Jenga as a Performance Art: Computational Generation of Surprisingly Stable Structures

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Abstract

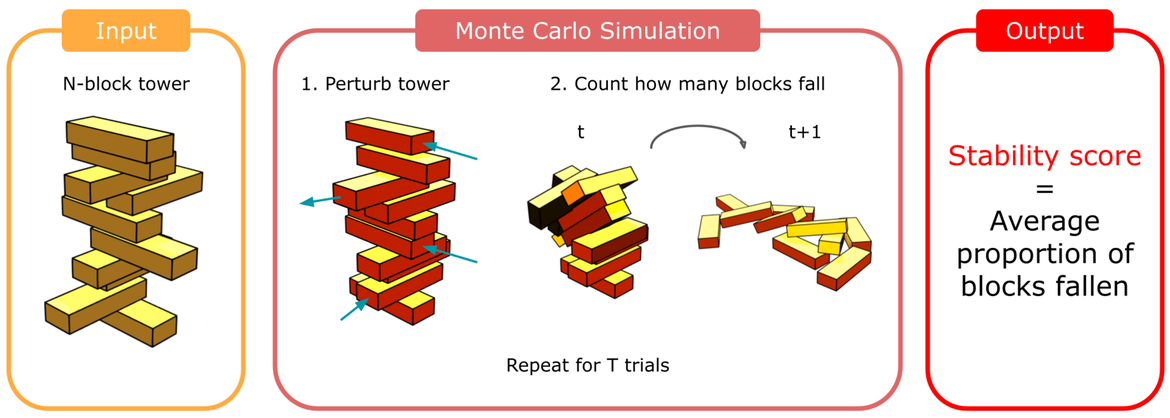
- Surprisingly stable and intriguing art pieces are everywhere. What is the link behind instability and aesthetics?
- To study this, we a) develop a method to **programmatically generate sculptures** of varying heights and stabilities using an intuitive physics engine and b) design a survey using these sculptures to study the relationship between their stability and aesthetic value.
- We find that an **intuitive physics engine based on the Bayesian theory of cognition accurately reflects human notions of stability**, and that **instability may contribute to a sculpture's visual appeal.**

Background

- Previous studies from Fillinger [1] have argued that there are two patterns of instability: gravitational instability, which is related to perceptual inbalance and disliked by human participants, and dynamic stability which may imply movement and is generally liked by participants.
- Vision is suggested to be probabilistic since it infers plausible scenes from images with prior beliefs. An "intuitive physics engine" (IPE) from Vul [2] models human judgements in vision-based intuitive physics tasks using probabilistic simulations. The IPE approximates and simplifies physics' representations just as people tend to do for rapid decisions

