

# Probabilistic Programming for Computer Graphics

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Brown University

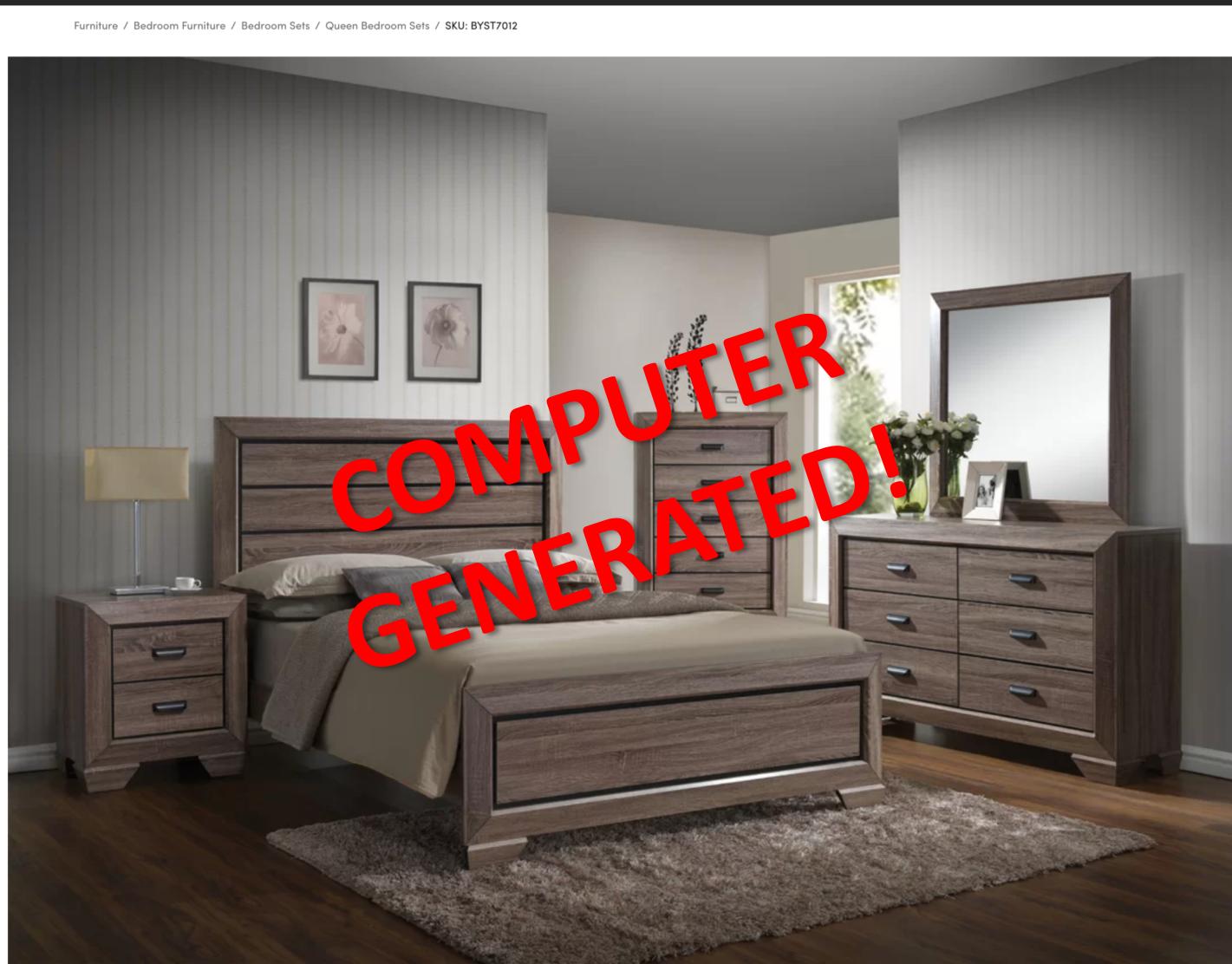


*“The difficulty of generating images has been overwhelmed by a five-thousand-fold improvement in price/performance of computing.*

*What remains hard is modeling...the grand challenges in three-dimensional graphics are to make simple modeling easy and to make complex modeling accessible to far more people.”*

