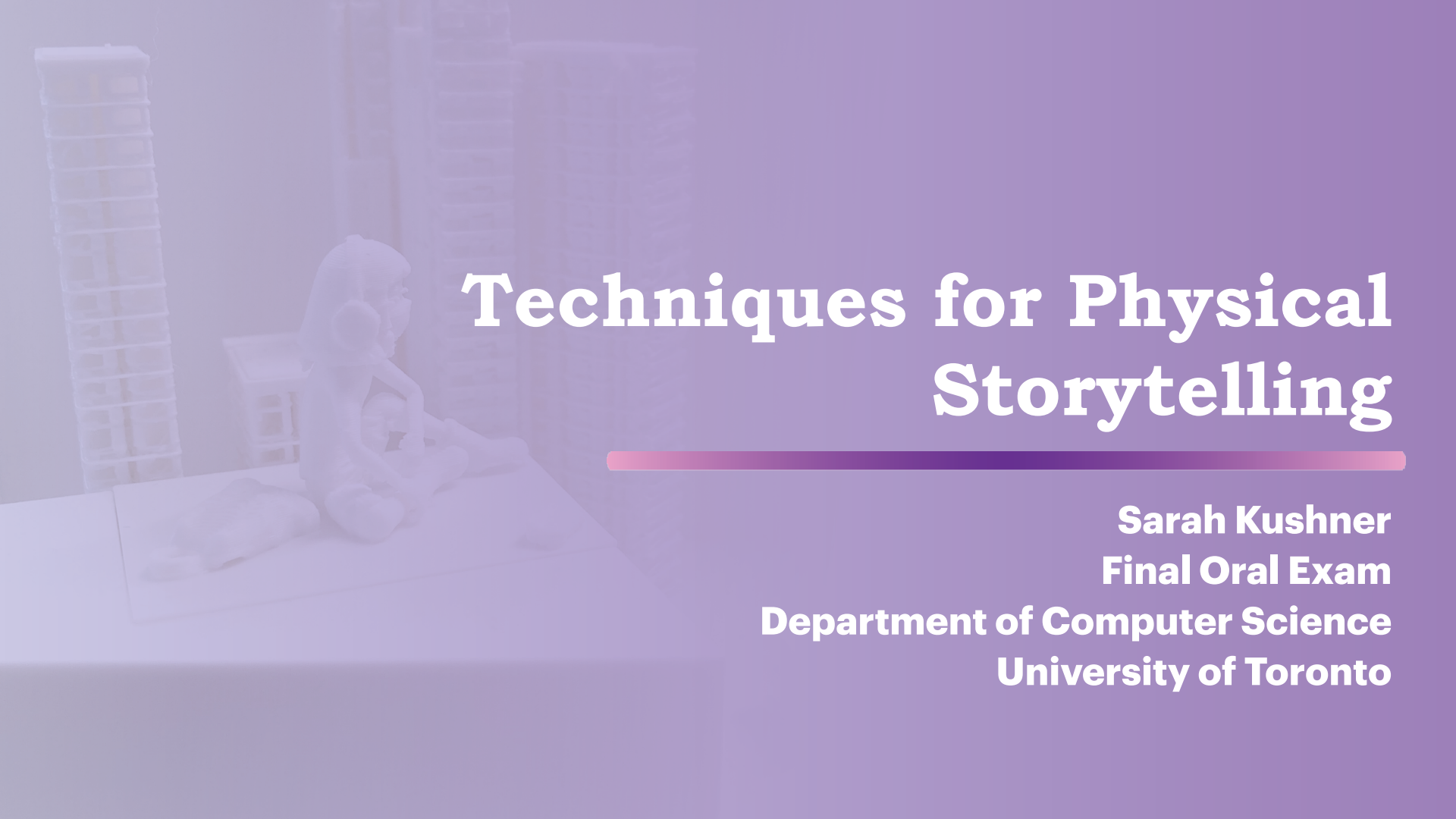




Techniques for Physical Storytelling

Sarah Kushner
Final Oral Exam
Department of Computer Science
University of Toronto

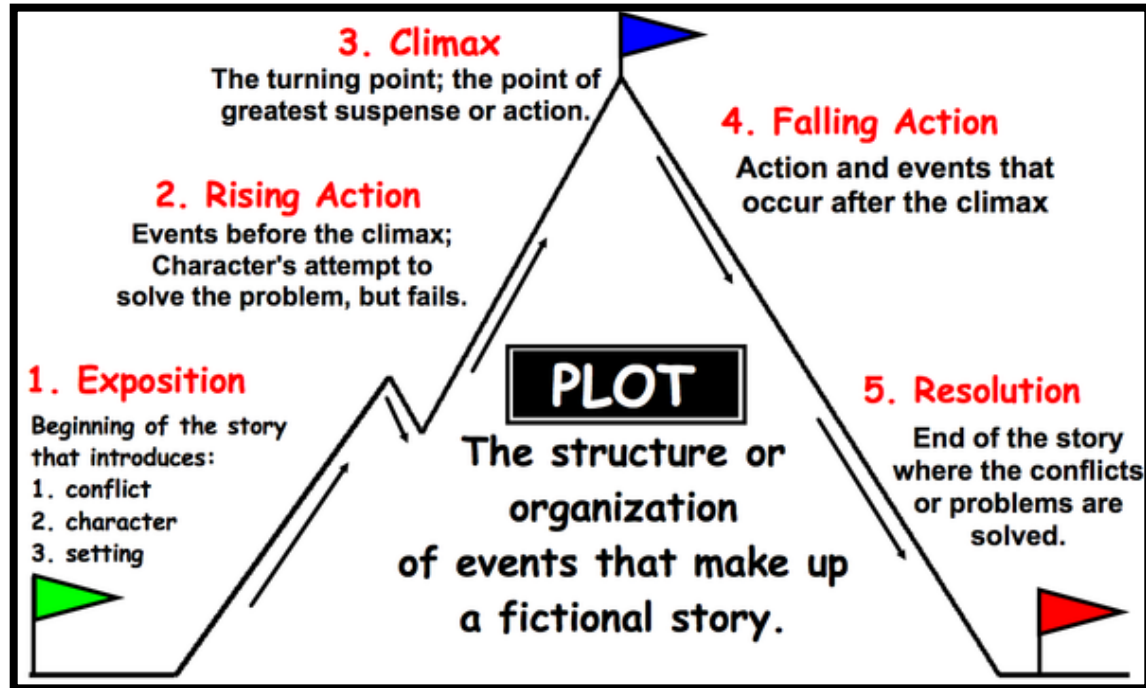
Large, abstract, overlapping purple shapes of various shades on the left side of the slide, including a large top-left shape and a smaller circle below it.

**What is a Physical Story &
why do we tell them?**



What is a Story?

What is a Story?



What is a *Physical* Story?



What is a *Physical Story*?

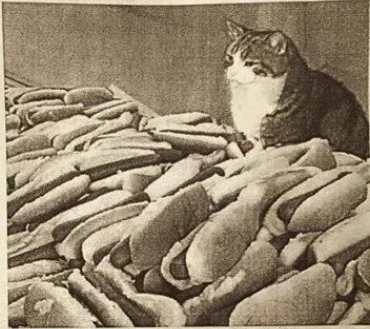


Karine Giboulo's exhibit (Housewarming, 2022)
Gardiner Museum in Toronto, ON, Canada.

Stories in still images

Name Lola

Write a story to match this picture. Use capitals and punctuation.



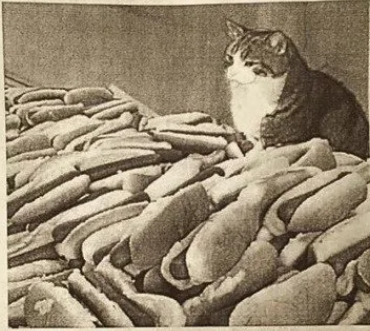
I ordered pizza!
Not hot dogs. I want
PIZZA! I AM SO MAD!

photo, story by Lola

Stories in still images

Name Lola

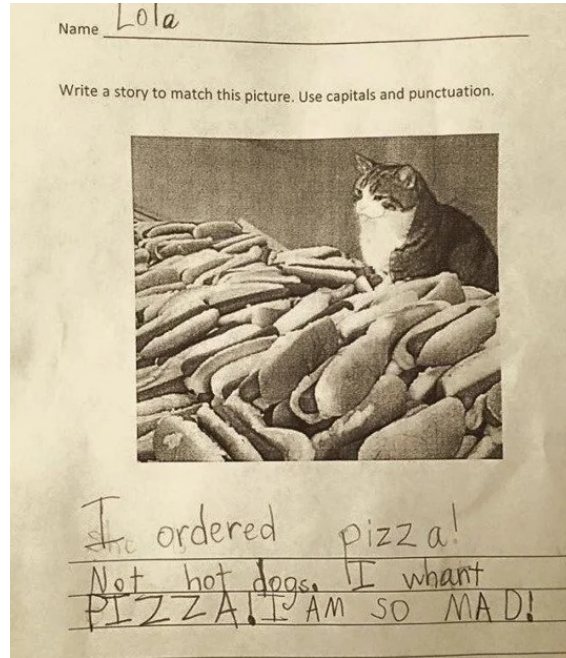
Write a story to match this picture. Use capitals and punctuation.



