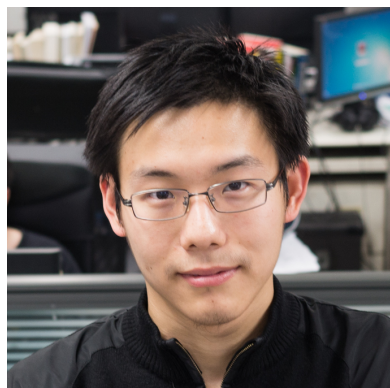


# Galileo: Perceiving Physical Object Properties by Integrating a Physics Engine with Deep Learning



Jiajun Wu\*



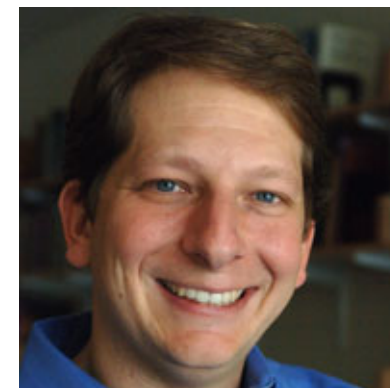
Ilker Yildirim\*



Joseph Lim



Bill Freeman



Josh Tenenbaum

NIPS 2015



(\* indicates equal contribution)



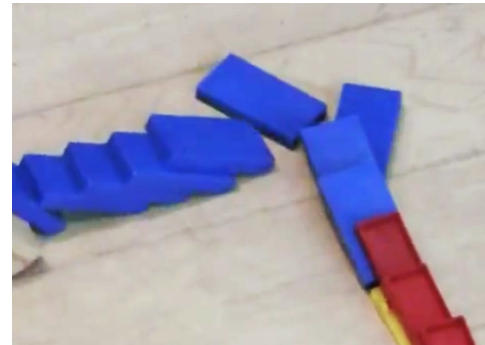
What can we learn from this video?



# Understanding Dynamic 3D Scenes

- What can we learn from this video?

- 3D object shapes
- Physical events
- Physical object properties
  - Masses
  - Coefficients of frictions



collisions

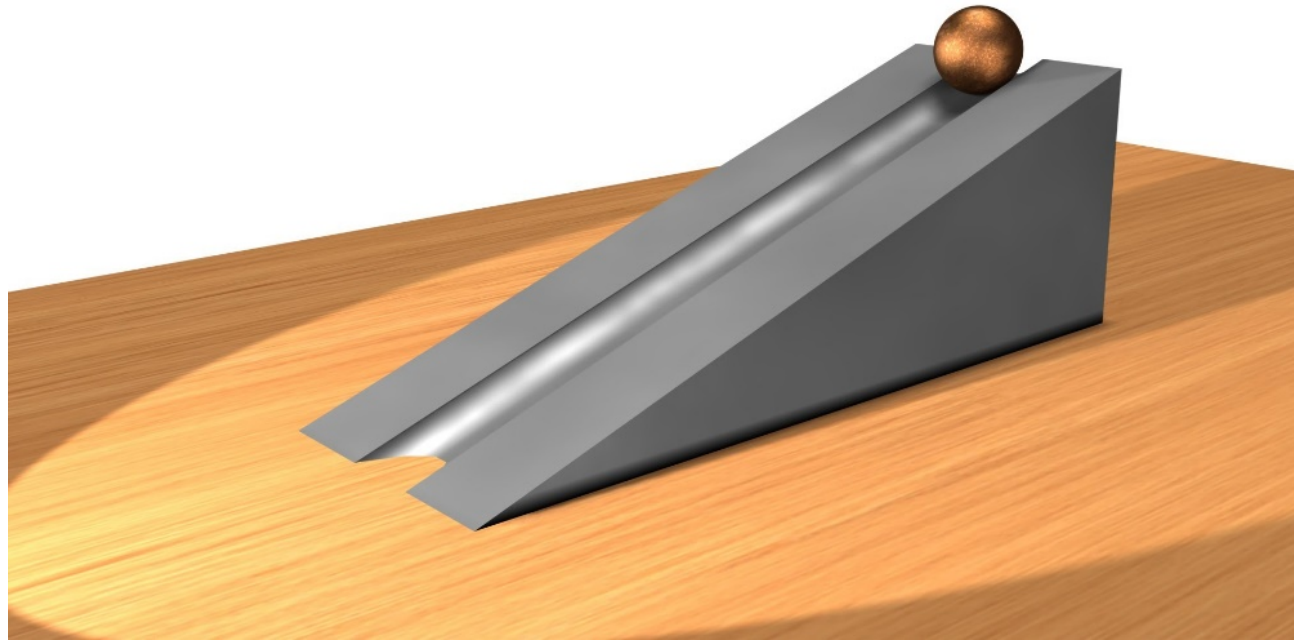


rolling

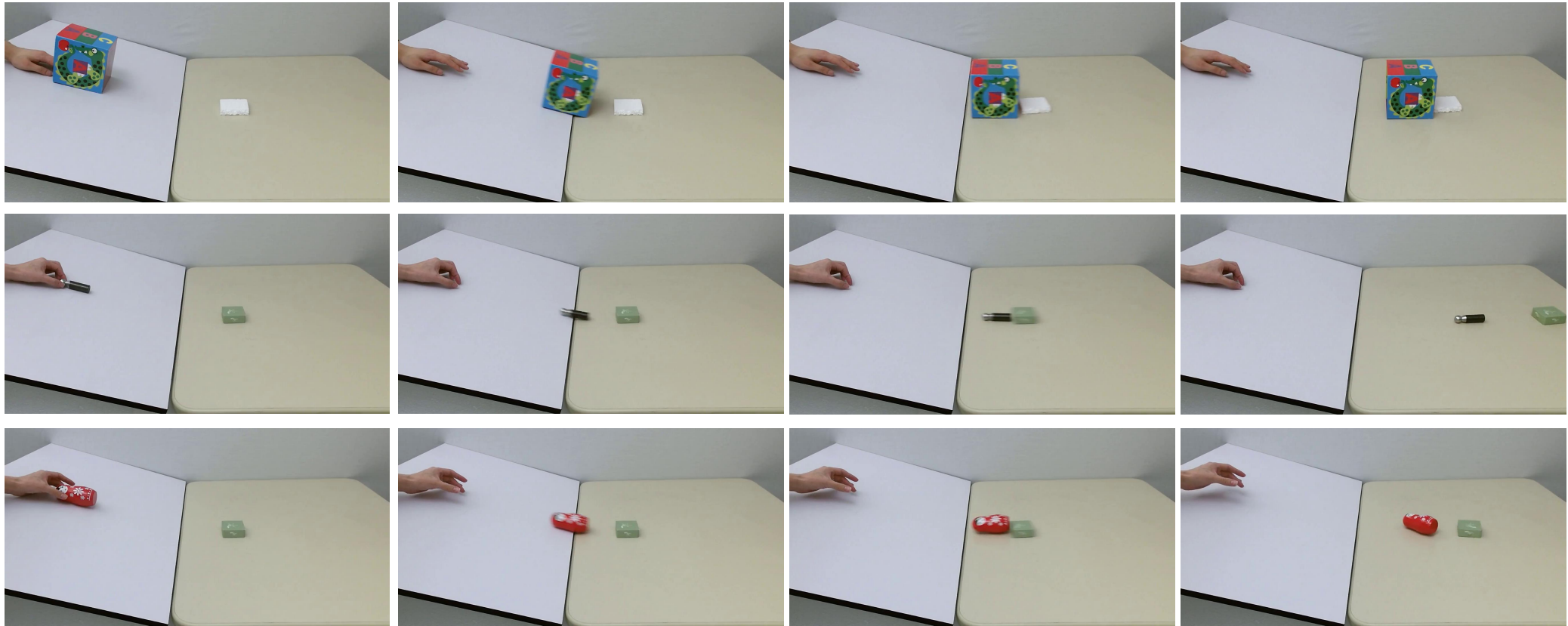
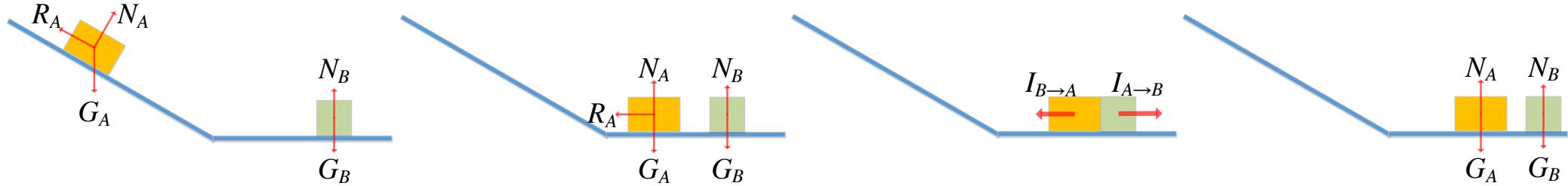
- Humans recover rich information from short videos.
- Generalization: Humans easily answer questions like
  - What will happen next?