– Bob Sproull, 1990

# Rendering is “solved”



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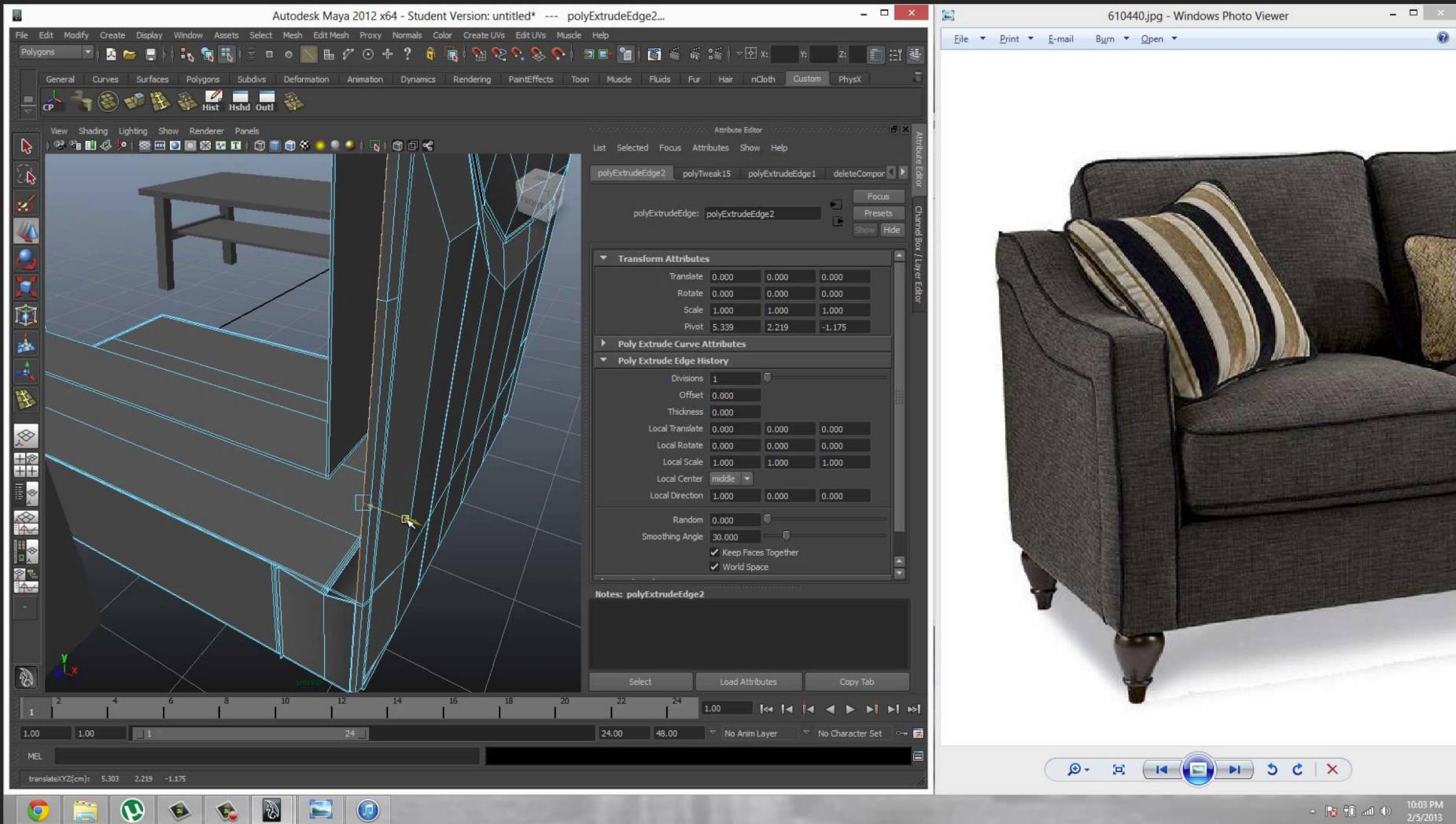
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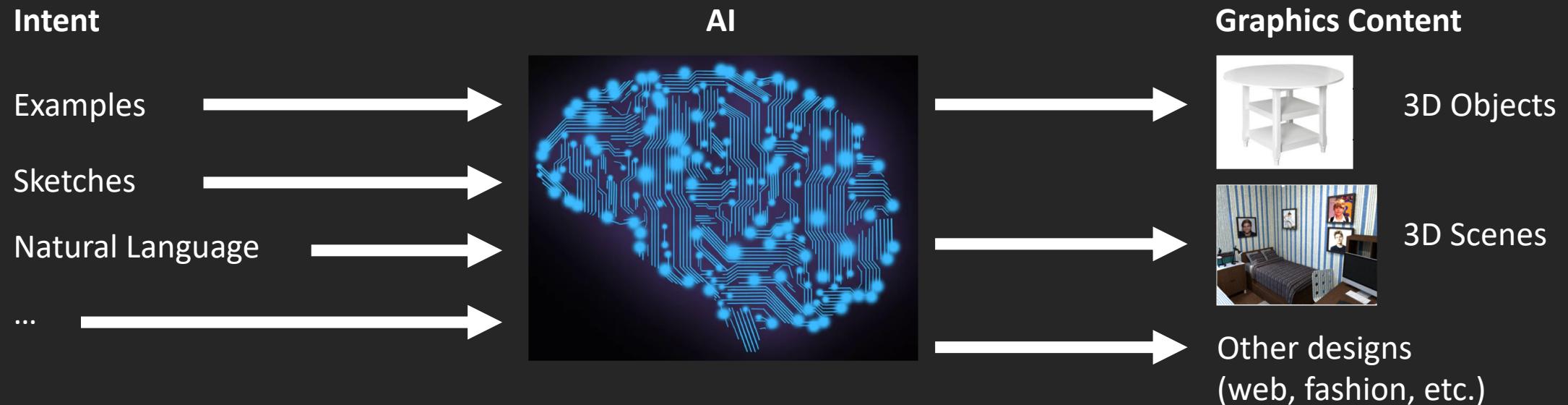