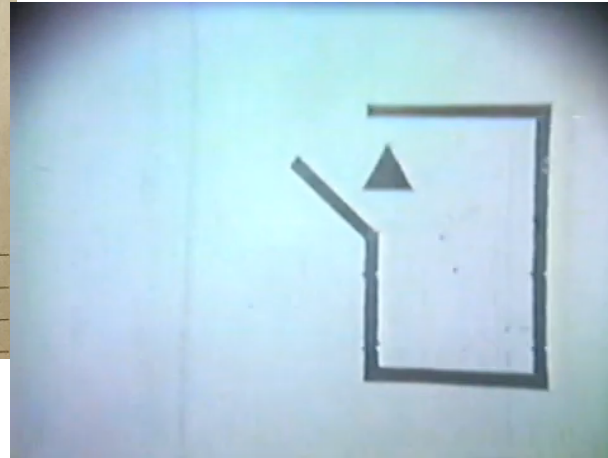
I ordered pizza!
Not hot dogs. I want
PIZZA! I AM SO MAD!

photo, story by Lola

Stories in moving images

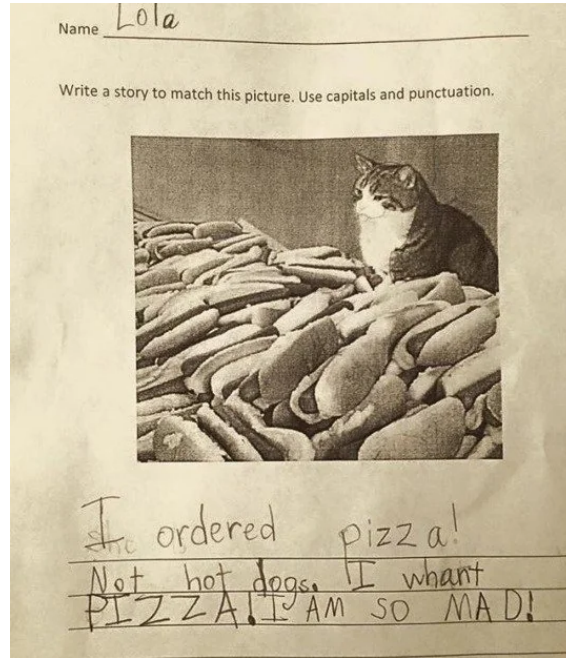


photo, story by Lola

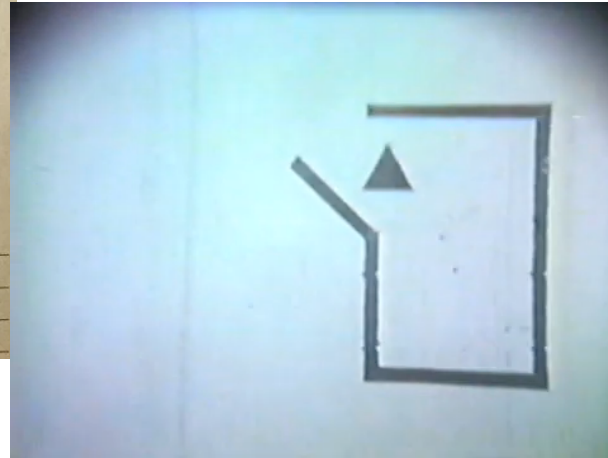


Abstract Film (Heider-Simmel Animation, 1944)

Stories in moving images

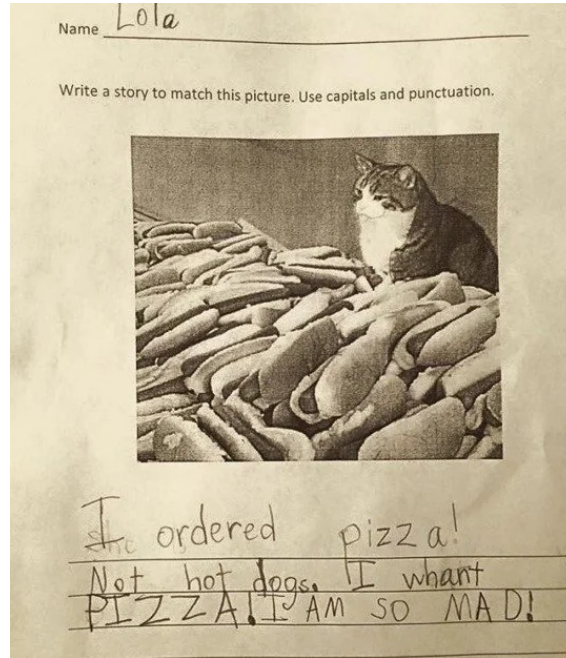


photo, story by Lola

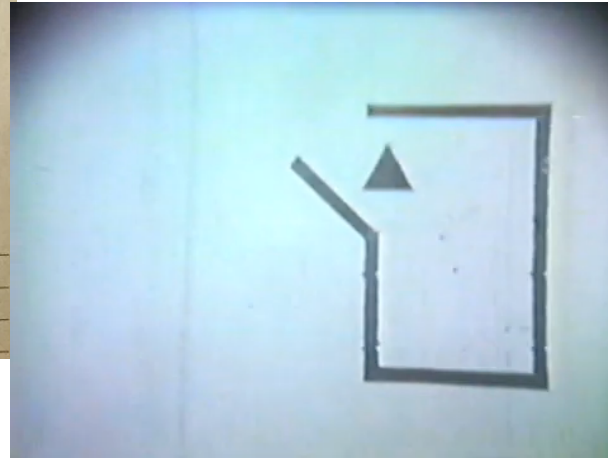


Abstract Film (Heider-Simmel Animation, 1944)

Stories in moving images

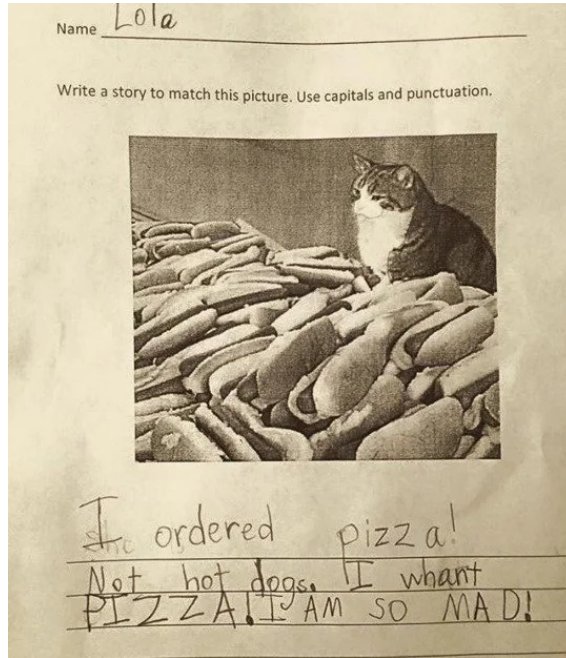


photo, story by Lola

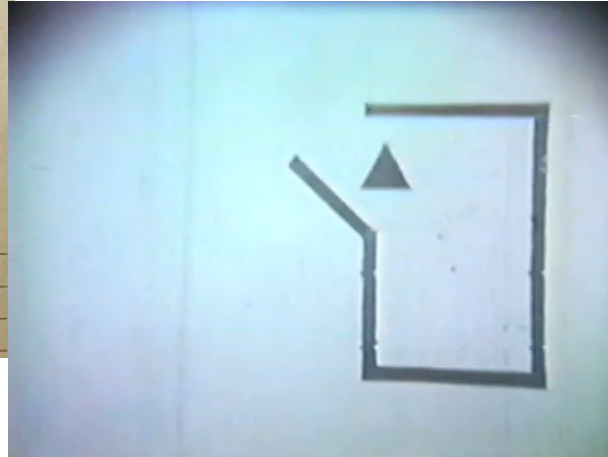


Abstract Film (Heider-Simmel Animation, 1944)

Stories in moving sculptures

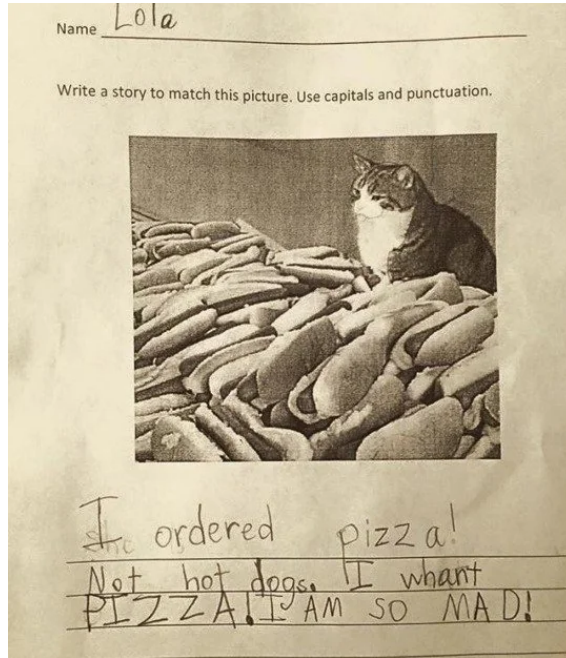


photo, story by Lola

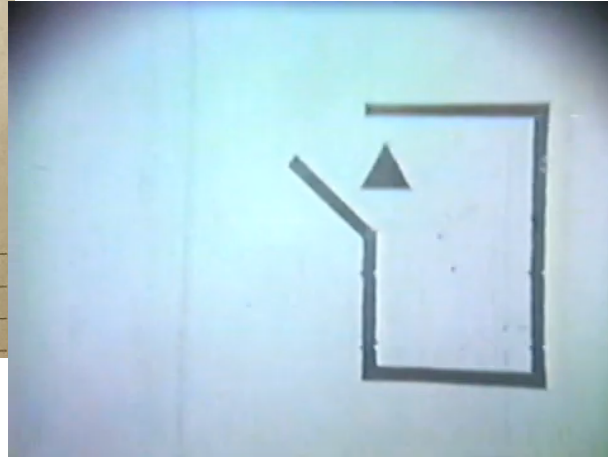


Abstract Film (Heider-Simmel Animation, 1944)