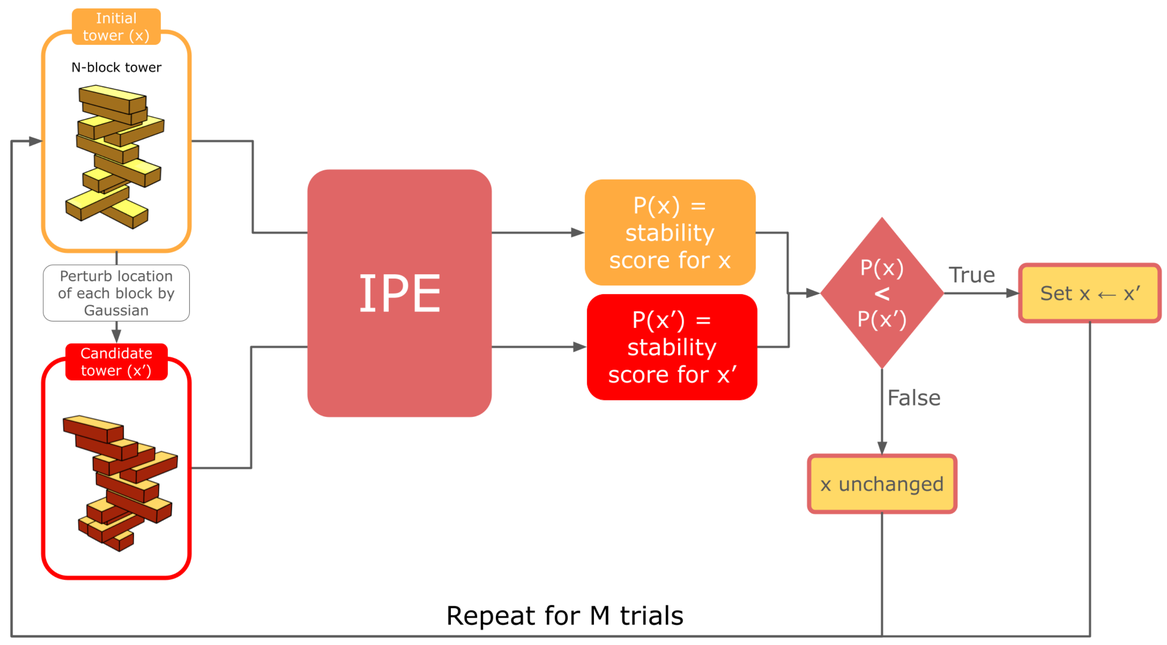
Intuitive Physics Engine Implementation

Simplified block world: we create towers composed of N 1.5 by 0.5 by 0.3 blocks as inputs to the IPE.

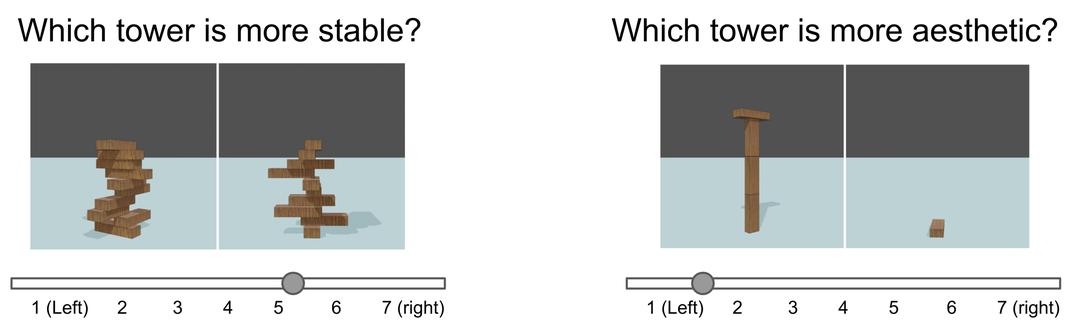


Building Sculptures with Intuitive Physics

Even in this simplified world, the function of sculptures $\rightarrow$ stability is non-convex and not injective! Thus, we use Metropolis-Hastings to sample towers from this stability distribution.