# A Simple Scenario in the Real World

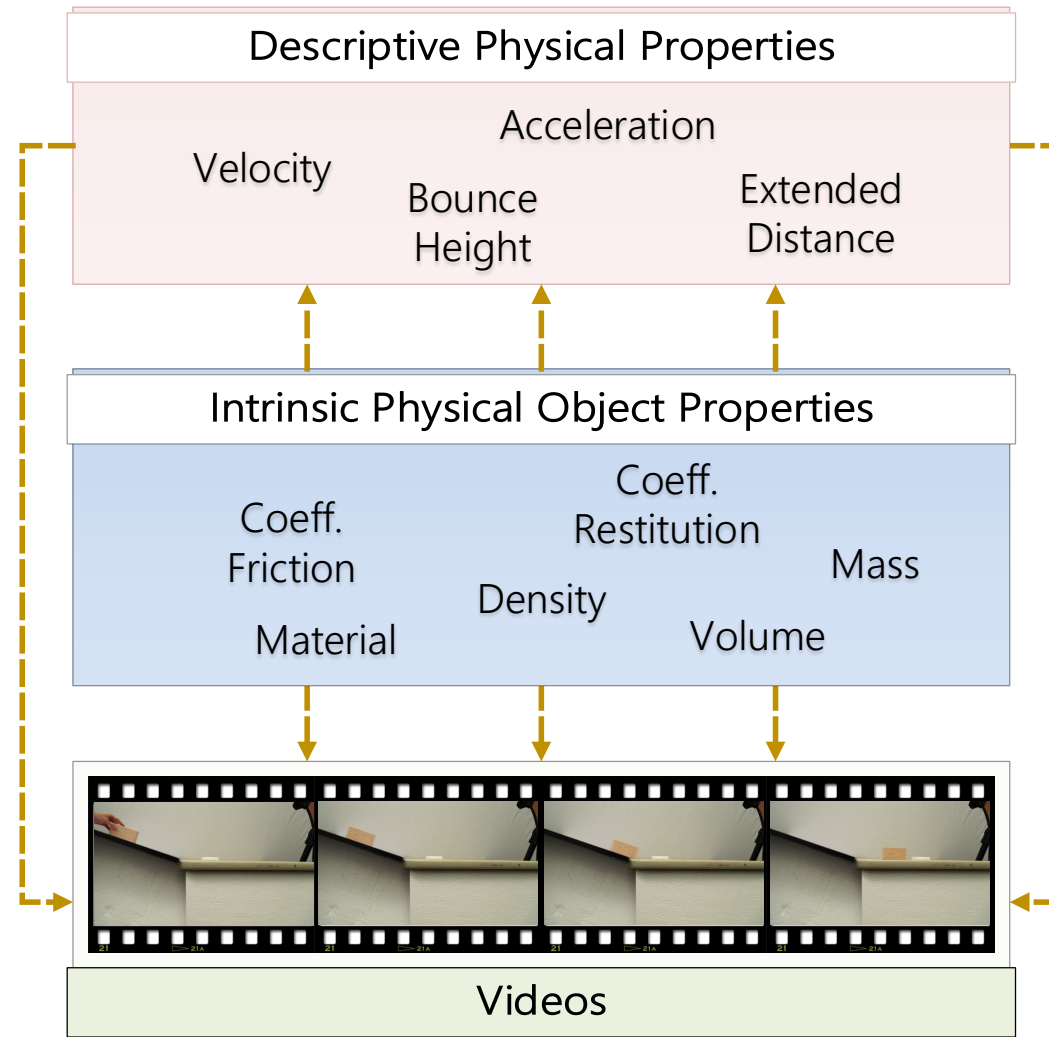
- Galileo's inclined surface experiment



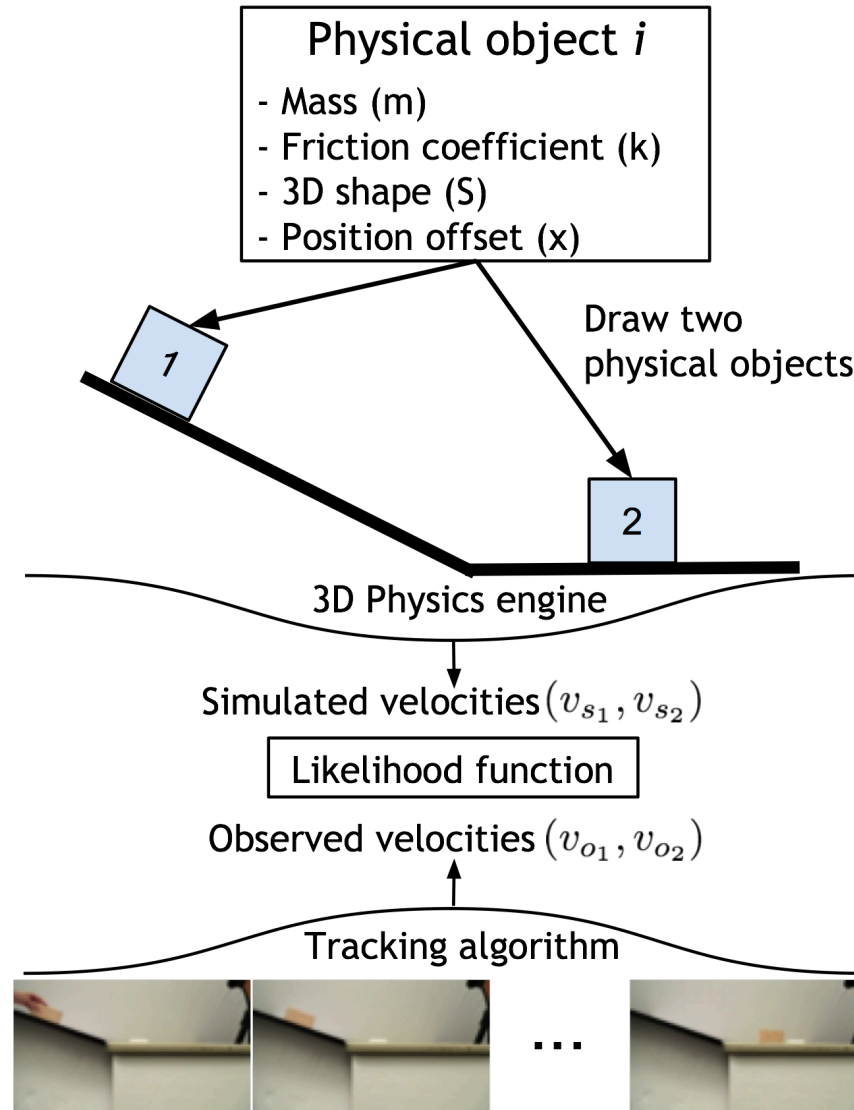
# Rich Physics in Simple Scenarios



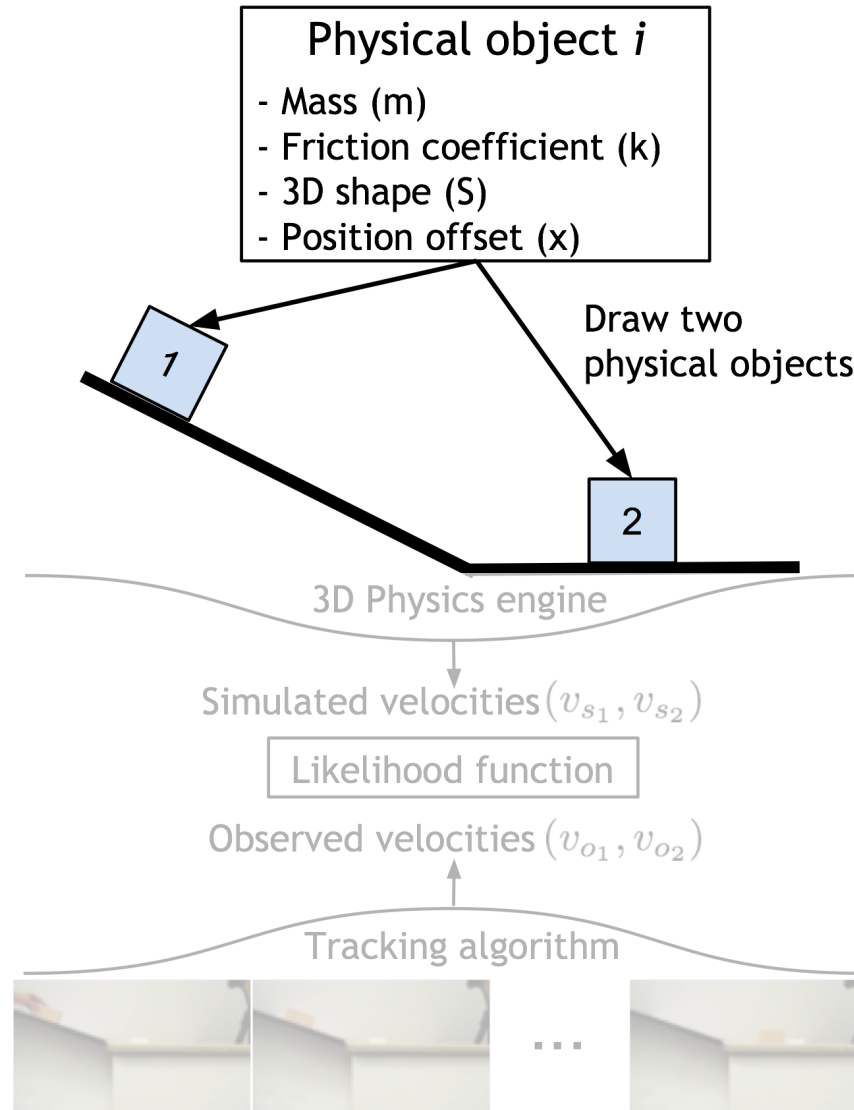
