Internship in ESA's Advanced Concepts Team
On
A dataset for exploring generative cellular automata as a design tool for space habitats and spacecraft

European Space Research and Technology Centre
ESA ESTEC

Candidates interested are encouraged to visit the ESA website:
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Topic description

Designing an exploration, transportation or habitation system for space environment requires navigating through a complex design space of numerous constraints and requirements for an optimal solution. In traditional engineering practices this is done through iterative process of trial and error which is time consuming and limited in the scope of proposed design solutions caused by human bias and cognitive restrictions.

To overcome these limitations, various generative design tools are emerging in AEC (Architecture, Engineering and Construction) industry to aid the design process by accelerating the simulation and optimization phases and therefore enabling a simultaneous generation of multitude of design alternatives in a very short time with unique and unforeseen engineering solutions. To that end, various artificial intelligence models are being experimented with by engineers that take advantage of previously generated data, help augment human creativity and automate complex, repetitive and time-consuming processes. However, to exploit the benefits of these models a sufficient amount of data is required for training purposes.

In this internship, therefore, the foundation will be laid for exploring the capabilities of modern artificial intelligence methods for the application in design processes of space architecture and infrastructure systems.

Candidate's task

To achieve this, the main goal of the internship will be to assemble a suitable dataset containing 3D models of spacecraft designs with labelled components (e.g., solar panels, antenna, hull, etc.). The assembled dataset is intended to form the basis for exploring a variety of machine learning models for the design and analysis of space-related structures (e.g., 3D object segmentation to label spacecraft components). Hence, ideally the dataset will be made publicly available.

In particular, the assembled dataset will be used to explore the usage of generative models to assist the design of space habitats and spacecraft. As a first step in this direction, we will use the created dataset to train generative cellular automata [1] as part of this internship. Generative cellular automata take inspiration from biology by discretising space into little cubes ("cells") with an internal state specifying what kind of material is occupying this part of space (e.g., "empty", "solar panel", "hull"). A cell's state is then continuously updated depending on the state of surrounding cells, allowing us to "grow" a valid design from, e.g., a single cell. More interestingly, the desired position of certain design elements can be specified in advance, and

the generative cellular automata will "complete" the design by growing the remaining parts of the spacecraft. Since the model is stochastic, a multitude of candidate designs can therefore be generated that respect the given design constraints.

Joining the ACT

Creativity and out-of-the-box thinking are essential in the ACT. Therefore, the team is constantly striving to be a diverse, inclusive and equitable workplace bringing together people from various backgrounds. We strongly encourage people from under-represented groups to apply to be part of our team as diversity is central to our mission and core values.

In order to make our hiring as fair as possible, we also ask applicants to not include photos in their CVs.

References

[1] D. Zhang et al., Learning to generate 3D shapes with generative cellular automata (ICLR 2021).