Stories in moving sculptures

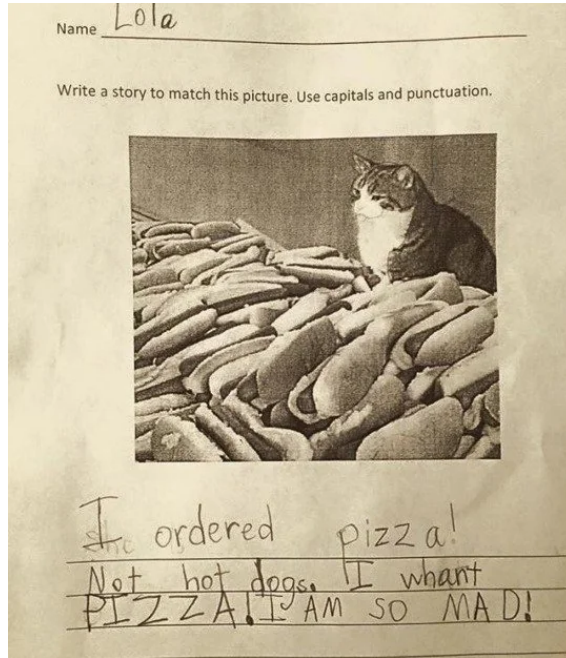


photo, story by Lola

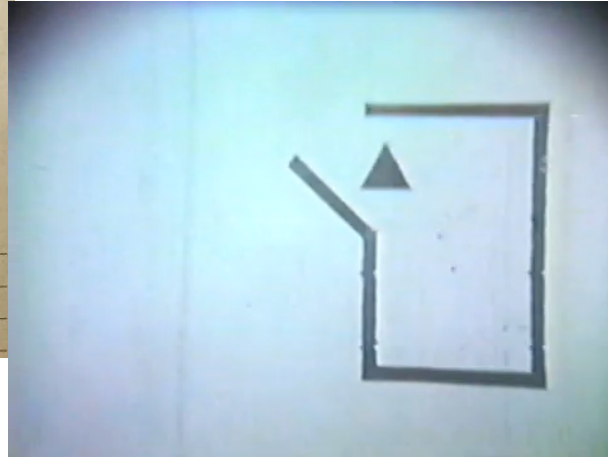


Abstract Film (Heider-Simmel Animation, 1944)

Stories in moving sculptures

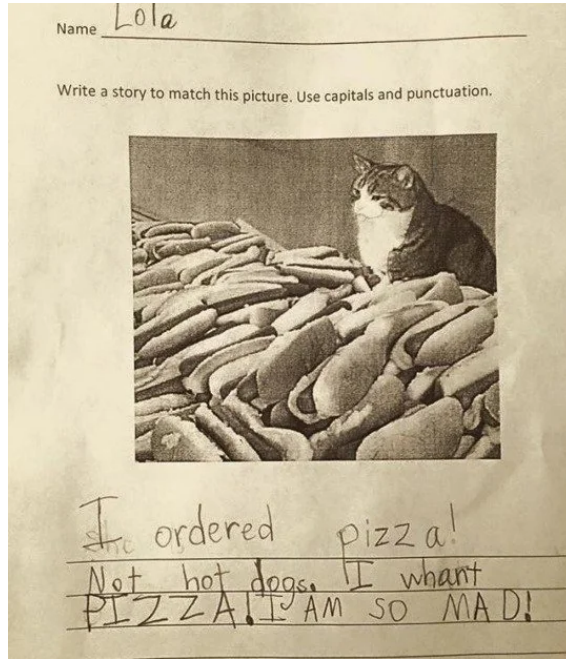


photo, story by Lola

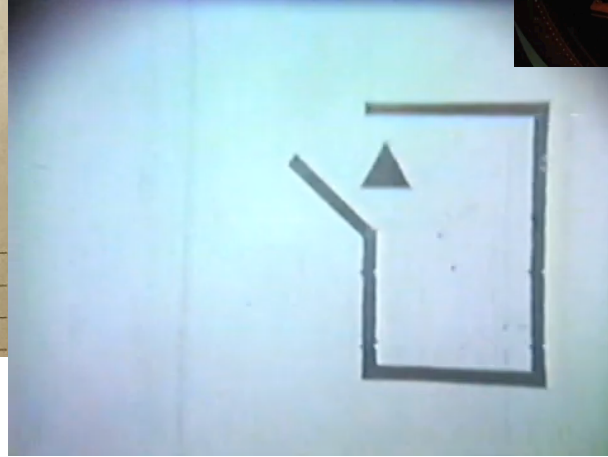


Abstract Film (Heider-Simmel Animation, 1944)

Stories in moving sculptures



photo, story by Lola



Abstract Film (Heider-Simmel Animation, 1944)



Amusement park ride (Symbolica, Efteling, 2017)



Why do we tell stories?

Why do we tell stories?

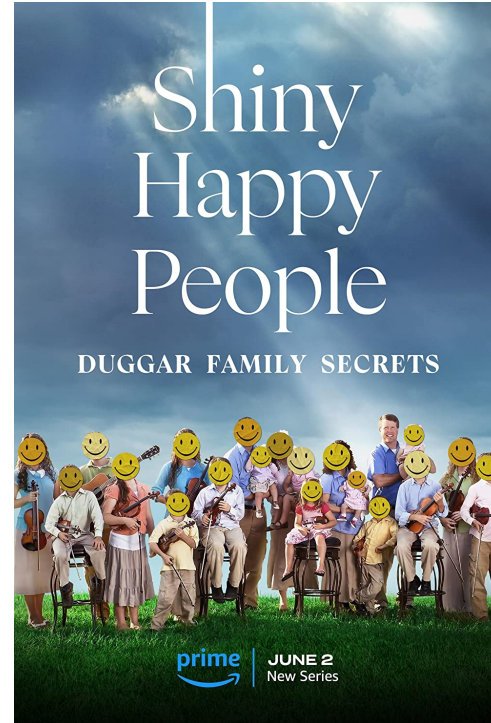


Paul teaching Grade 6 students
about animatronics

Why do we tell stories?



Paul teaching Grade 6 students about animatronics



Documentary film (Shiny Happy People, 2023)



Why do we tell stories?

Why do we tell stories?



Stand up comedy (Sabrina Wu on Verified Stand-up, 2023)

Why do we tell stories?



Stand up comedy (Sabrina Wu on Verified Stand-up, 2023)



My friend Sarah excited to meet Stitch at Disney World



Why do we tell stories?

Why do we tell stories?



CBC show about a non-binary character (Sort Of, 2021)

Why do we tell stories?



CBC show about a non-binary character (Sort Of, 2021)



Grade 6 student showing her Grade 2 friend the story she wrote

Why do we tell physical stories?