# ...but making things to render is *hard*



YouTube, Nate Birkas (<https://www.youtube.com/watch?v=xrs9iaHdj8w>)

# AI to the rescue!?



“Given intent, product graphics content that satisfies the intent”

→ An inference problem!



Probabilistic Programming?

# Uses for PPLs in Graphics

An inference engine for “inverse design”

A representation of learnable generative models

A tool for structuring complex deep net computations

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# Inverse design via inference

“Metropolis Procedural Modeling” (Reversible-Jump MCMC)

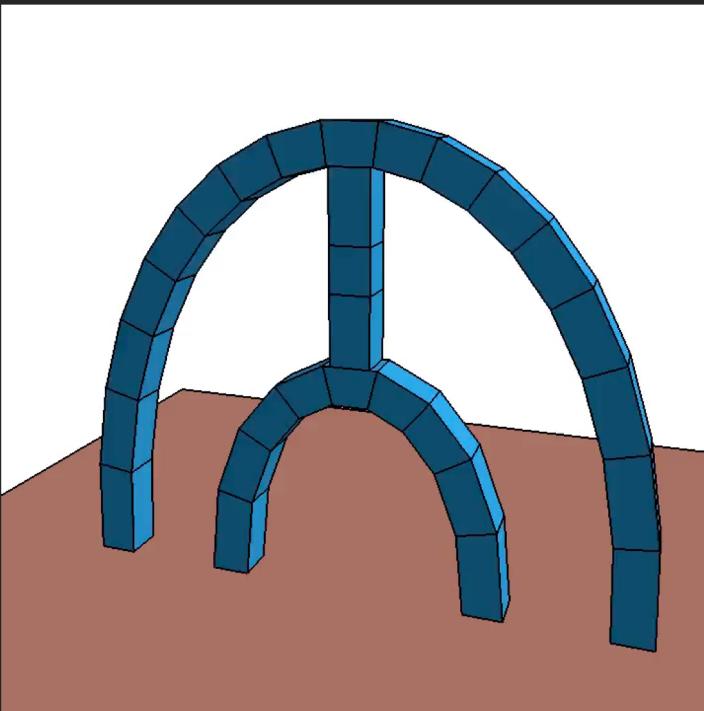


[Talton et al. 2011]

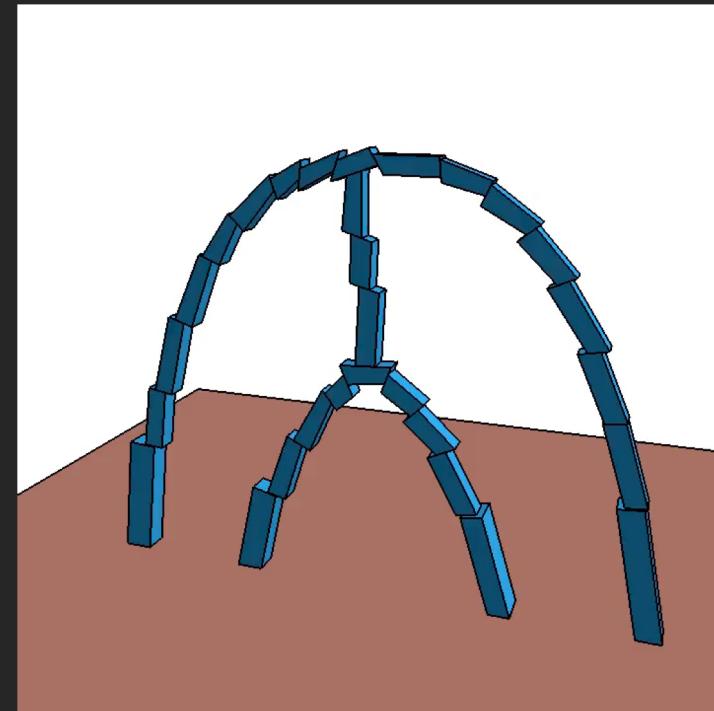
# Inverse design via inference

**Handling very tight constraints with Hamiltonian Monte Carlo**

MH



HMC



[Ritchie et al. 2015]