# Modeling the Physical World



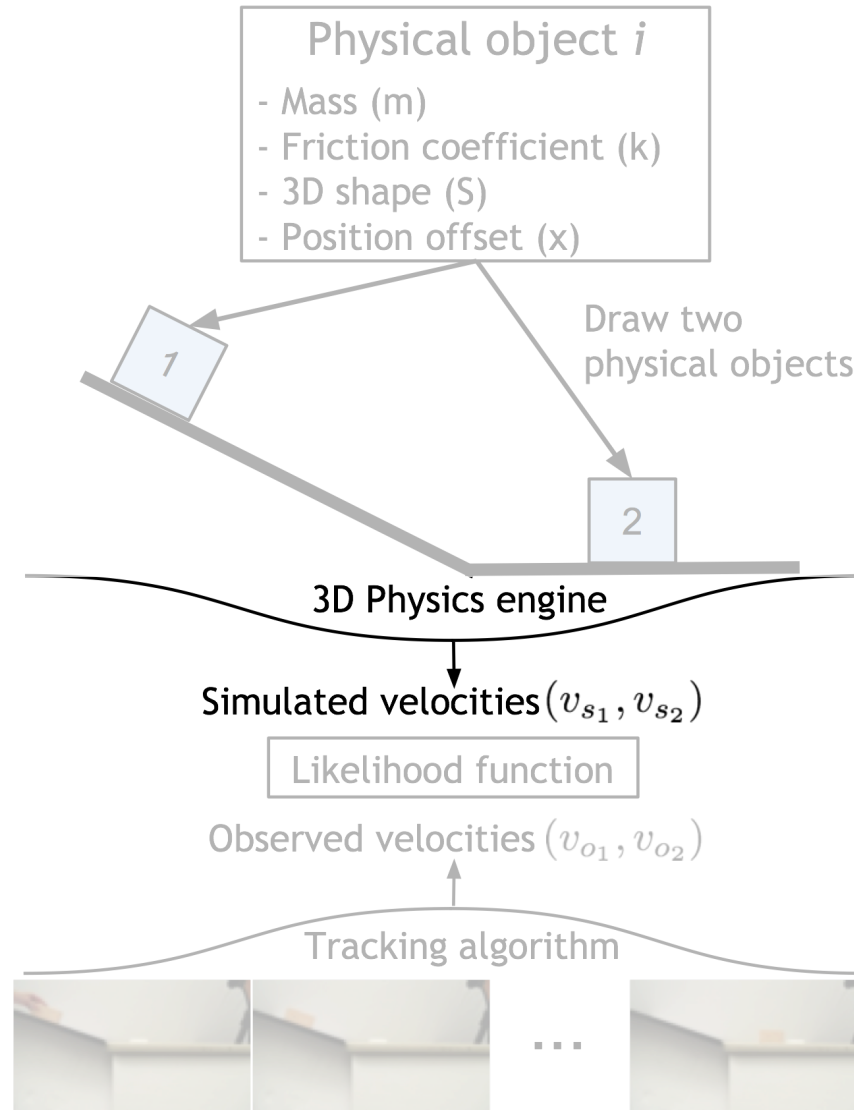
# Our Model: Galileo



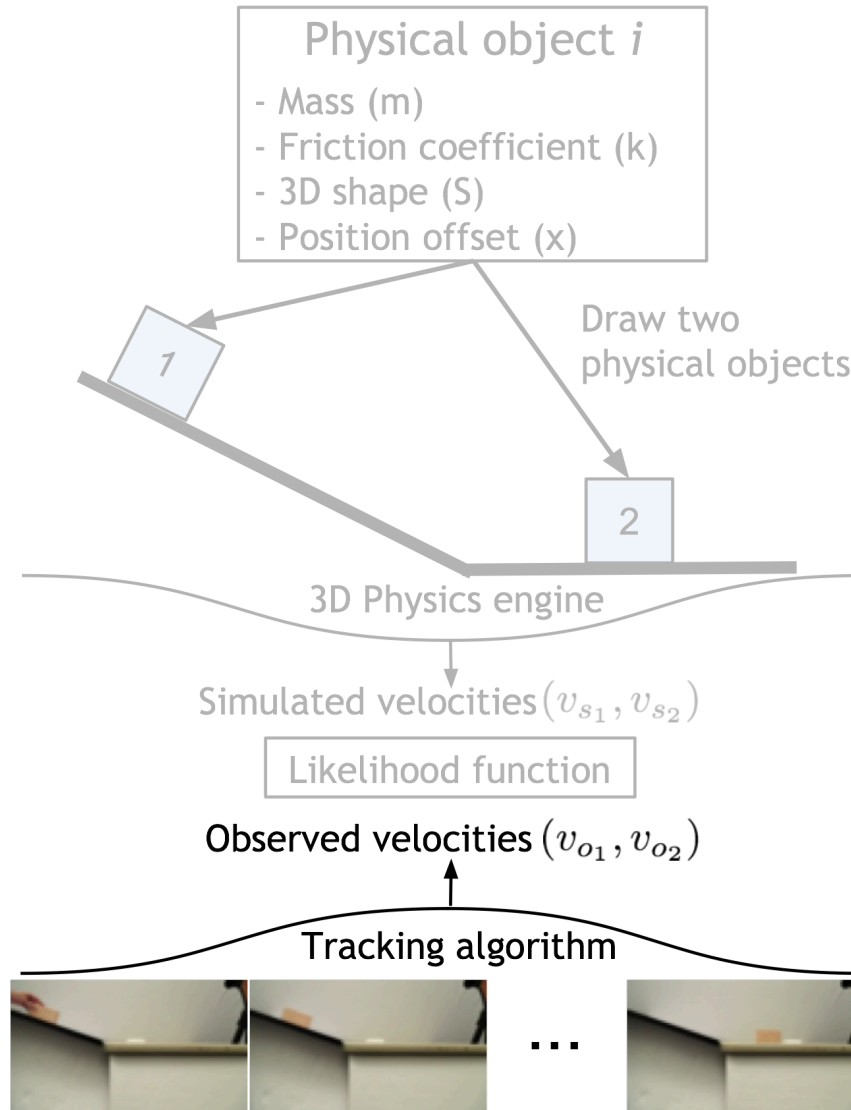
# Our Model: Galileo



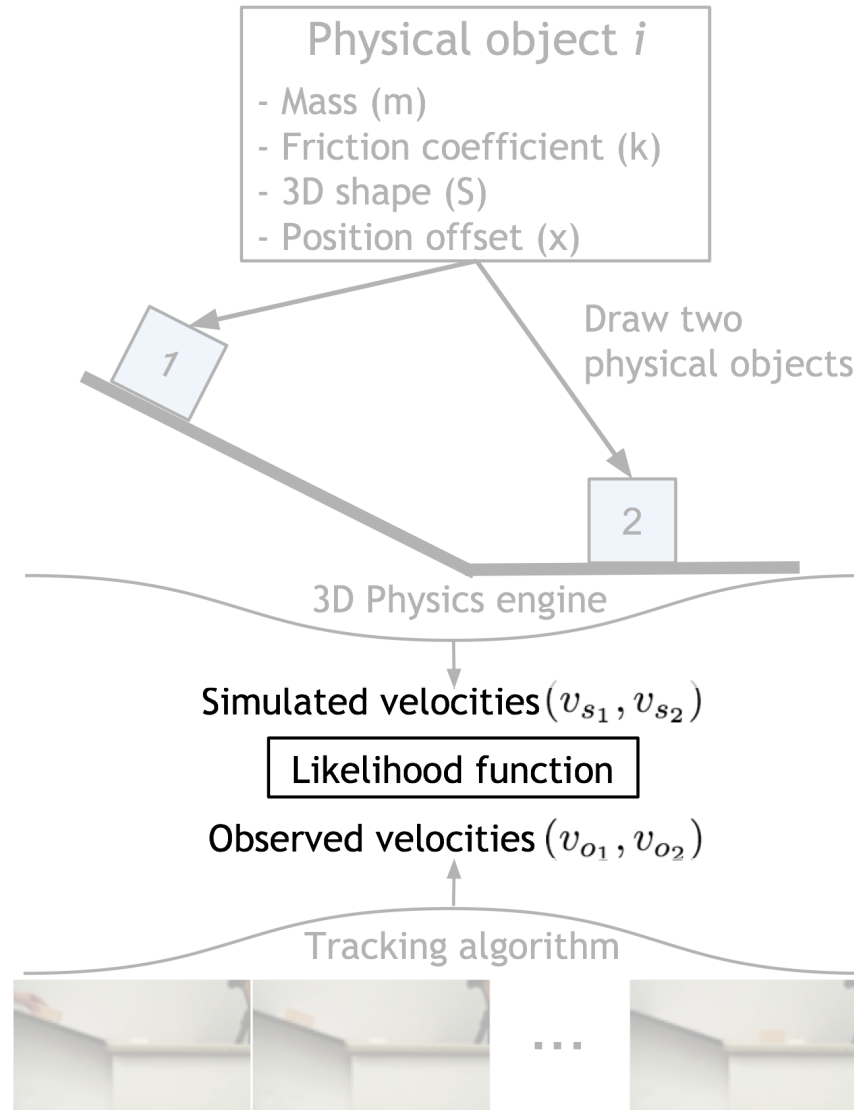
