DRY STACKING STRATEGIES AND AUTONOMOUS BUILDING

*"Our research aims to attack the general problem of **construction and structure stability**, to better understand **assembly planning with irregular, found or deformable[1] construction elements**"*

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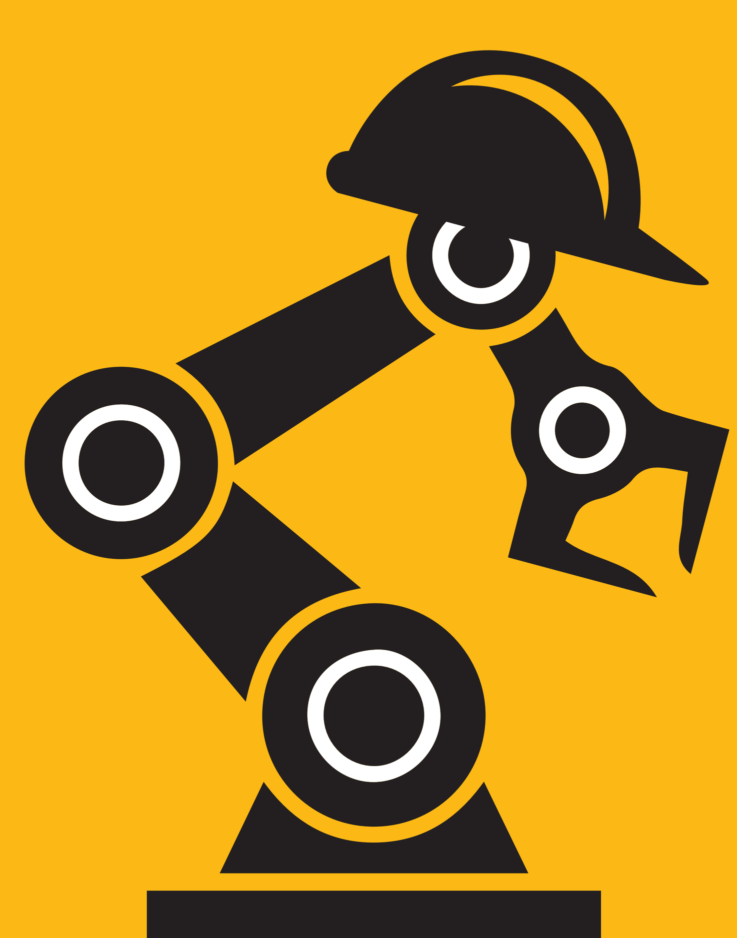
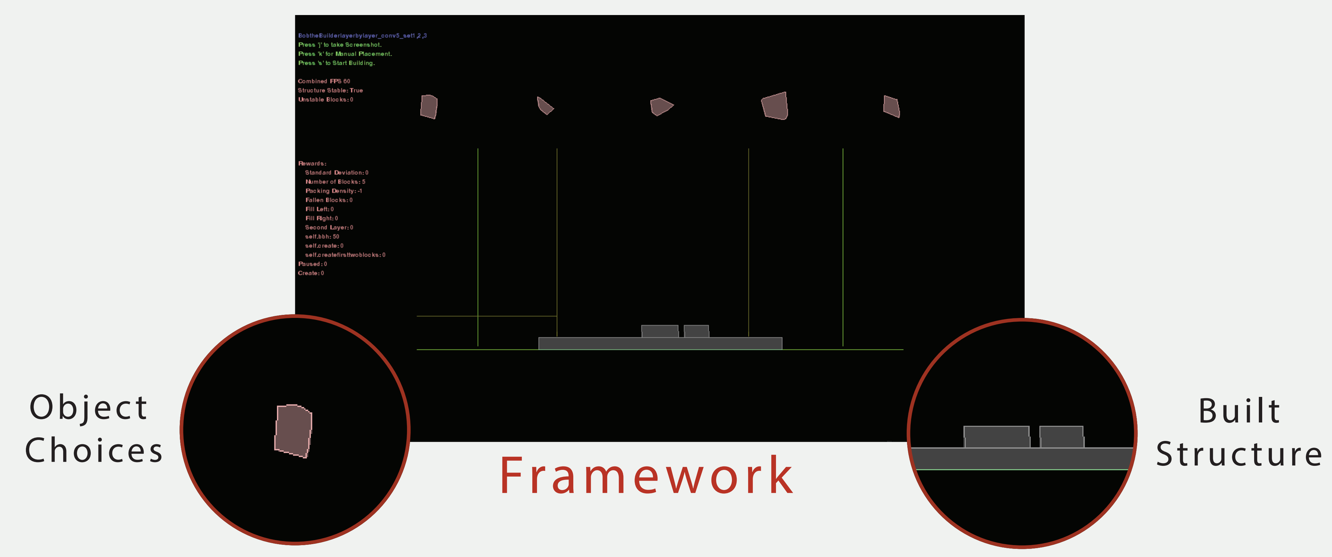