# Inverse design via inference

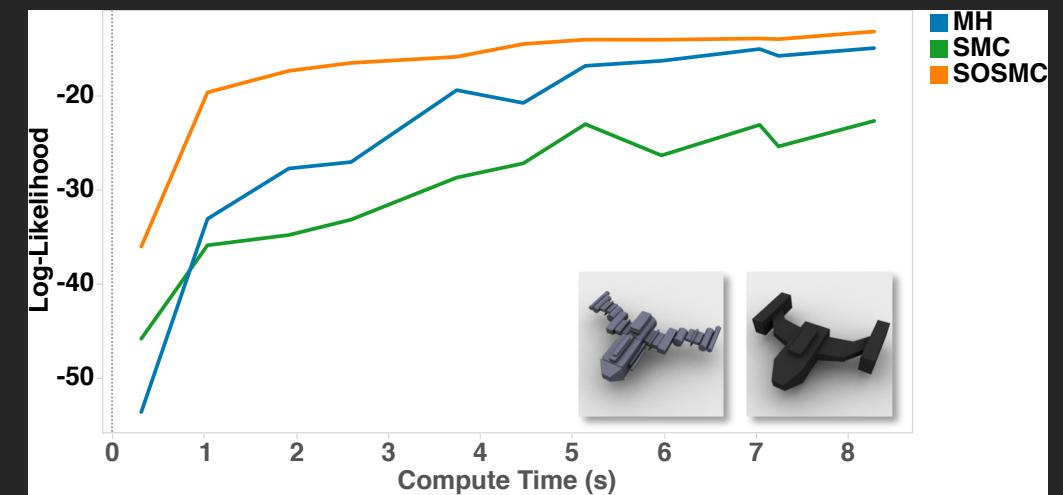
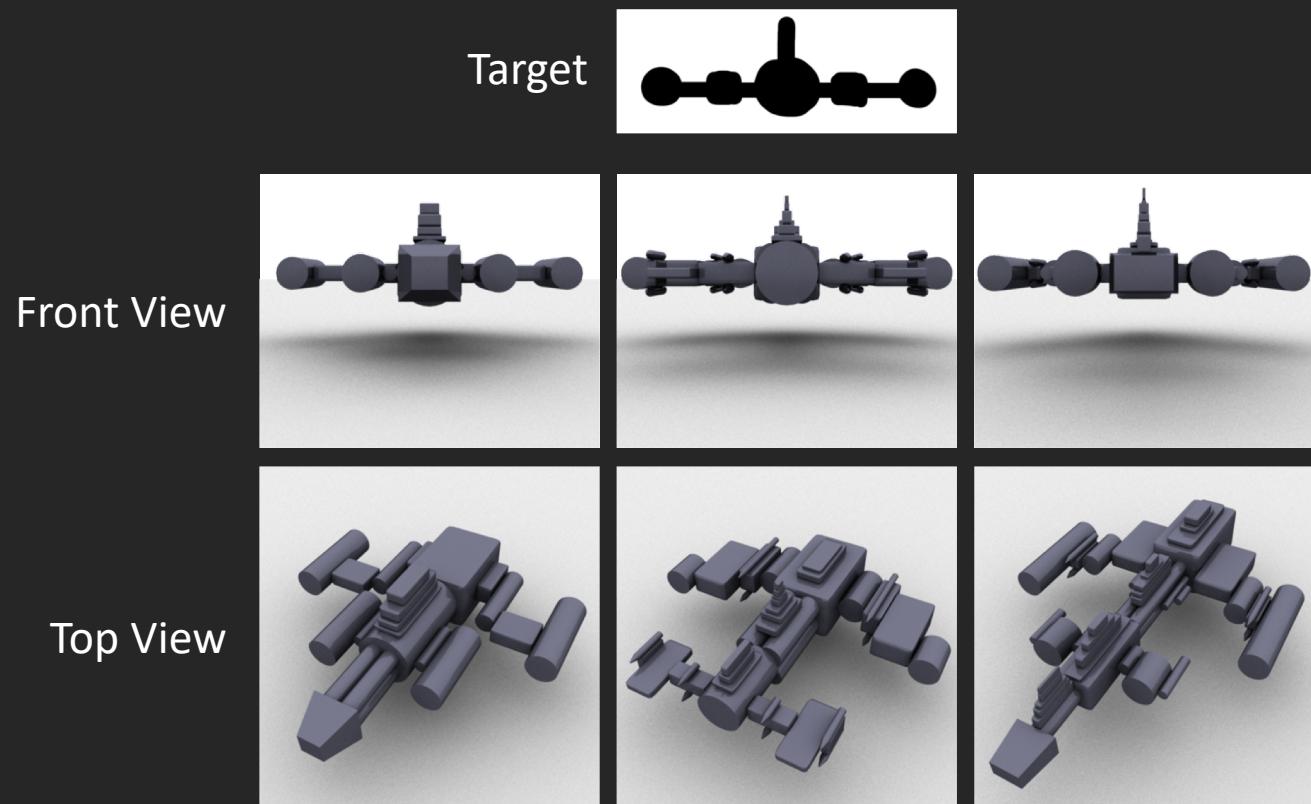
**Handling very tight constraints with Hamiltonian Monte Carlo**