# Our Model: Galileo



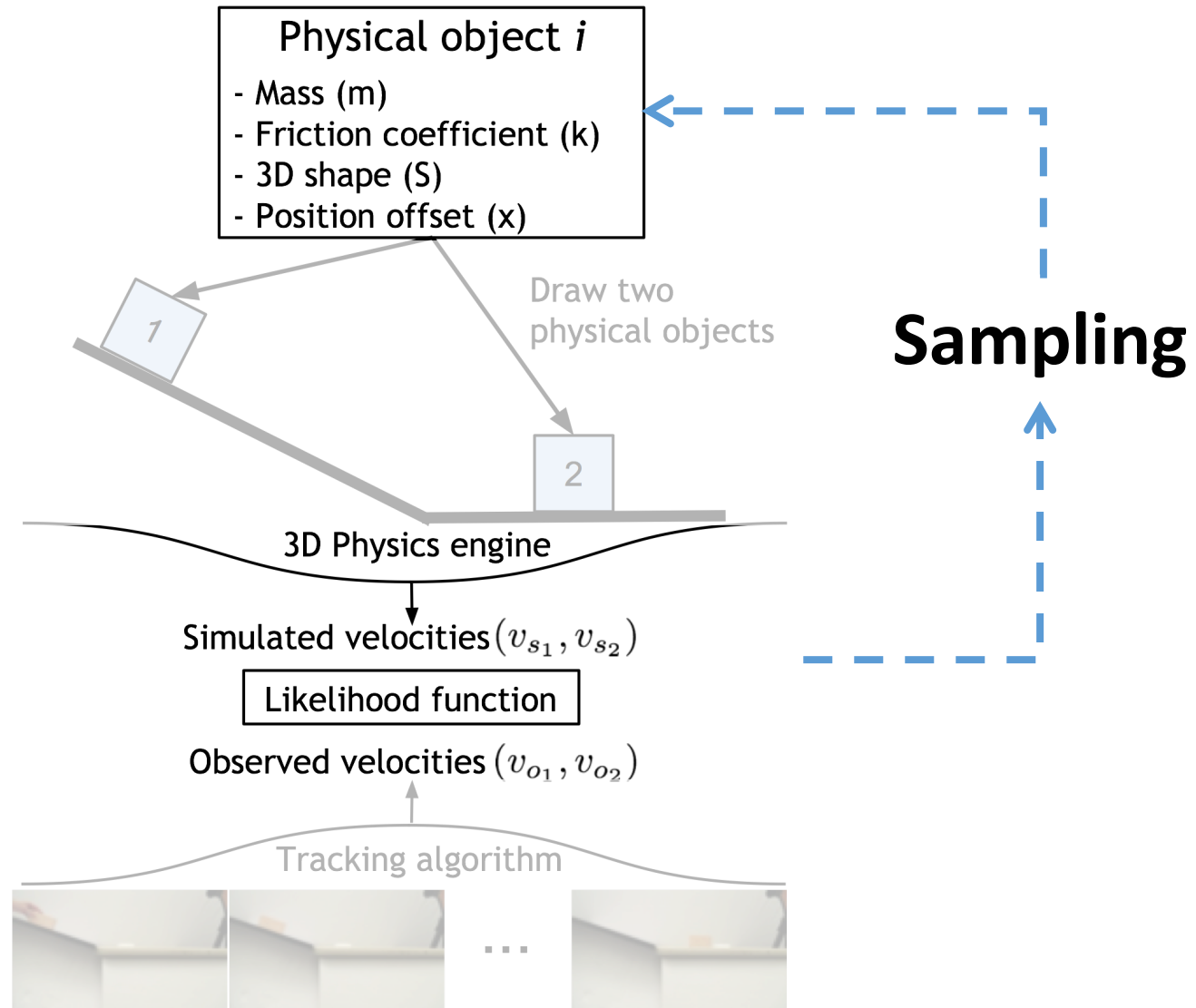
# Our Model: Galileo



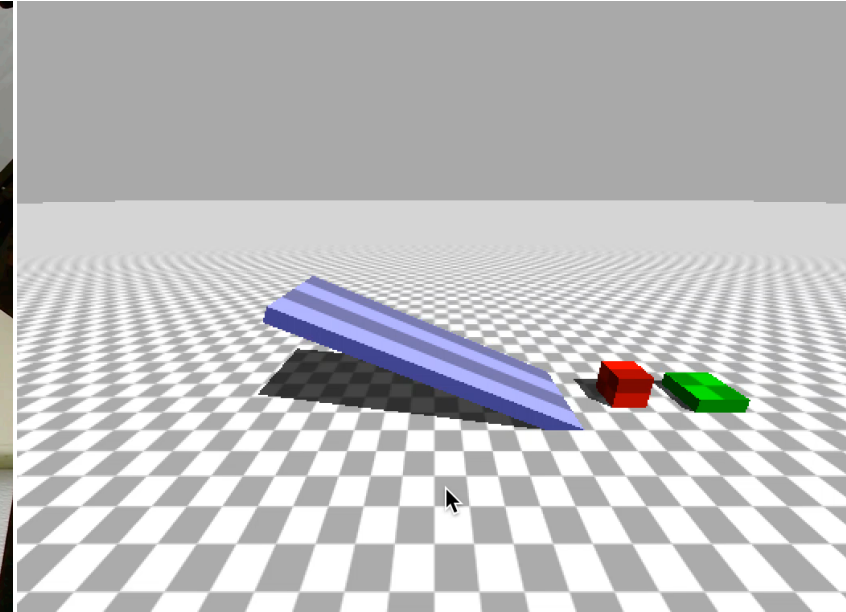
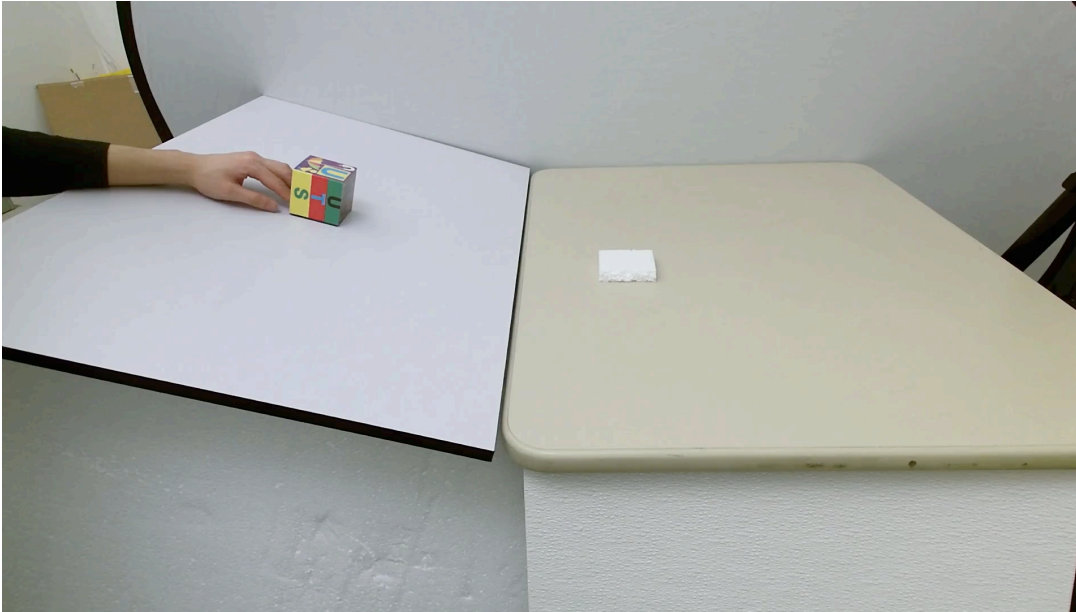
# Our Model: Galileo