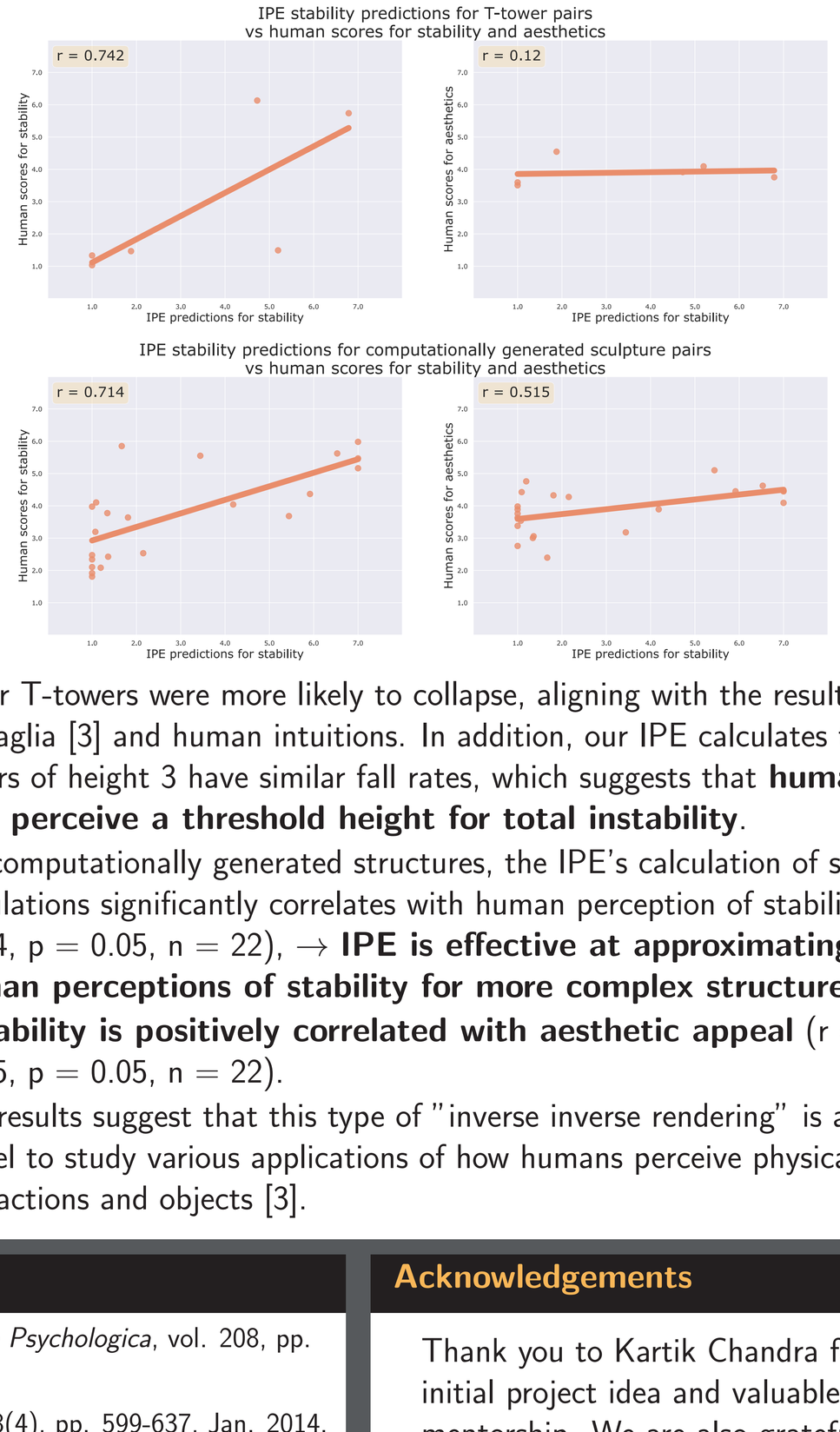


Survey Design



We generated both "T" shape and randomly generated towers. Using an architecture preference backstory, we asked participants to assign a score from 1 to 7 to each their randomly assigned tower pairs, with 1 representing the left structure being the most stable or aesthetically pleasing and 7 representing the right structure being the most stable or aesthetically pleasing.

Results and Discussion



- Taller T-towers were more likely to collapse, aligning with the results of Battaglia [3] and human intuitions. In addition, our IPE calculates that towers of height 3 have similar fall rates, which suggests that **humans may perceive a threshold height for total instability**.
- For computationally generated structures, the IPE's calculation of stability calculations significantly correlates with human perception of stability ($r = 0.714$, $p = 0.05$, $n = 22$), $\rightarrow$ **IPE is effective at approximating human perceptions of stability for more complex structures.**
- **Instability is positively correlated with aesthetic appeal** ($r = 0.515$, $p = 0.05$, $n = 22$).
- Our results suggest that this type of "inverse inverse rendering" is a strong model to study various applications of how humans perceive physical interactions and objects [3].

References

[2] M.G. Fillinger, et al., "On the relation between perceived stability and aesthetic appreciation." *Acta Psychologica*, vol. 208, pp. 103082, July 2020.

[3] E. Vul, et al., "One and done? optimal decisions from very few samples." *Cognitive Science*, vol. 38(4), pp. 599-637, Jan. 2014.

[1] P.W. Battaglia, et al., "Simulation as an engine of physical scene understanding." *Proceedings of the National Academy of Sciences*, vol. 110(45), pp. 18327-32, Oct 2013.

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