[Ritchie et al. 2015]

# Inverse design via inference

Faster structure inference with Sequential Monte Carlo (SMC)



# Inverse design via inference

Even faster inference with Neurally-Guided Procedural Models

## Real-Time SMC Comparisons

Visualizing the highest-probability  
particle at each step of the algorithm

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A representation of learnable generative models

A tool for structuring complex deep net computations

# Uses for PPLs in Graphics

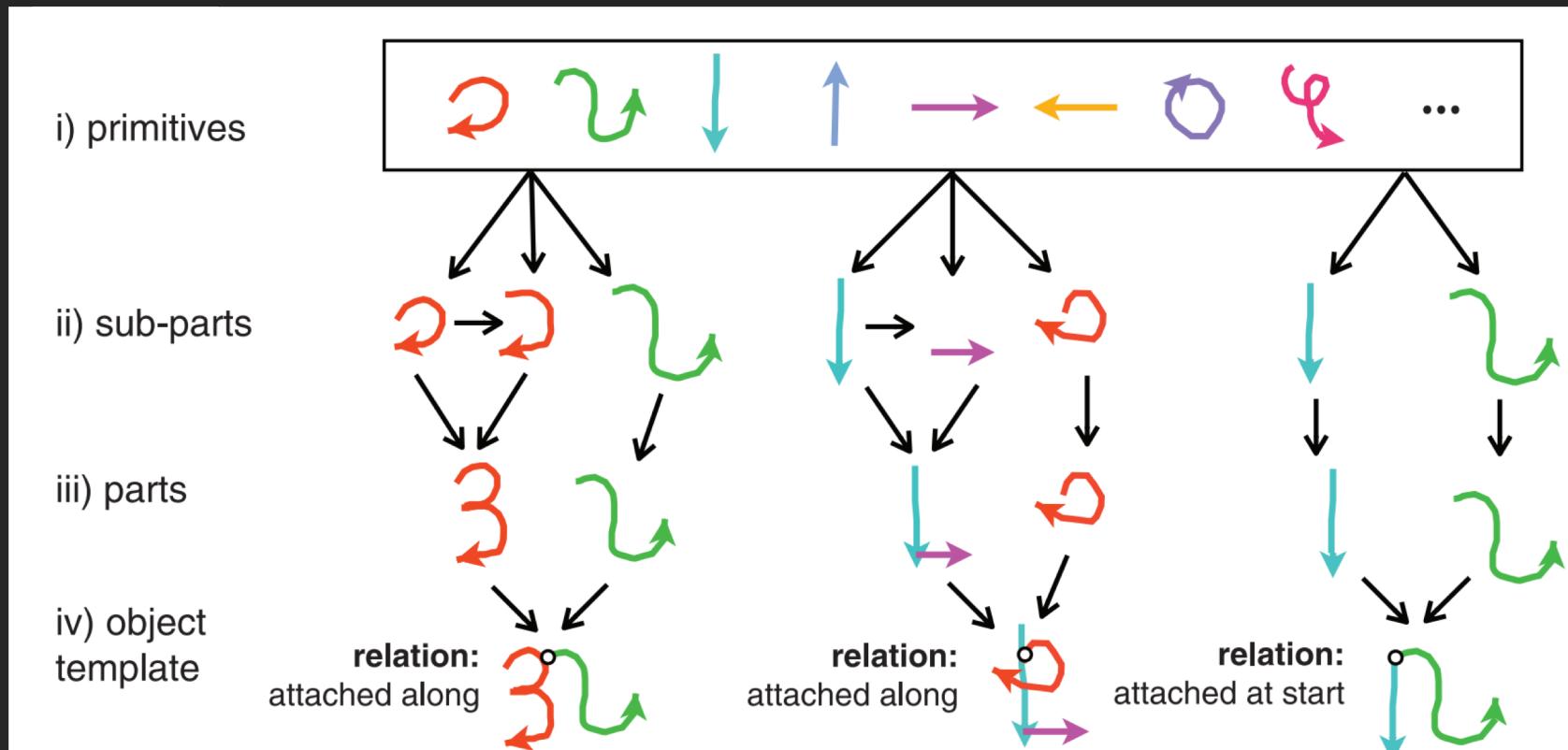
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# Learning generative programs from examples