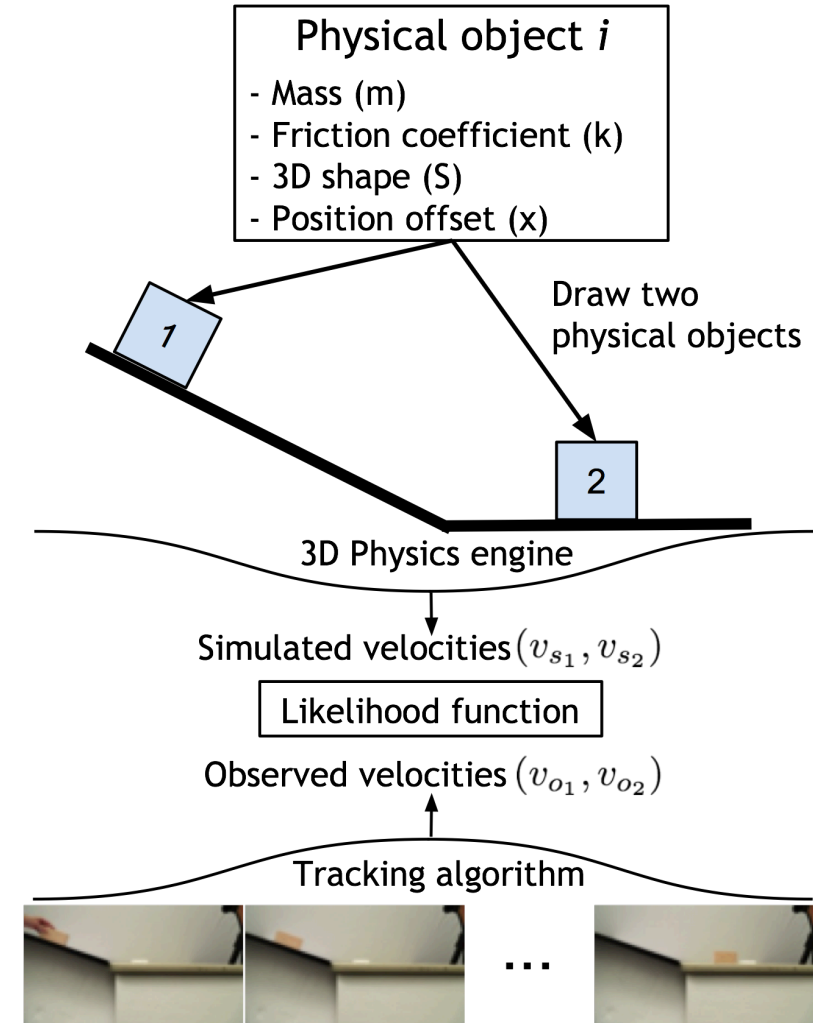
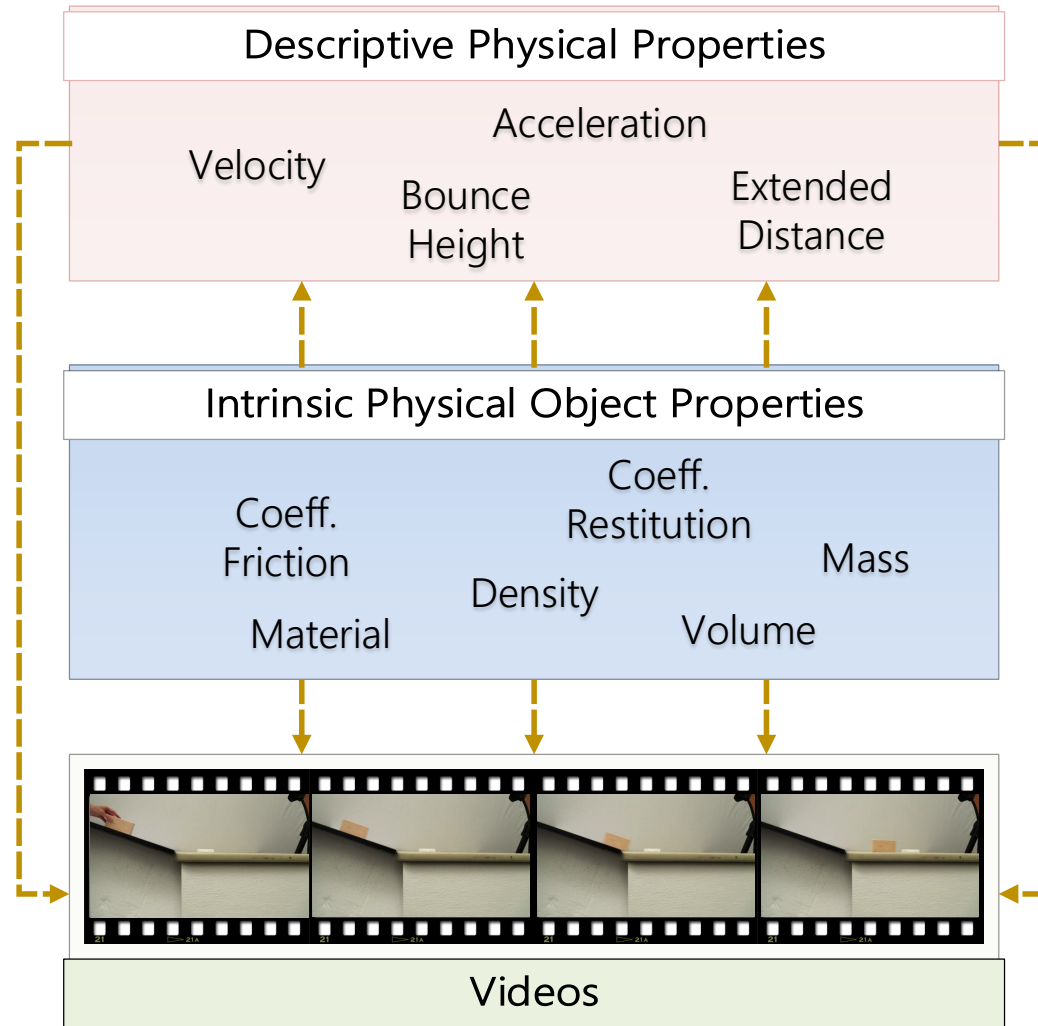
# Our Model: Galileo