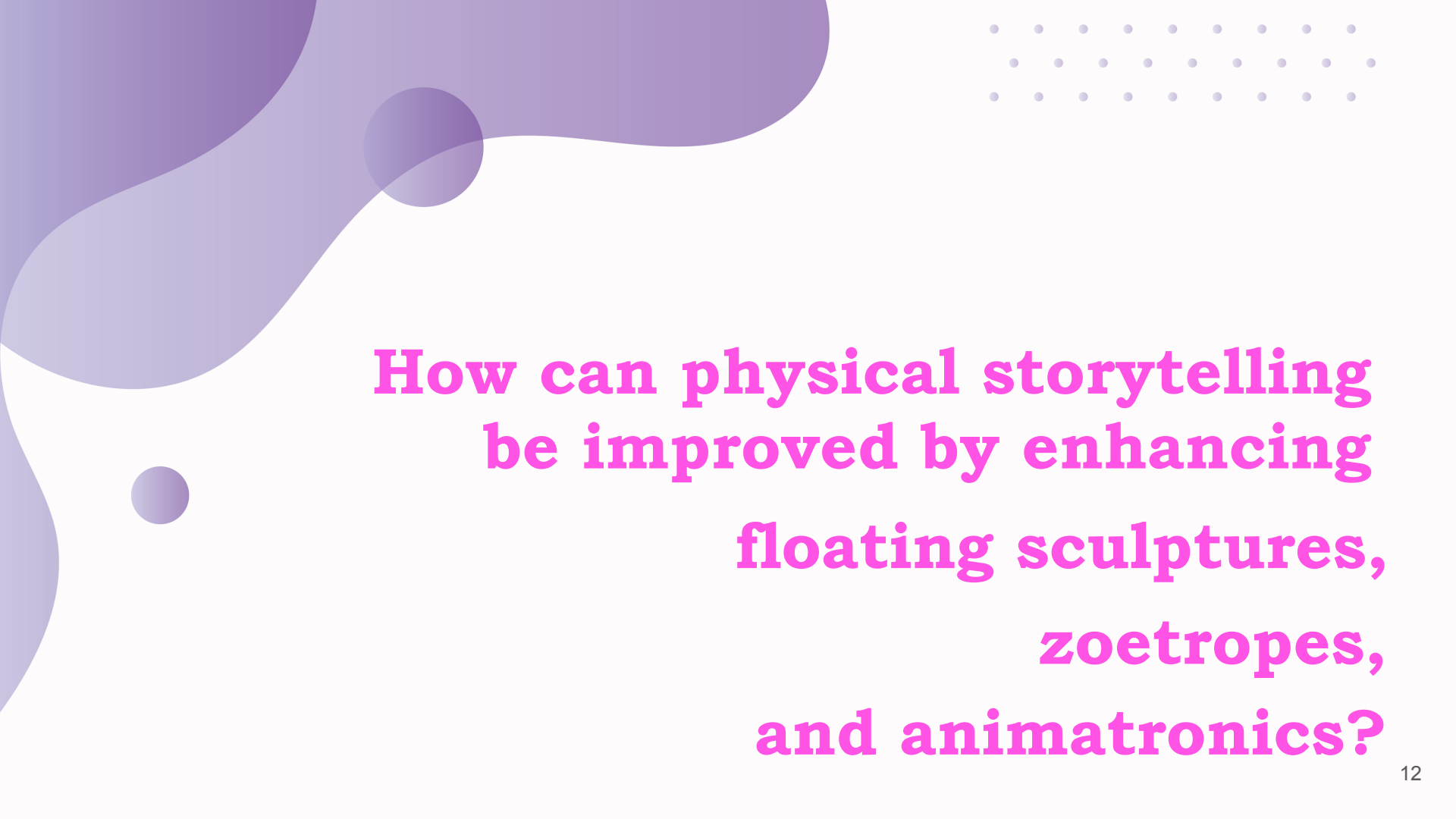


Pirates of the Caribbean, Disney World

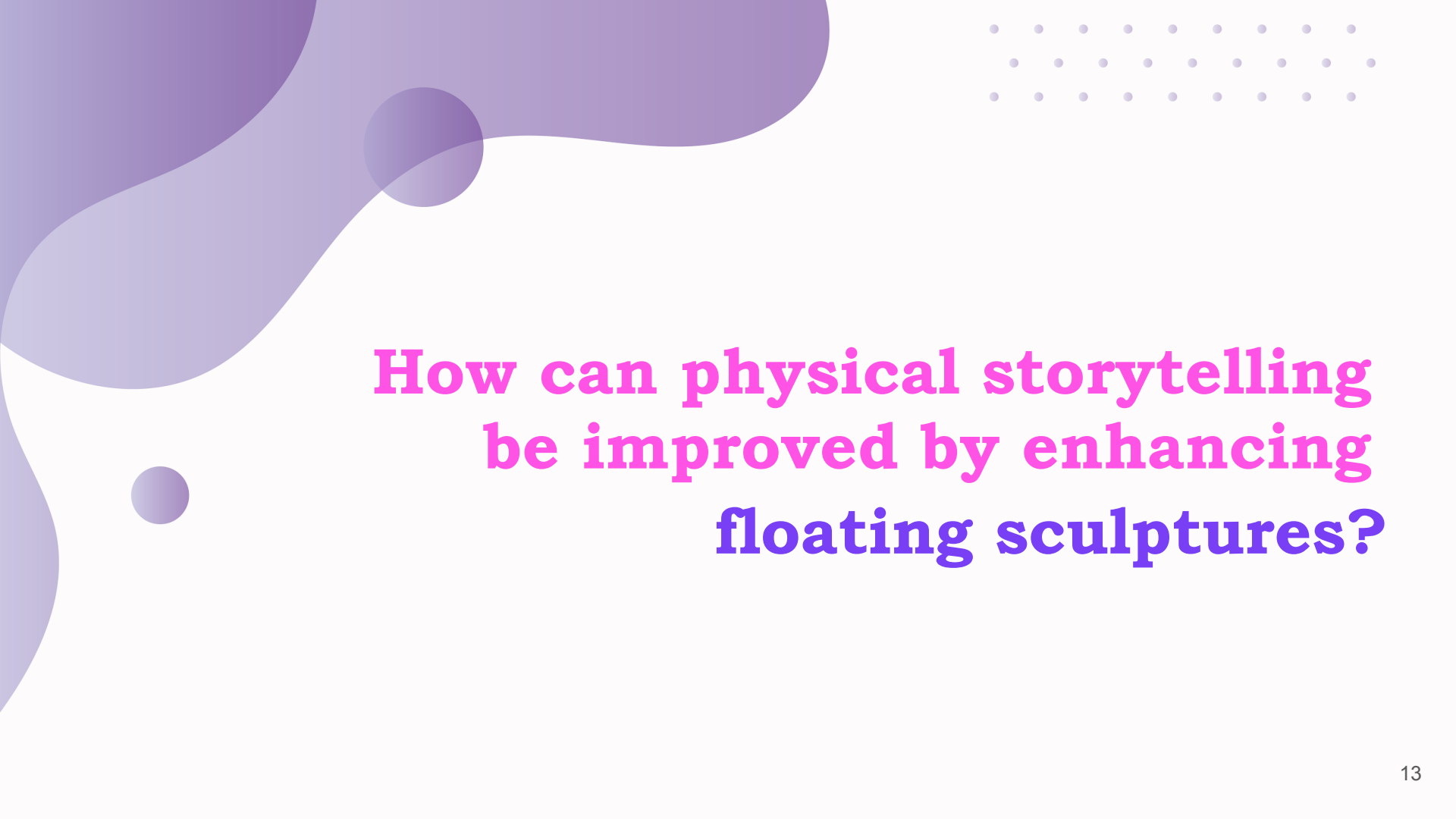
Why do we tell physical stories?



Pirates of the Caribbean, Disney World



**How can physical storytelling
be improved by enhancing
floating sculptures,
zoetropes,
and animatronics?**



**How can physical storytelling
be improved by enhancing
floating sculptures?**

Floating Sculptures



Why?

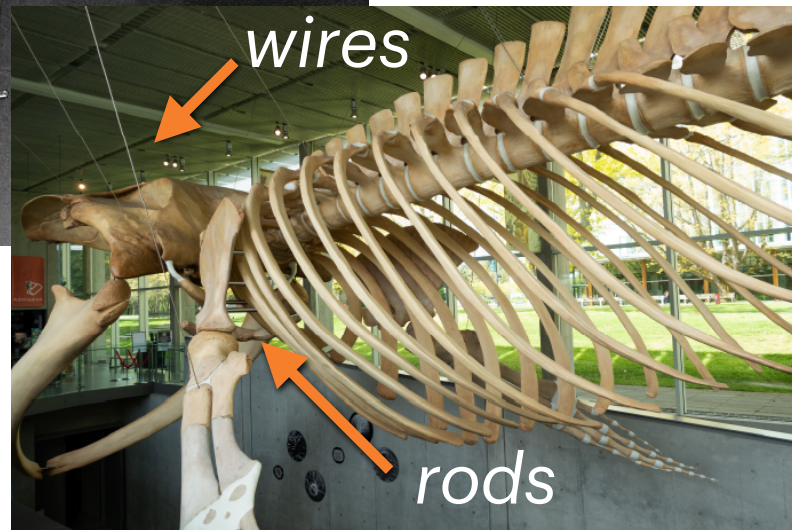
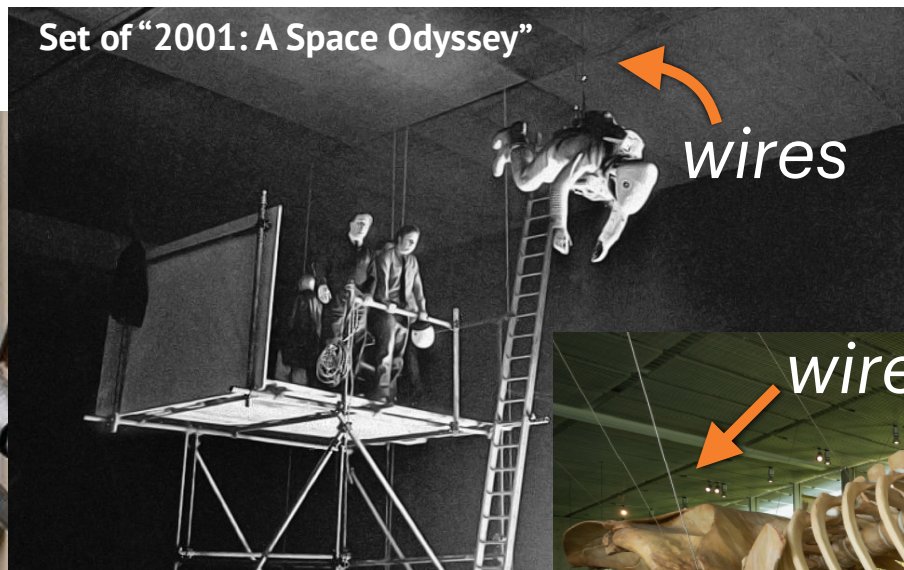
Why?