Related: Concept Learning



[Lake et al. 2015]

# Learning generative programs from examples

Learning procedural graphics programs

A small number of examples

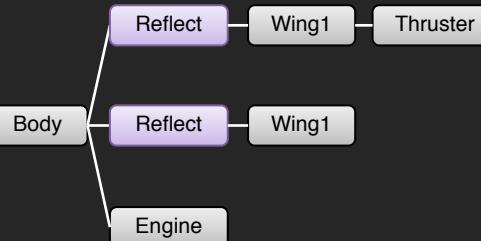


Probabilistic  
Program

Large variety of outputs



Common part library



[Ritchie et al. 2018]

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**A representation of learnable generative models**

A tool for structuring complex deep net computations

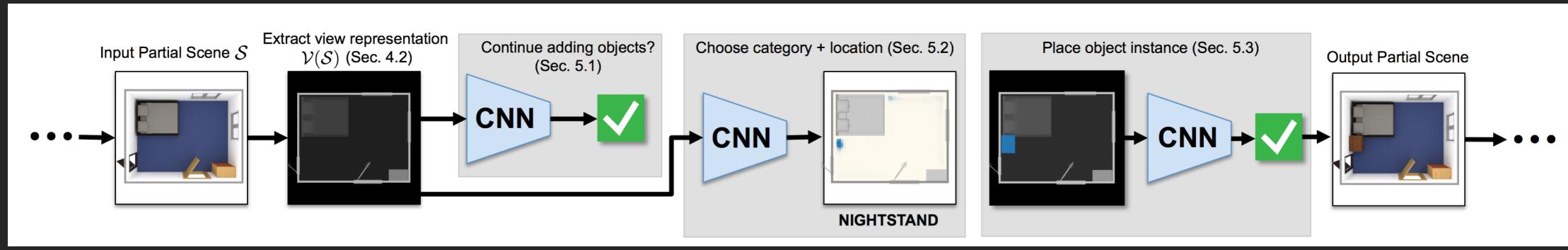
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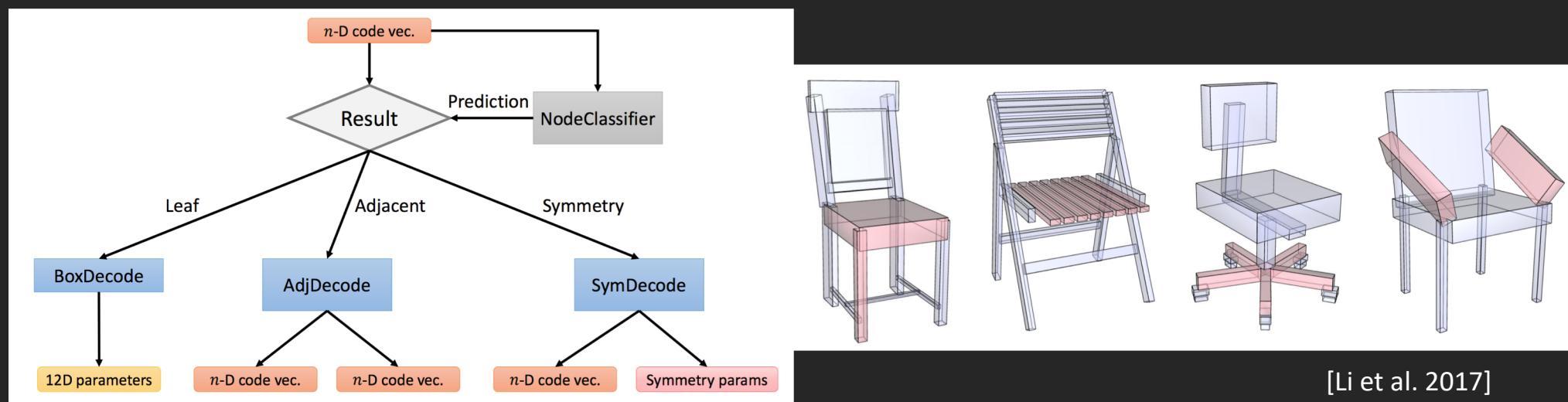
A representation of learnable generative models