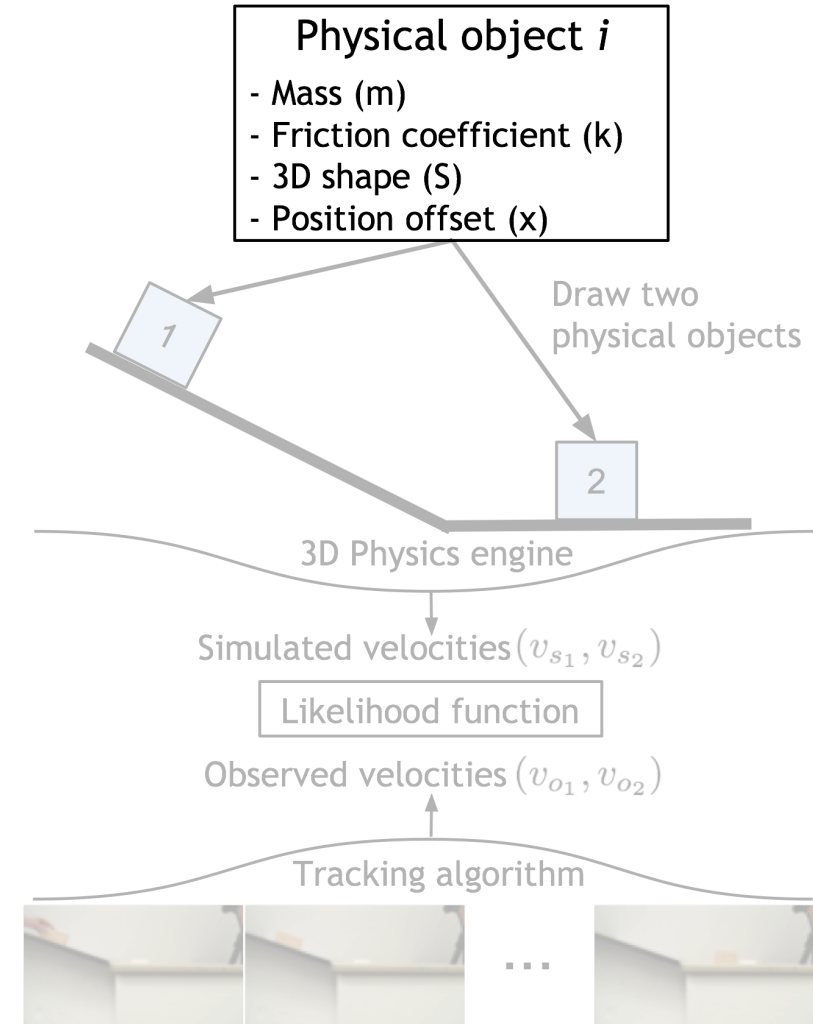
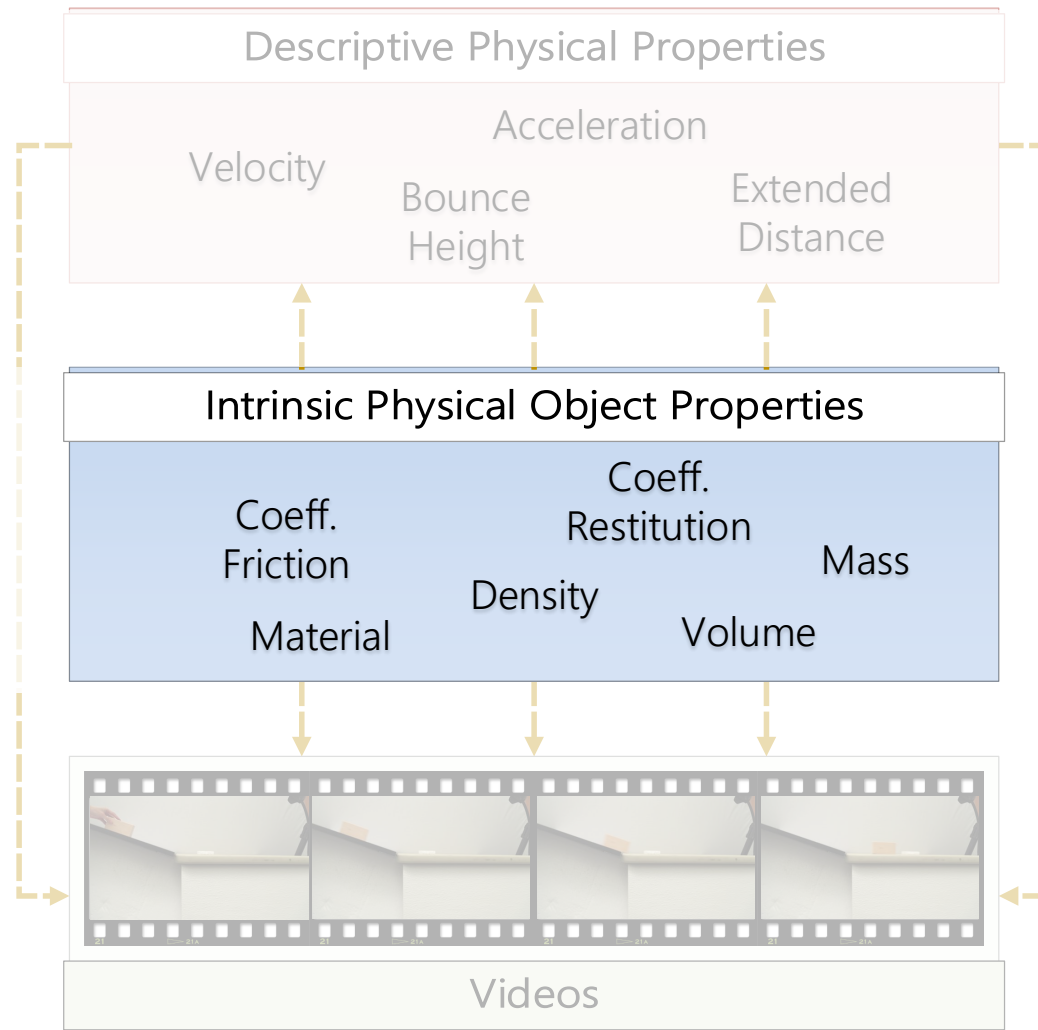
# Results



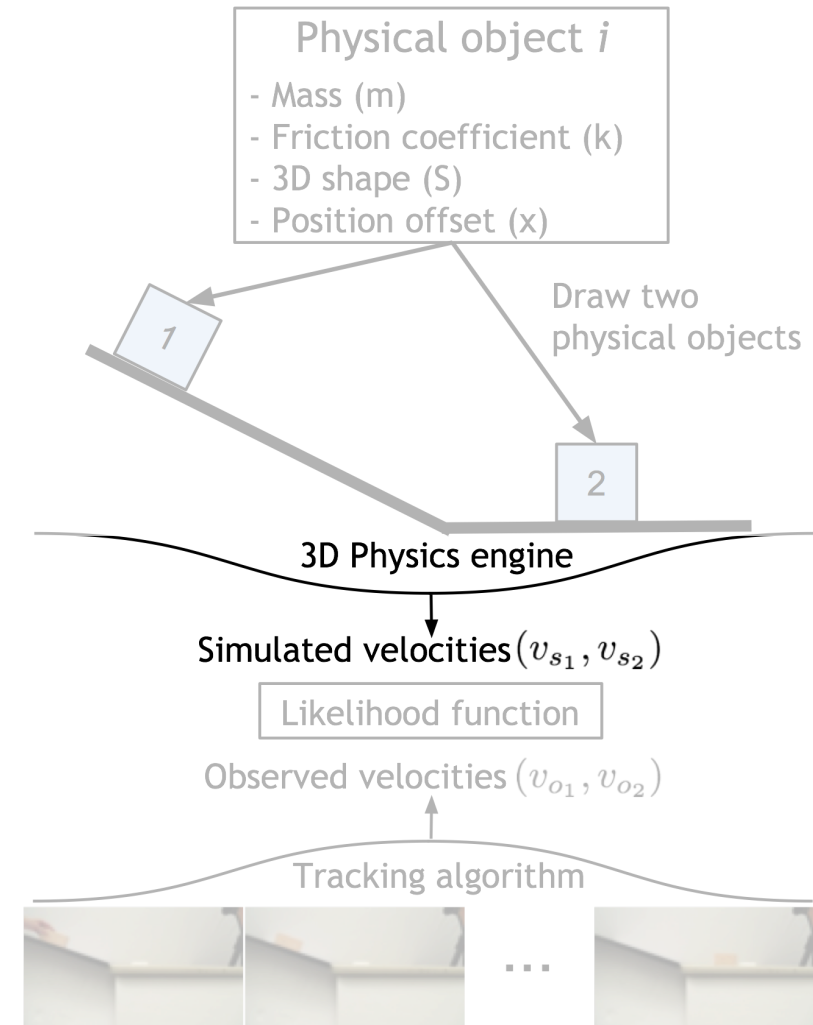
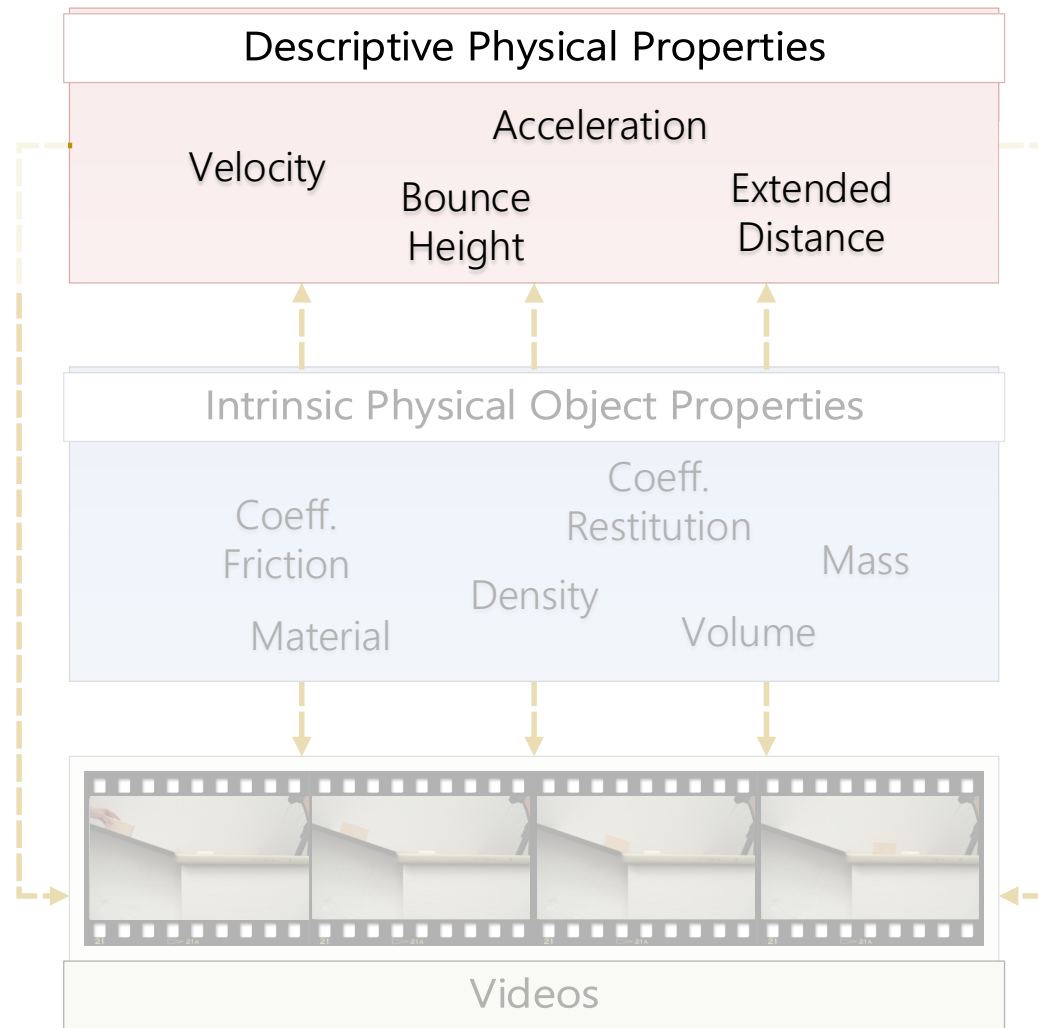
# Galileo as an Interpretation of Physical Scenes



