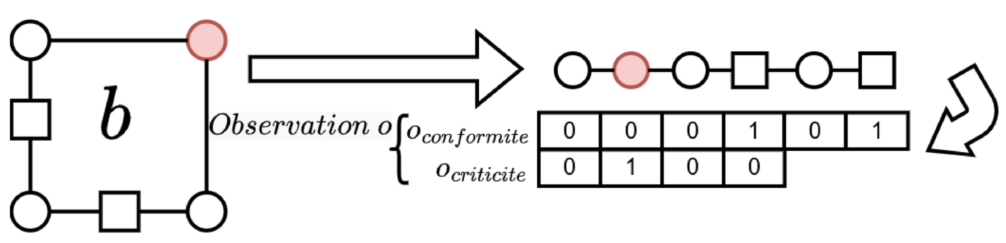
The a_i actions modify the topology of the block structure in order to satisfy the vertices by bringing out non-conformities.



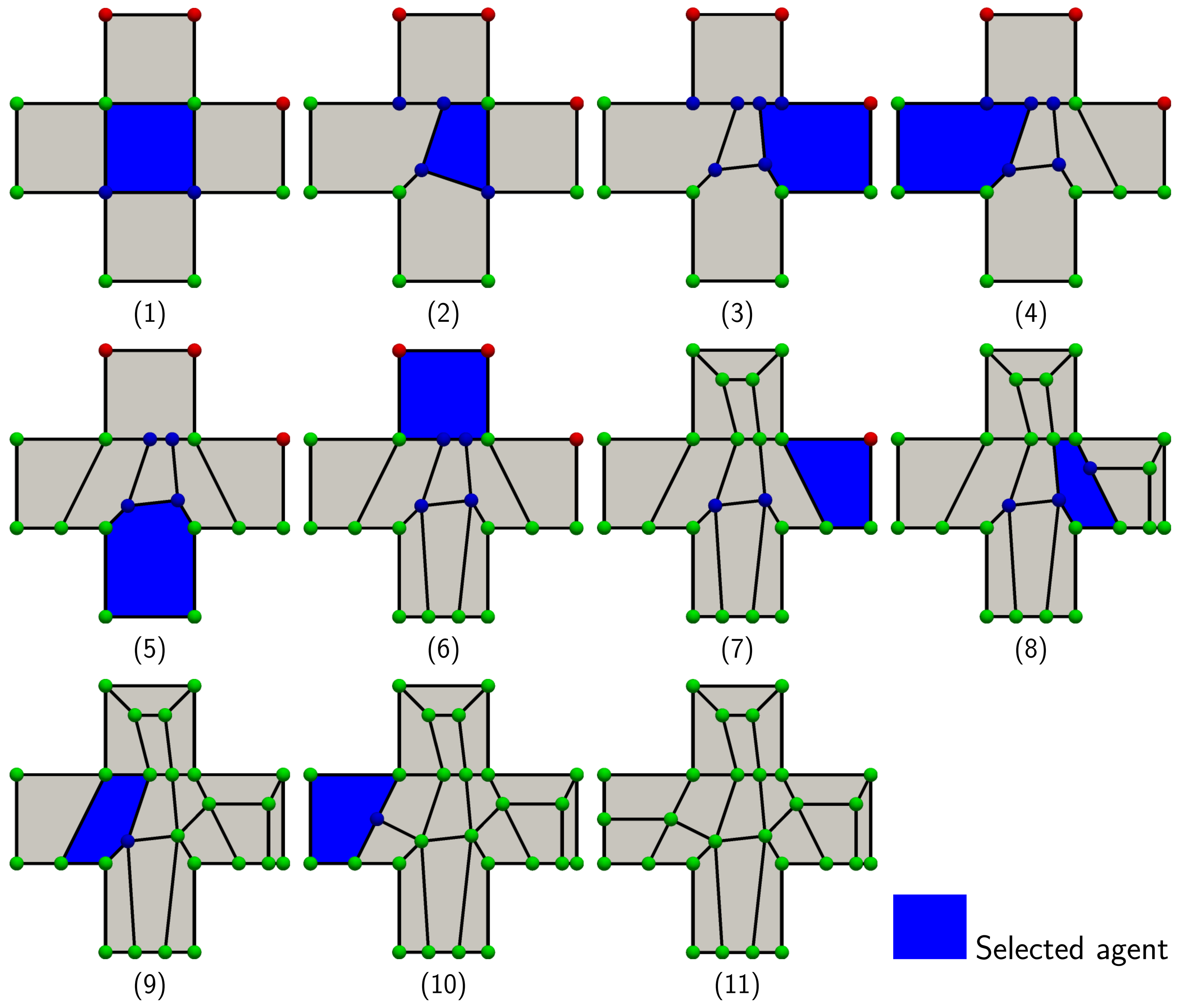
(a) Criticality actions (b) Propagation actions

Figure 4. Dangling vertices introduced by criticality actions.