**A tool for structuring complex deep net computations**

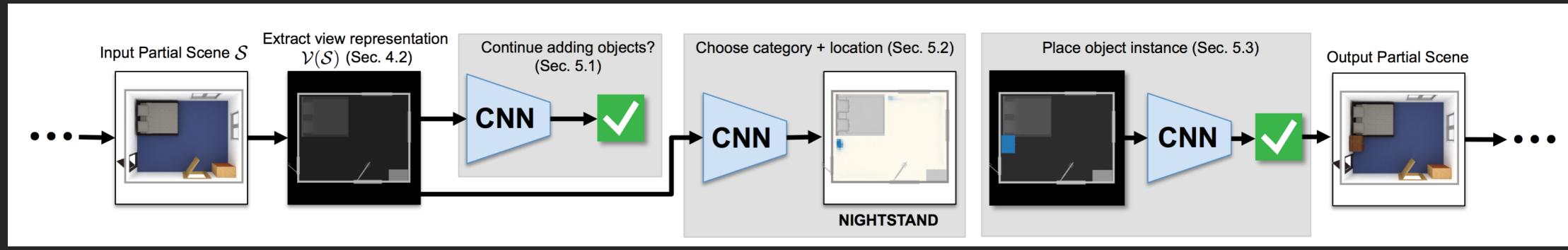
# Graphics generative models are becoming increasingly structured and complex



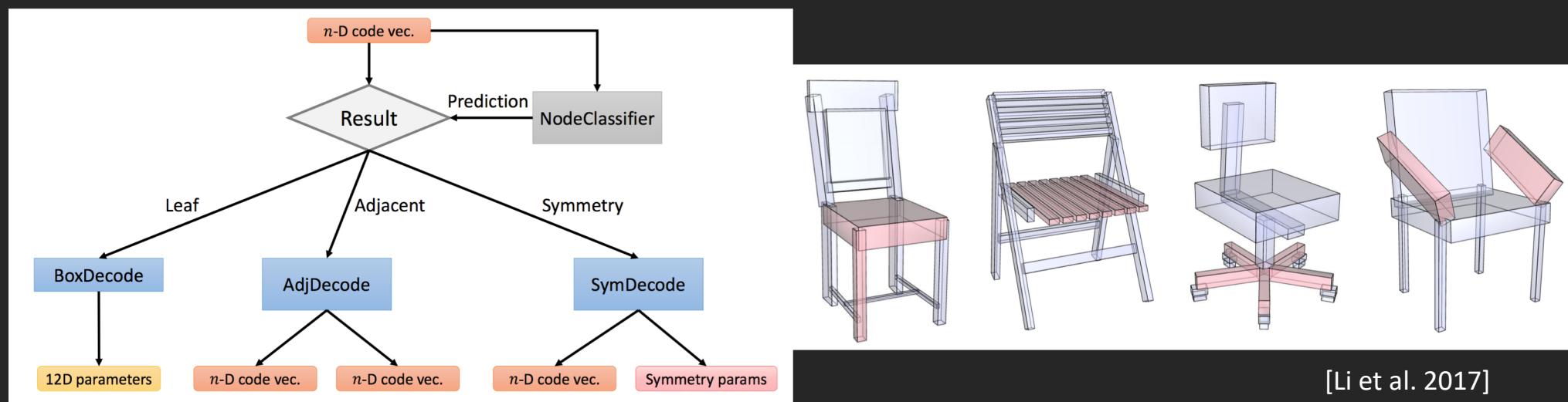
[Wang et al. 2018]



# These pipelines look like programs...



[Wang et al. 2018]



[Li et al. 2017]