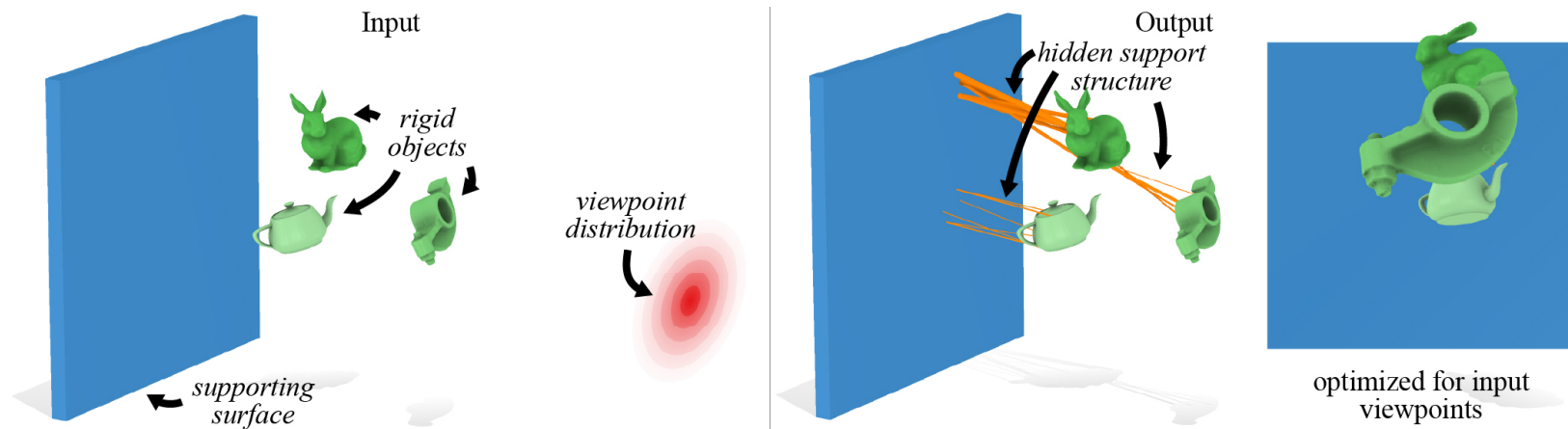
Why?

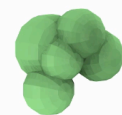


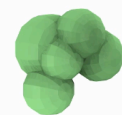
Why?



This isn't so easy.









Floating Sculptures Research Goals

Floating Sculptures Research Goals

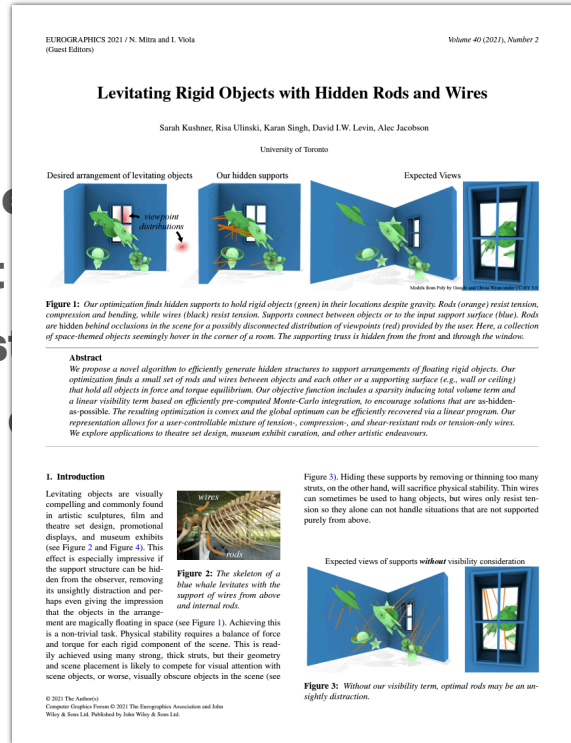
- 1. Provide a method of generating supports hidden from the viewer so that unsightly supports don't distract from the story which also satisfy force and torque balance constraints**

Floating Sculptures Research Goals

- 1. Provide a method of generating supports hidden from the viewer so that unsightly supports don't distract from the story which also satisfy force and torque balance constraints**
- 2. Validate our method via constructing examples of wire and rod structures in real life**

Floating Sculptures Research Goals

1. Provide a method of generating unsightly supports don't and torque balance constraints
2. Validate our method via structures in real life

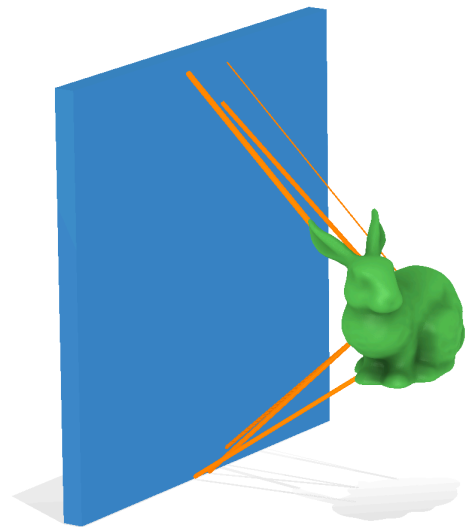


Levitating Rigid Objects with Hidden Rods and Wires
Kushner, Ulinski, Singh, Levin, Jacobson
Eurographics 2021

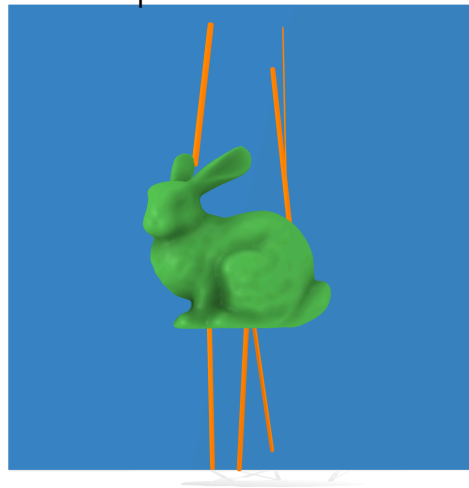
from the viewer so that
which also satisfy force
of wire and rod

What we want:

1. Hold **rigid objects** in place under a force (usually gravity)
2. Hide **supporting rods** from **viewpoints**



Expected view



How?

1. Hold **rigid objects** in place under a force



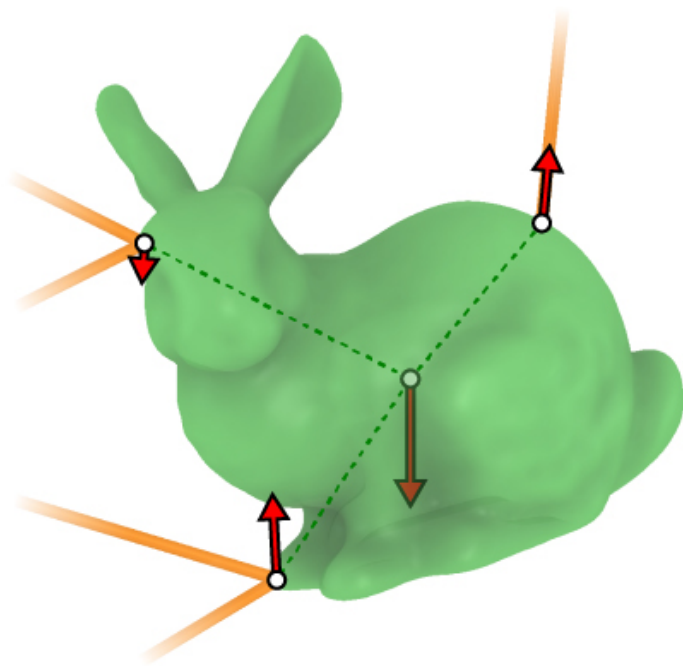
Select edges from graph to become rods



Select edges from graph to become rods



Are the rods structurally sound?

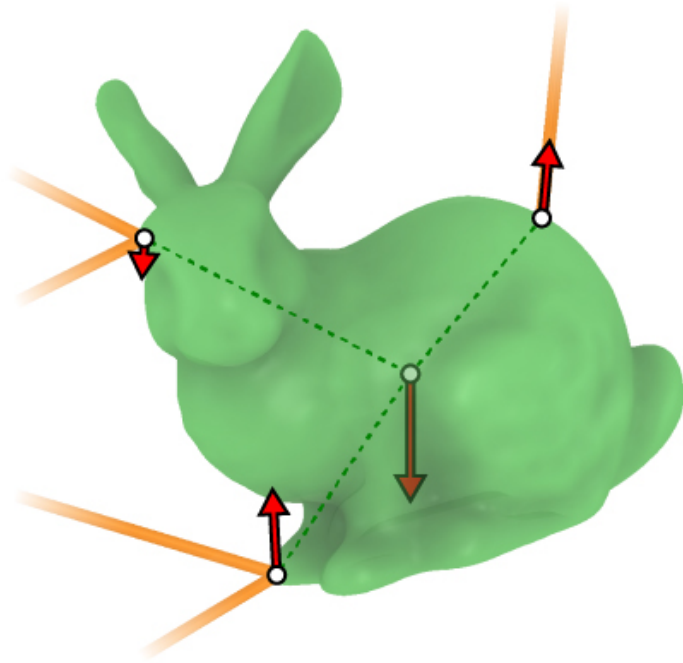


Minimize the total rod volume:

$$\min \sum \ell_i a_i$$

Subject to: $a_i \geq 0$

Are the rods structurally sound?