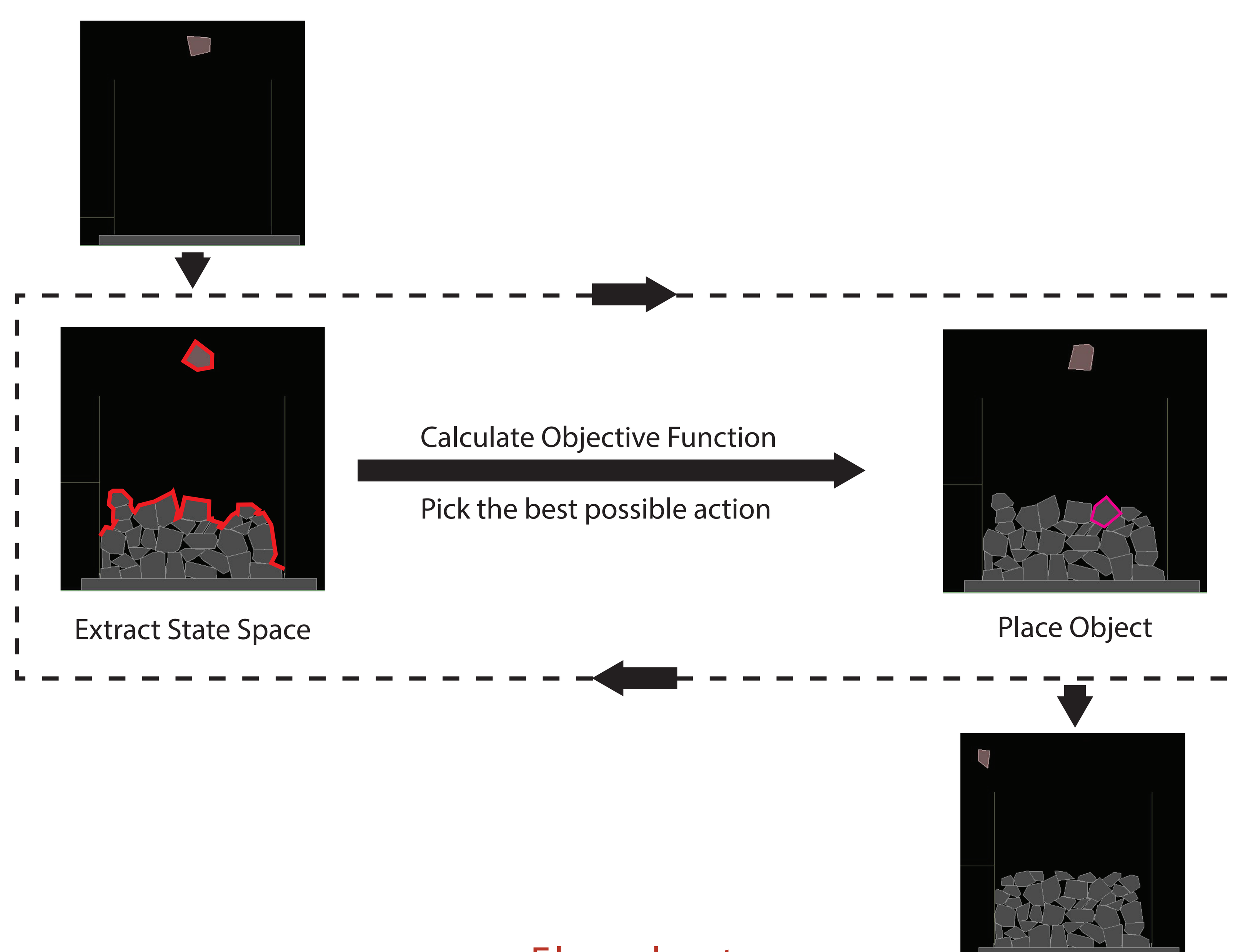
MOTIVATION

Modern construction and construction robots[2] use well-specified **and predictable elements**. This **simplifies** material **production** and enables **structural planning**. However, most pre-historic human construction used **irregular natural building materials** such as sticks and stones. In several scenarios, building with found objects might be the only possibility. For example, in extraterrestrial construction where **transport costs** are **limiting**, or in disaster areas where **temporary structures** need to be built **quickly** and possibly without functioning supply infrastructure. We explore a simplified setting of building **dry stacked structures from rigid, irregularly shaped objects**.

SIMULATION EXPERIMENT



Framework



Flowchart

METHODS

We built a simplified 2D version of the problem using a rigid body simulator to simulate the assembly process and predict structural stability. Each object is modeled as a convex polygon. Objects that are to be placed 'float' at specific locations in the testbed. The edges of the candidate object and the top contour surface of the target structure are extracted. After preprocessing, this forms the state space.

As part of our initial tests and analysis on incremental structure stability, we designed a set of features to determine the objective function to select the best possible action from the allowable action space.