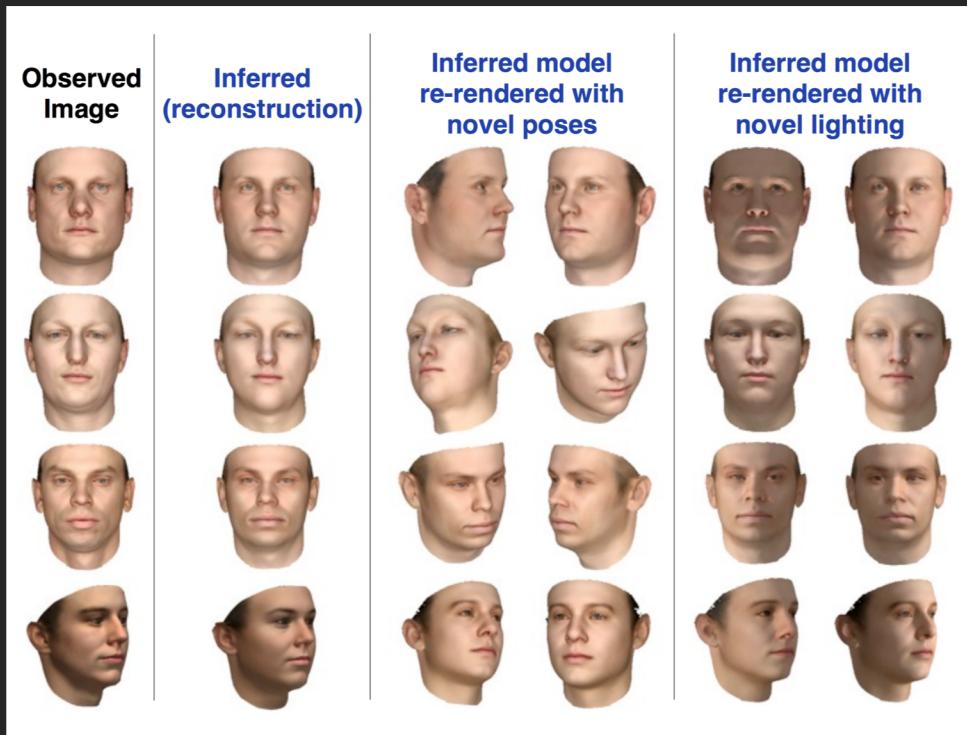
# LOOKING AHEAD

# Static → Functional Content Generation

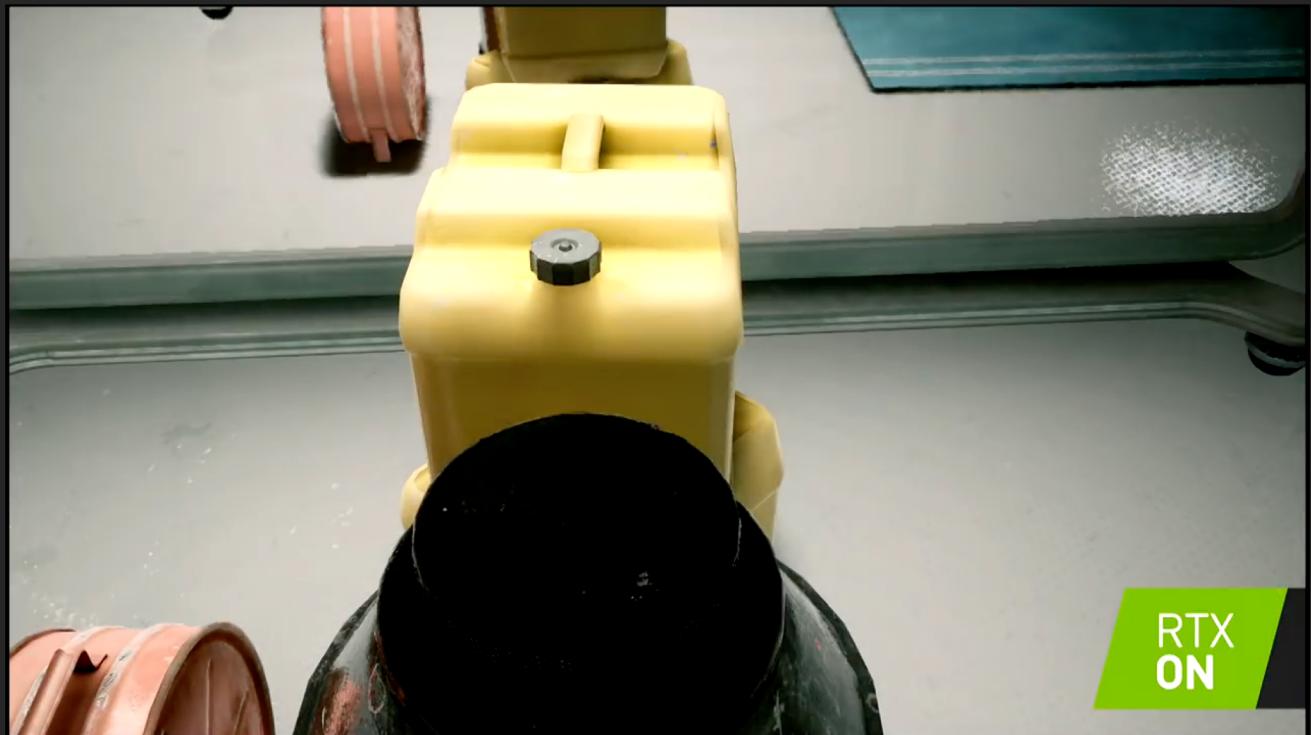


VirtualHome: Simulating Household Activities via Programs  
[Puig et al. 2018]

# Inverse rendering++



[Kulkarni et al. 2015], Picture



Mundfish, "Atomic Heart"