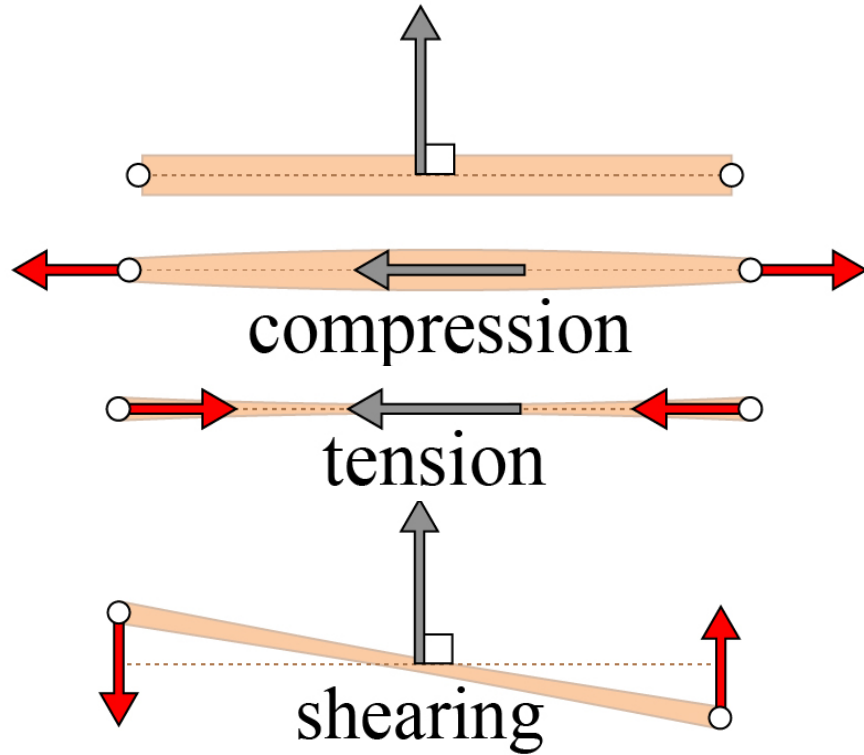
Minimize the total rod volume:

$$\min \sum \ell_i a_i$$

Subject to: $a_i \geq 0$

total force = -applied force

The rods must not break



Minimize the total rod volume:

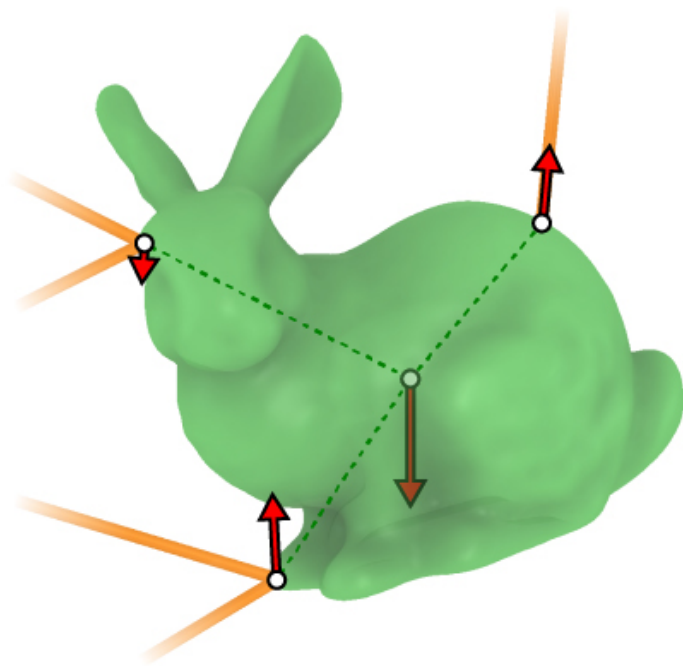
$$\min \sum \ell_i a_i$$

Subject to: $a_i \geq 0$

total force = -applied force

force of each rod $\leq \max$

We need force + torque balance



Minimize the total rod volume:

$$\min \sum \ell_i a_i$$

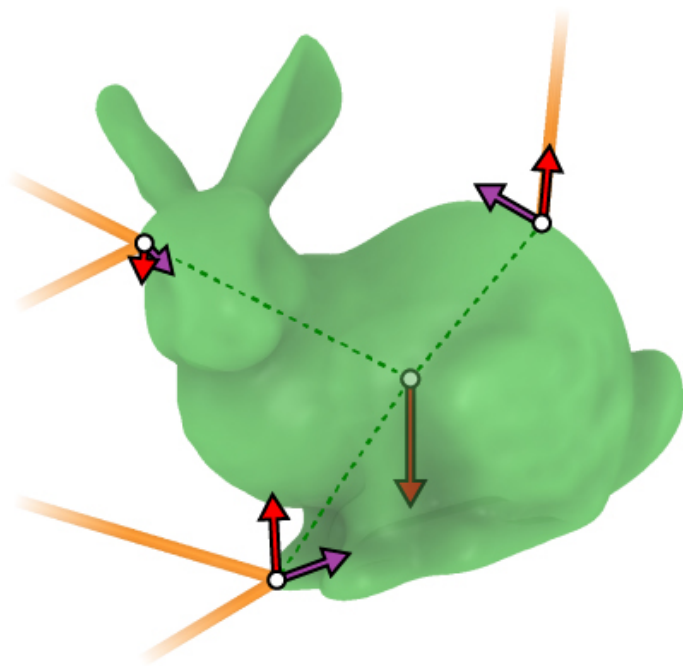
Subject to: $a_i \geq 0$

total force = -applied force

force of each rod $\leq$ max

internal torque = 0

We need force + torque balance



Minimize the total rod volume:

$$\min \sum \ell_i a_i$$

Subject to: $a_i \geq 0$

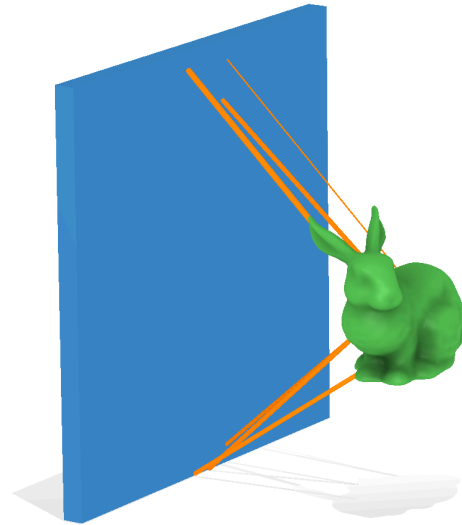
total force = -applied force

force of each rod $\leq$ max

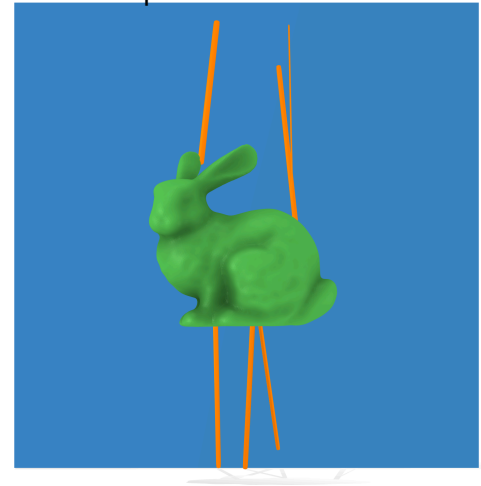
internal torque = 0

Physical constraints work, but the supports are visible

1. Hold **rigid objects** in place

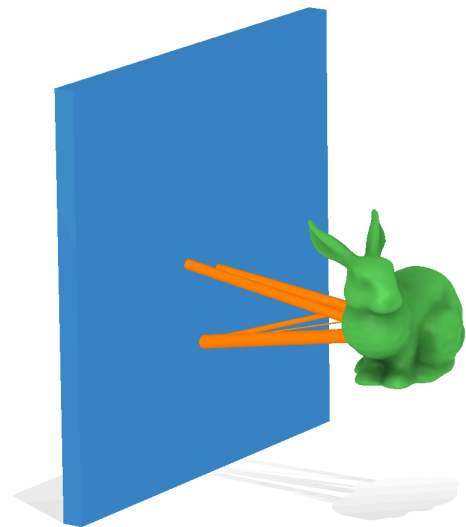


Expected view



We want invisible supports

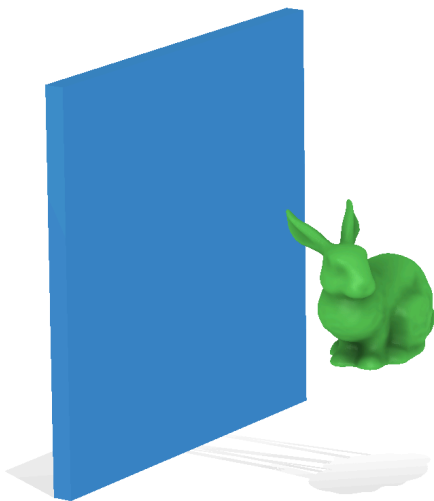
1. Hold **rigid objects** in place
2. Hide **supporting rods** from **viewpoints**