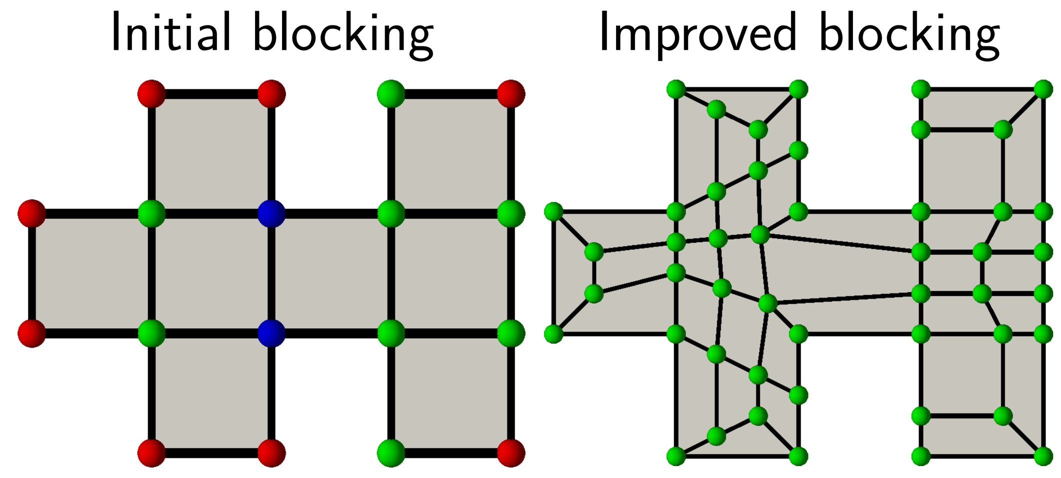
The observation is all the information useful to the agent in order to make a decision.

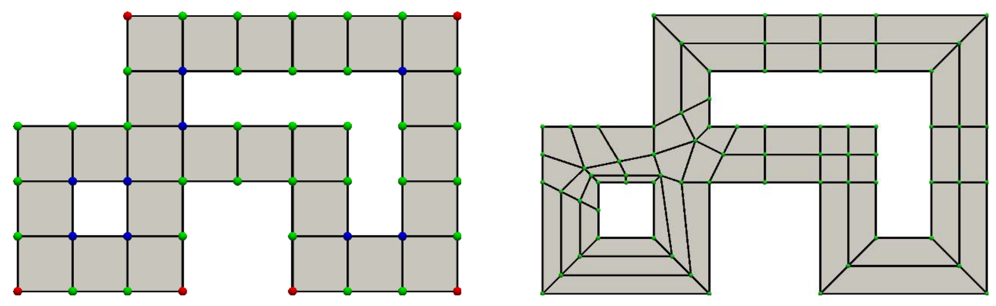


Example of execution



Results





Work in progress

- Proof of termination of the algorithm
- Modification of the coordinating agent so that its observation depends on the gains obtained
- Addition of a learning algorithm for the coordinating agent that observes the gains made by each agent
- Adapting a subset selection problem on faces and solve it with a Ant Colony Optimization Meta-Heuristic [2] [3]

References

[1] J. Gregson and A. Sheffer and E. Zhang. *All-Hex Mesh Generation via Volumetric PolyCube Deformation.* Computer Graphics Forum (Special Issue of Symposium on Geometry Processing 2011.

[2] Christine Solnon, Derek Bridge. An Ant Colony Optimization Meta-Heuristic for Subset Selection Problems. Nadia Nedjah; Luiza de Macedo Mourelle. System Engineering using Particle Swarm Optimization, Nova Science publishers, pp.3-25, 2006, 1-60021-119-4. hal-01541555

[3] Gianmarco Cherchi, Pierre Alliez, Riccardo Scateni, Max Lyon, David Bommes. Selective Padding for Polycube-Based Hexahedral Meshing. Computer Graphics Forum, Wiley, 2019,10.1111/cgf.13593.hal-01970790

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