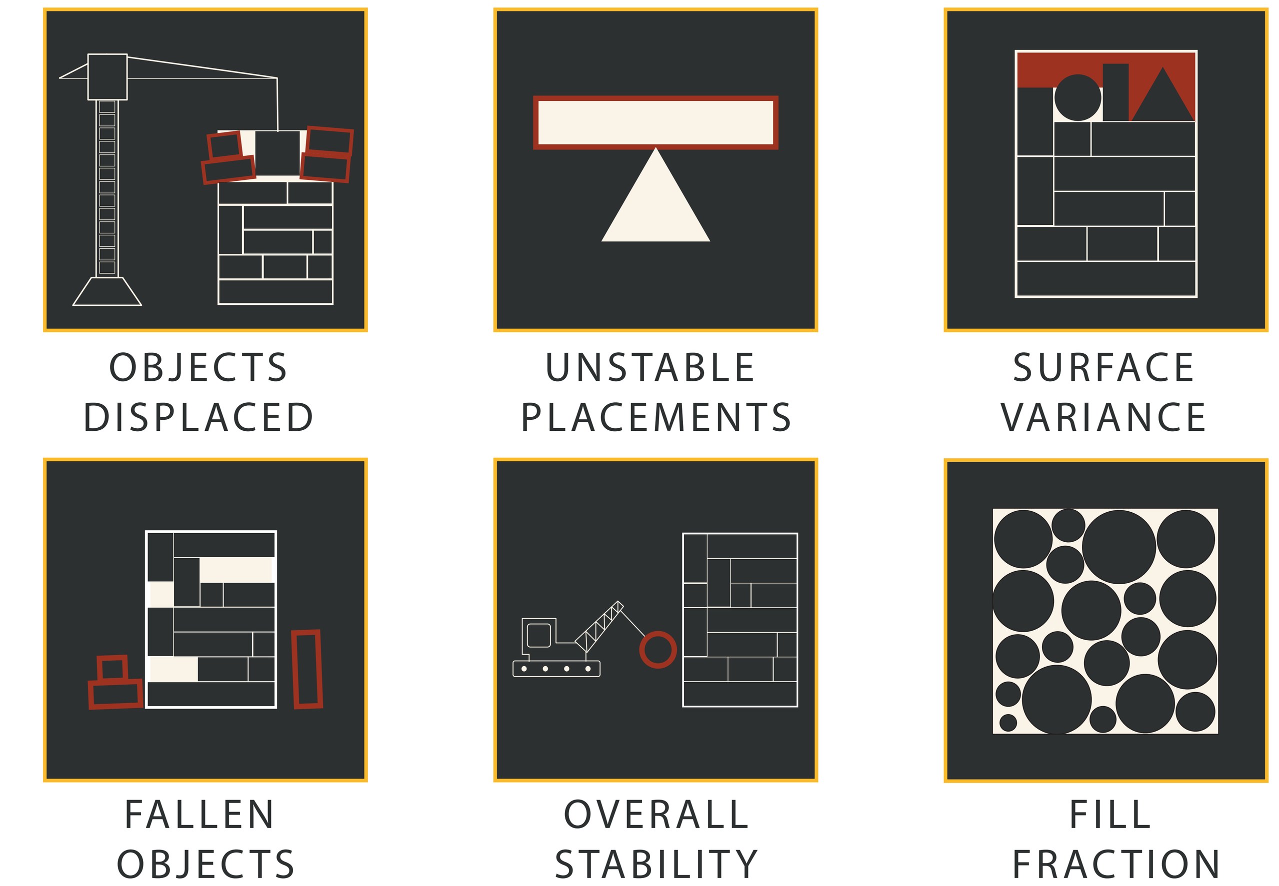


Illustration of various features used in the objective function

This step is repeated until we reach the final state of the assembly process. We measure the stability of the structure by shaking the platform in a lemniscate motion and assessing the movement of the blocks before and after the shake.

RESULTS

We ran tests based on different algorithms derived from known heuristc approaches to dry stacking[3]. Based on the algorithm in use, certain adjustments were made to the features incorporated into the model. From our test data, we observed that some features were not correlated to structural stability as previously assumed. The correlogram plot on the left depicts the correlation matrix of the various features. The most crucial observation, among others, was that Surface Variance and Unstable Placements are the most highly correlated features w.r.t Overall Structure Stability.

FUTURE WORK

Current work involves the design of features which take into account the stability of the individual objects along with the physics-related aspects of the system model. Such features would serve as a better representation for the model than the previous naïve geometric features. Additionally, in order to achieve a more general assembly model, we need to move away from hand-tuning the various parameters and towards a self-learning framework.

REFERENCE

[1] Nils Napp and Radhika Nagpal. Distributed amorphous ramp construction in unstructured environments. Robotica, 32(02):279–290, 2014.
[2] Kirstin Petersen, Radhika Nagpal, and Justin Werfel. Termes: An autonomous robotic system for three-dimensional collective construction. June 2011.
[3] John Vivian. Building Stone Walls, Storey Publishing, LLC; Second Edition edition (January 3, 1976)