Expected view



Our formulation



Minimize the total rod volume
and visibility:

$$\min \sum \ell_i a_i + \text{vis}_i$$

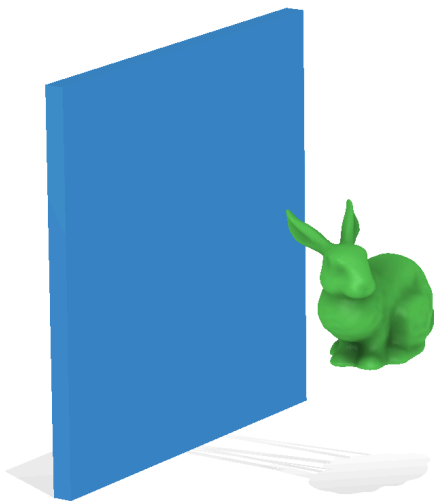
Subject to: $a_i \geq 0$

total force = -applied force

force of each rod $\leq$ max

internal torque = 0

Our formulation



Minimize the total rod volume
and visibility:

$$\min \sum \ell_i a_i + \text{vis}_i$$

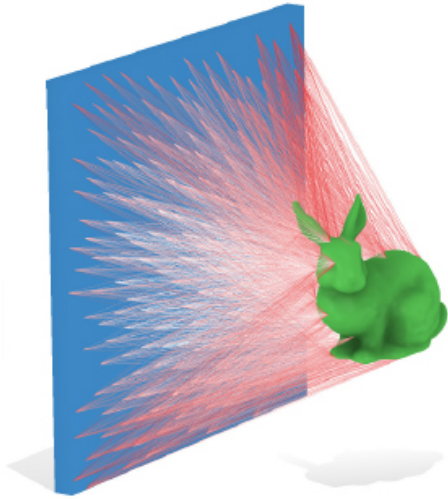
Subject to: $a_i \geq 0$

total force = -applied force

force of each rod $\leq$ max

internal torque = 0

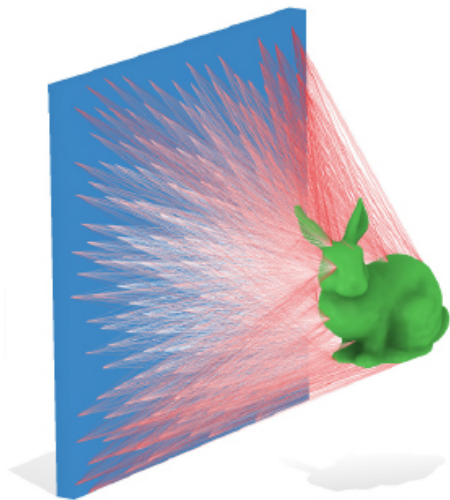
Visibility term computation



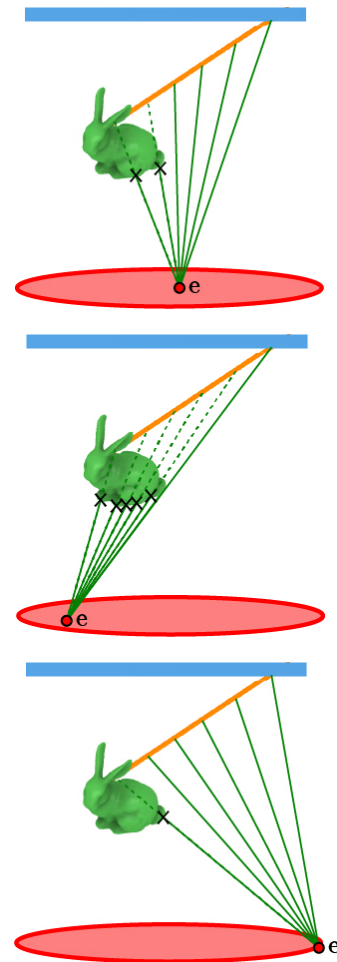