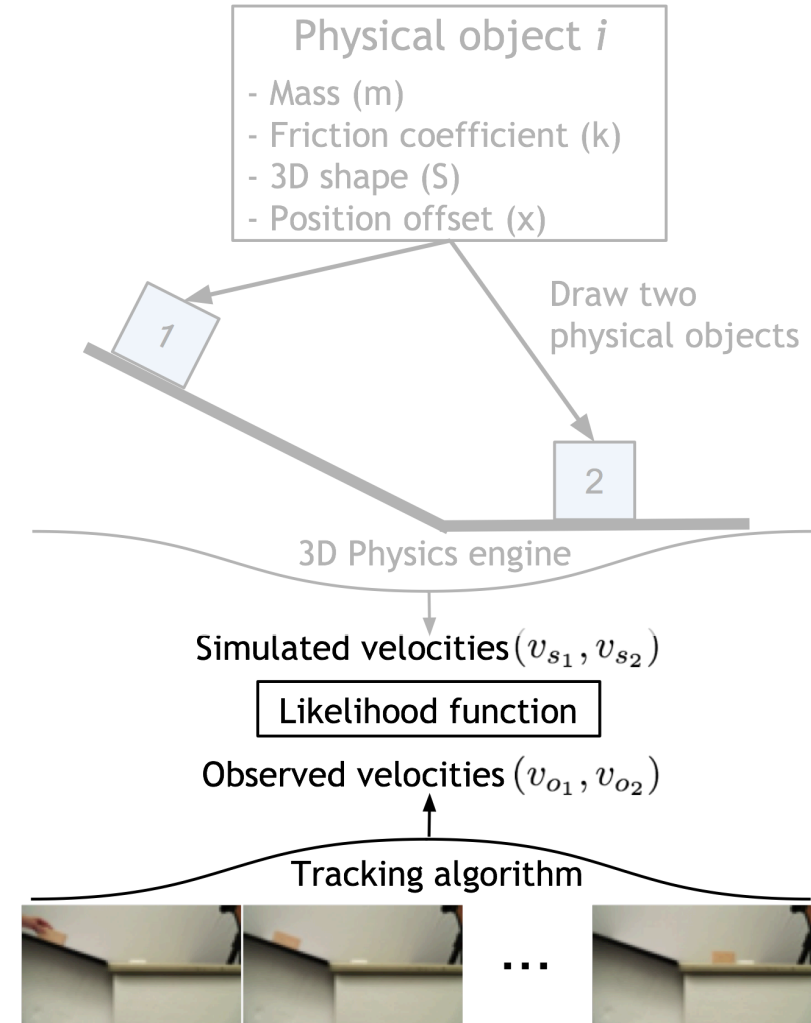
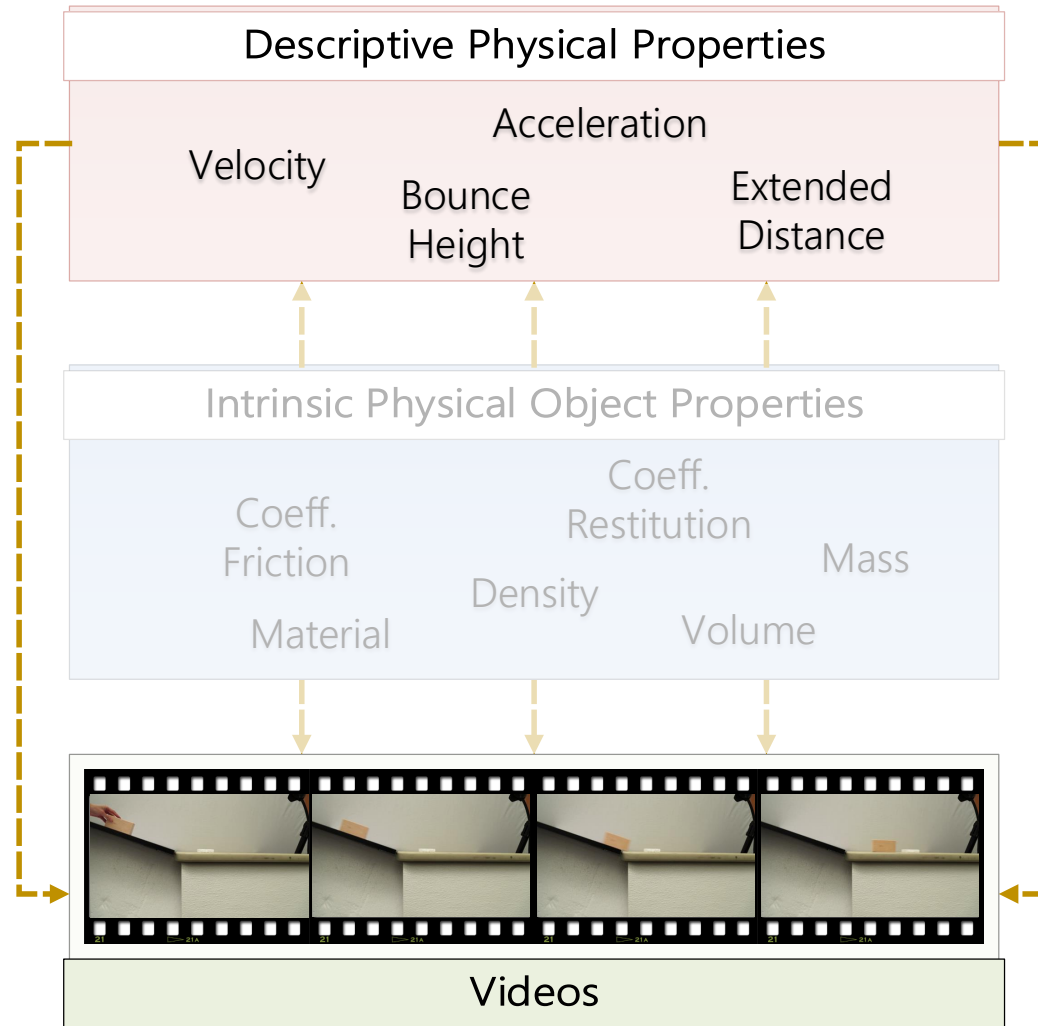
# Galileo as an Interpretation of Physical Scenes



# Galileo as an Interpretation of Physical Scenes

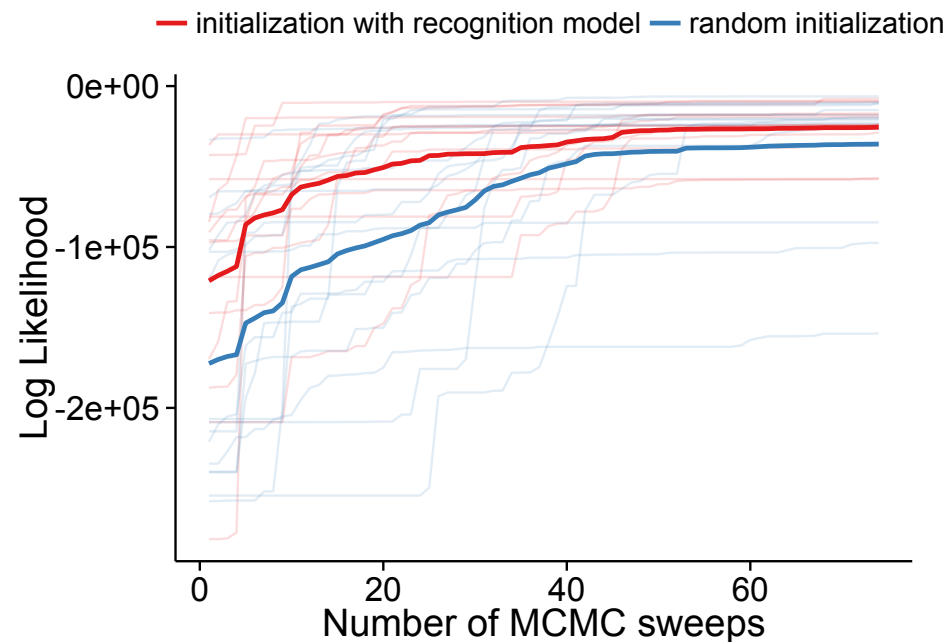
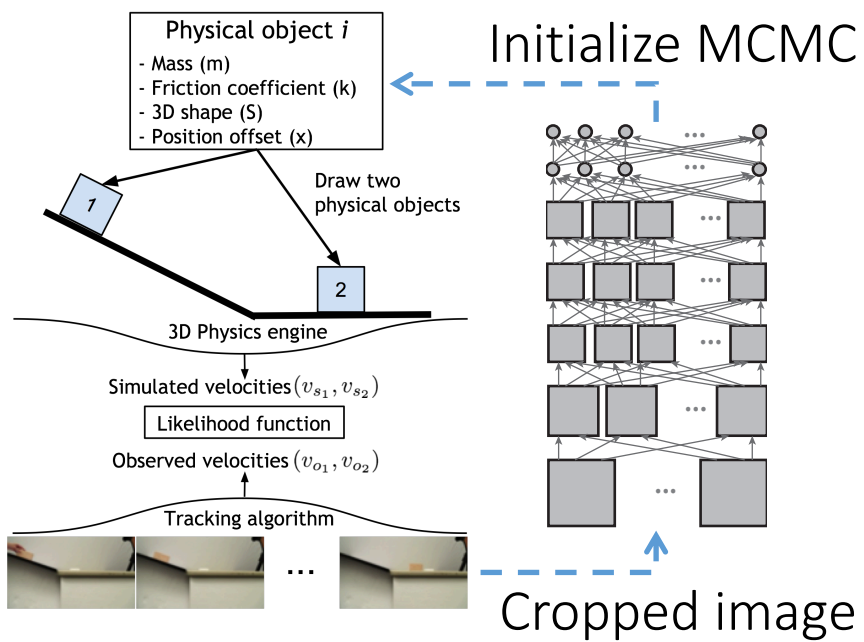
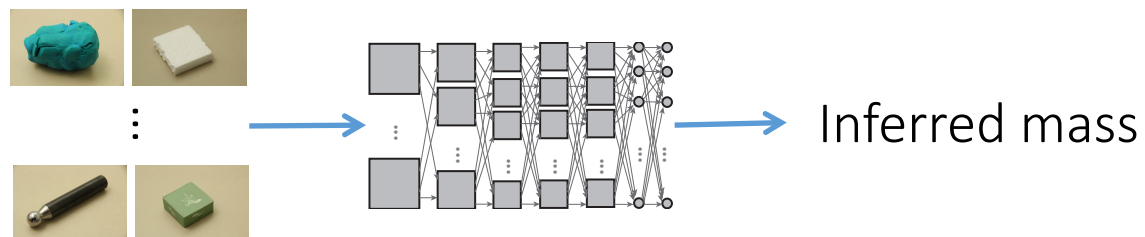


# Galileo as an Interpretation of Physical Scenes



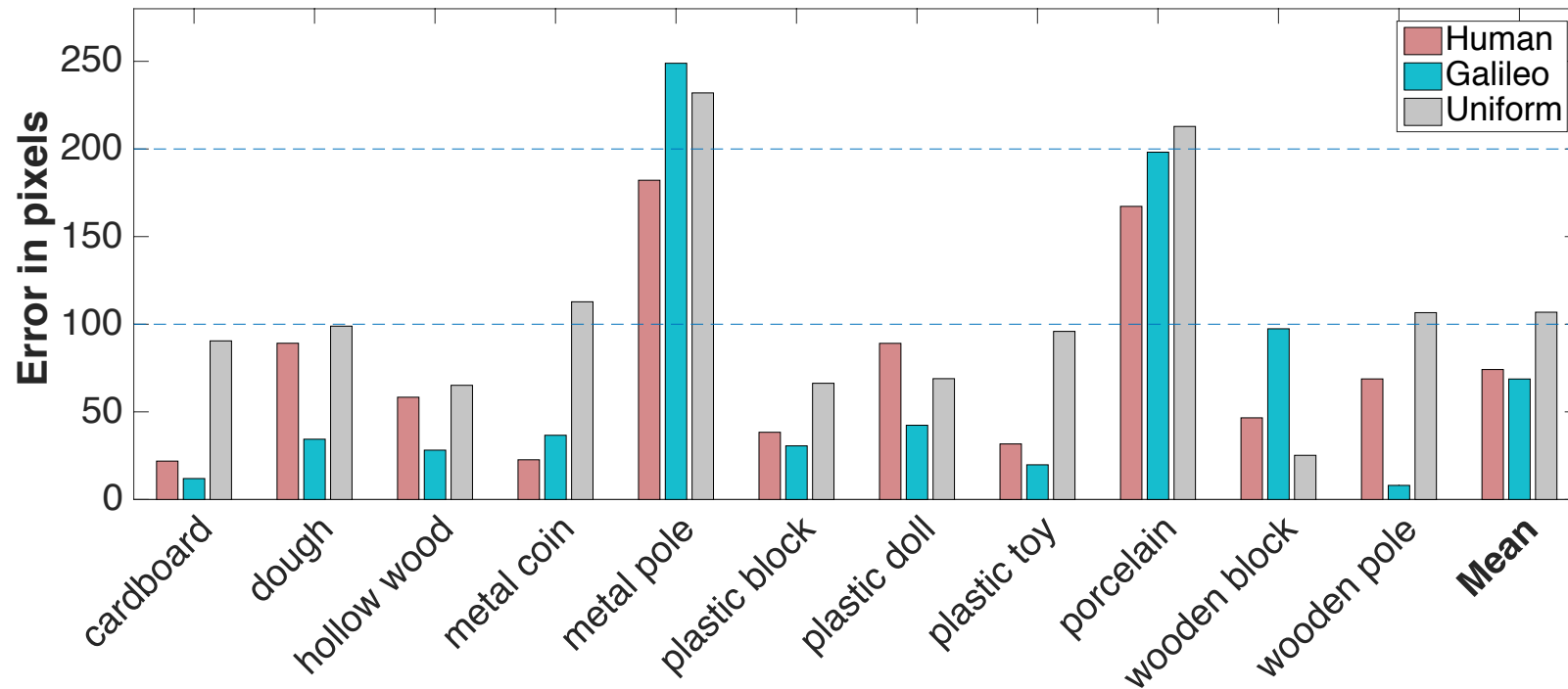
# Generative + Recognition Model

If the model has prior knowledge like humans do...



# Behavior Tests

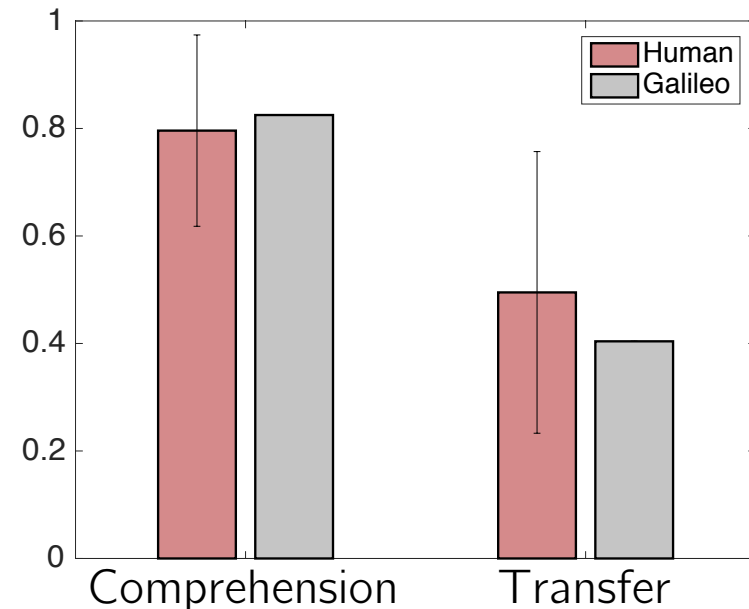
- Prediction task
  - How far will the object travel after collision?



Method	Mean
Human	75.3
Galileo	71.9
Uniform	106.4

# Behavior Tests

- Comprehension task
  - Which of the two objects is heavier?
- Transfer task
  - Will the object slide shown in a new scene setting?



	Comprehension	Transfer
Human vs. Galileo	0.51	0.56
Human vs. Truth	0.68	0.42
Galileo vs. Truth	0.52	0.20

Correlation coefficients between pairs of responses