edges coloured by visibility



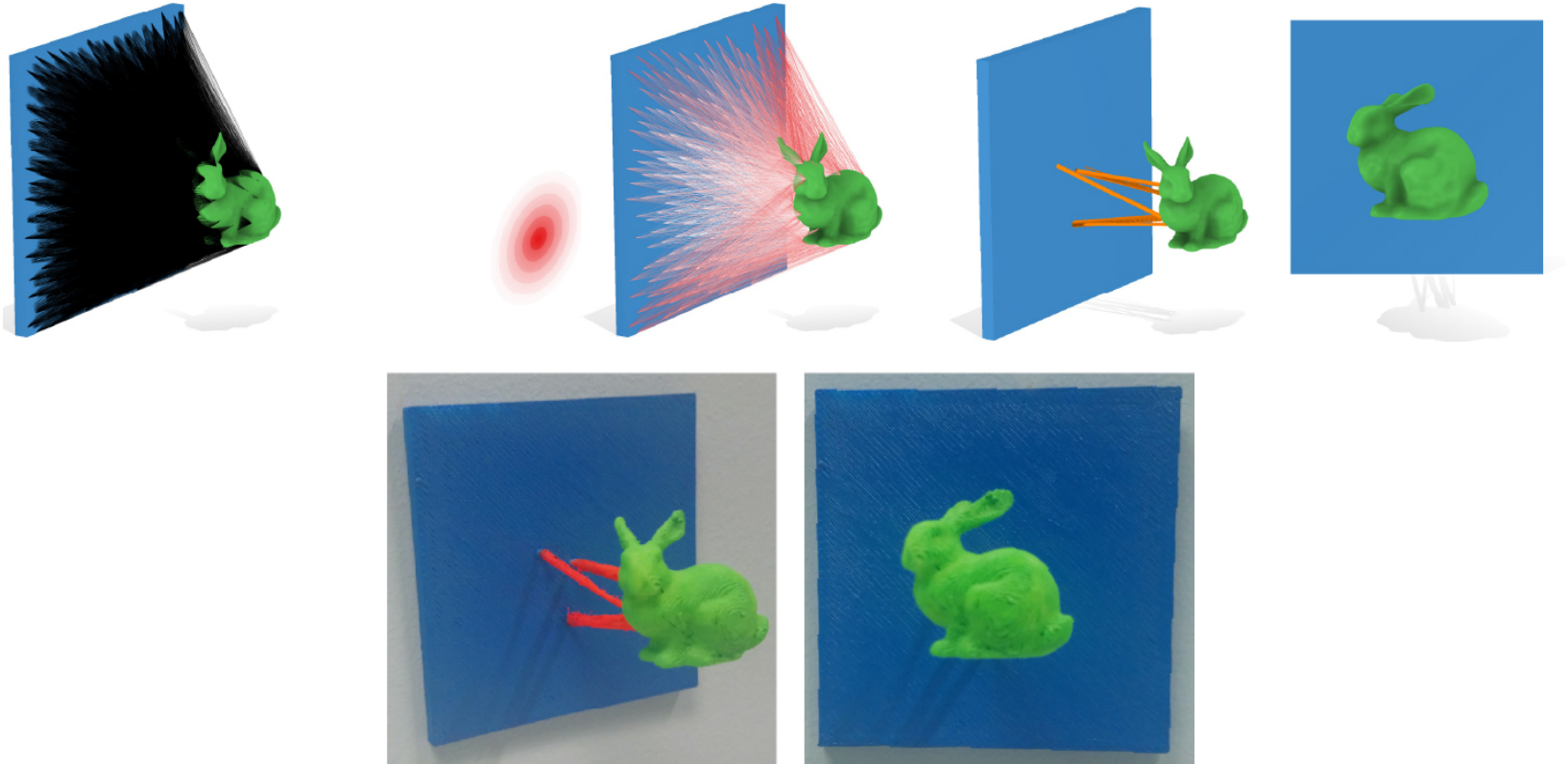
Visibility term computation



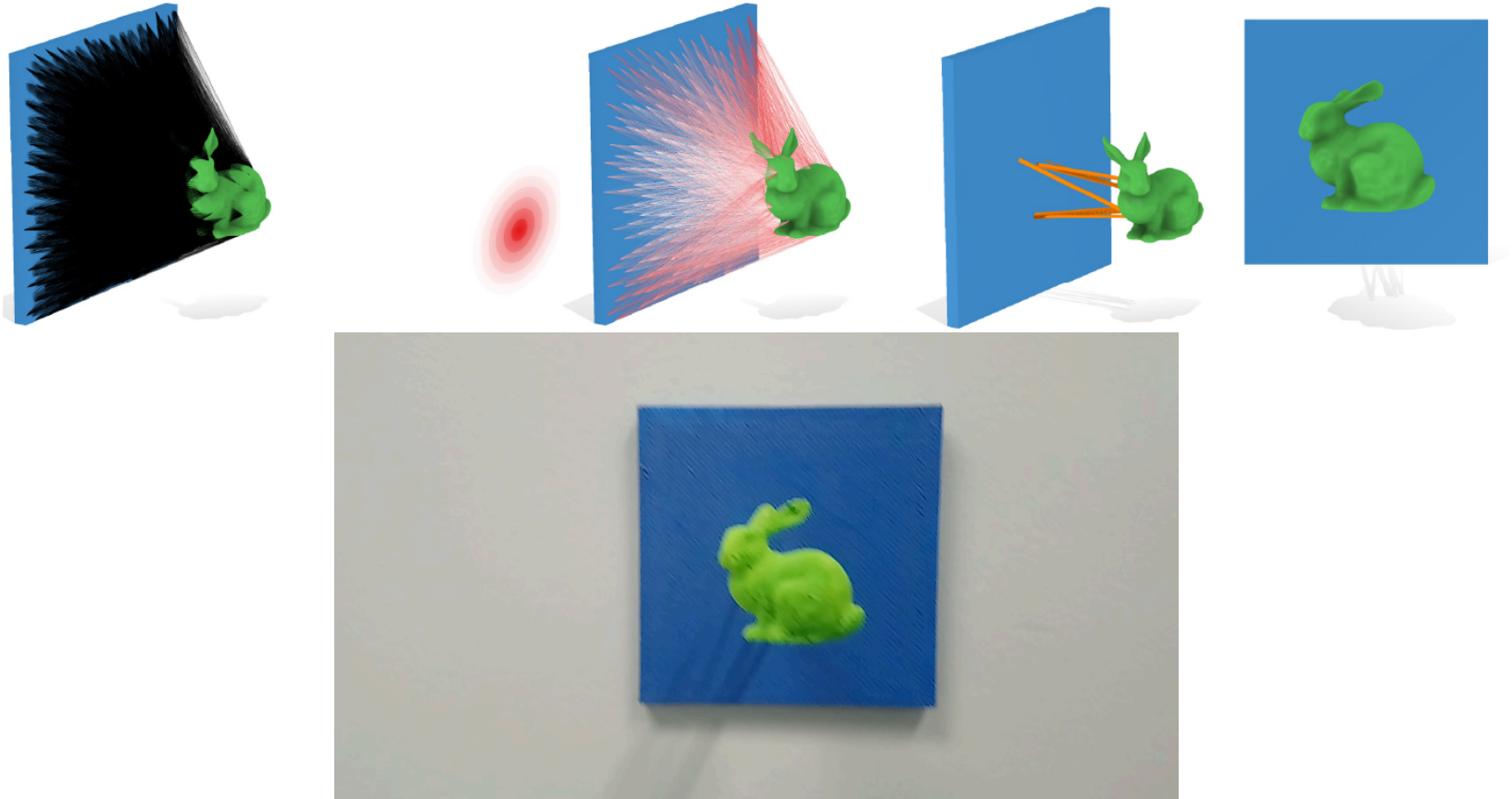
edges coloured by visibility



Visibility term achieves our main goals



Visibility term achieves our main goals



Assembled Spooky Decoration



Assembled Spooky Decoration



Assembled Spooky Decoration



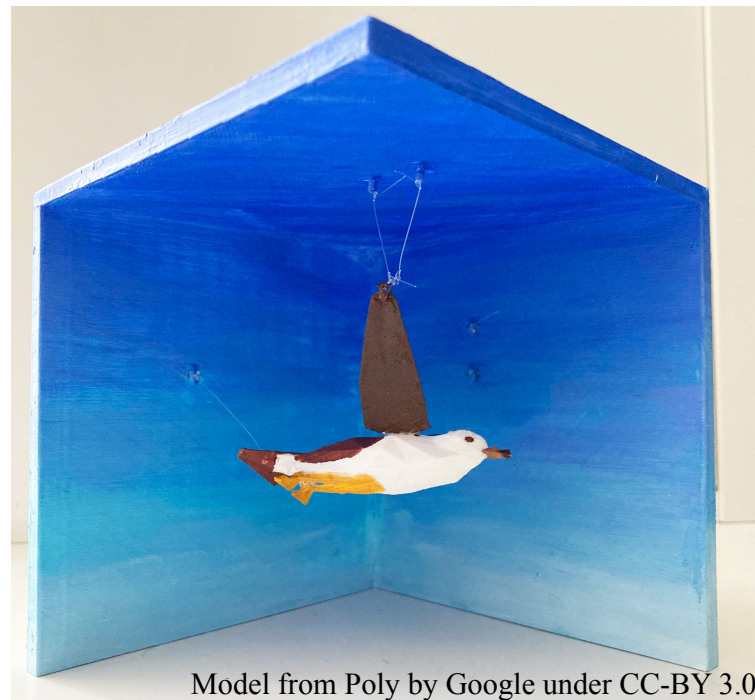
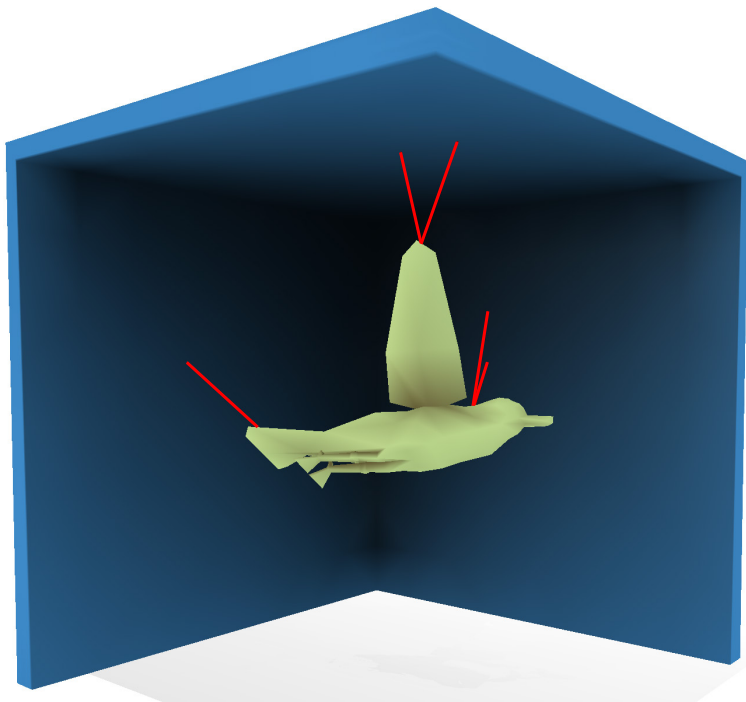
Rocket Ship Room Decoration



Rocket Ship Room Decoration

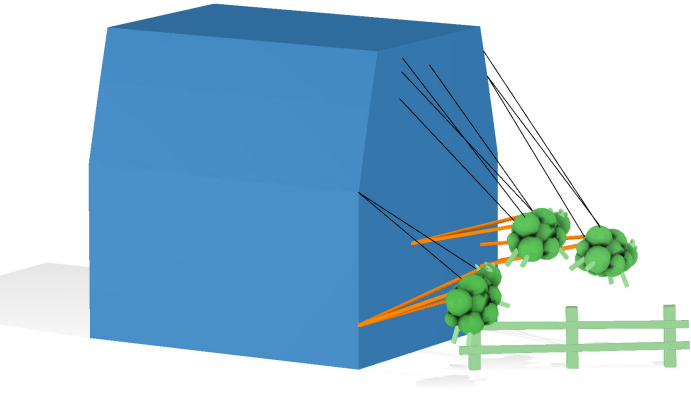


Seagull - Wires only

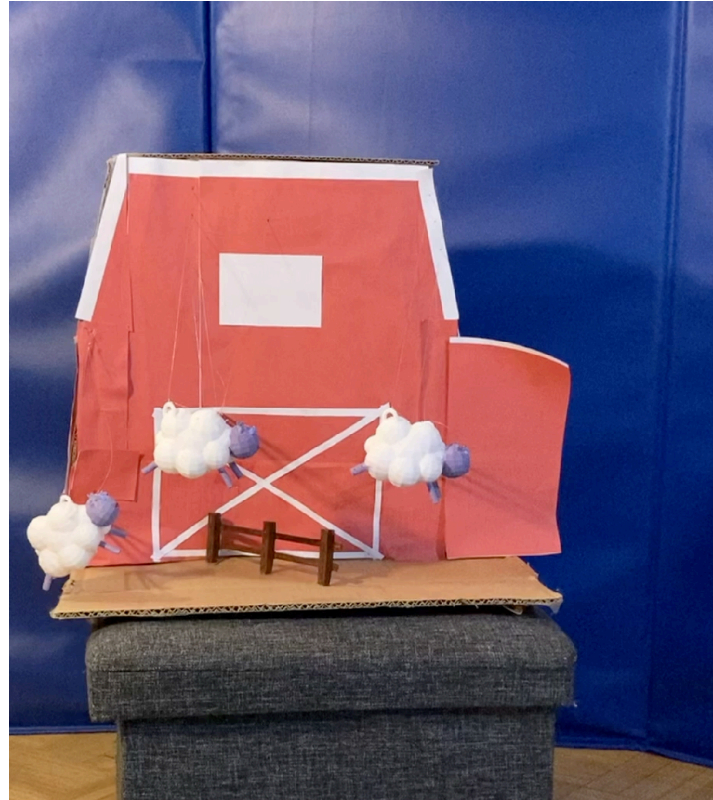
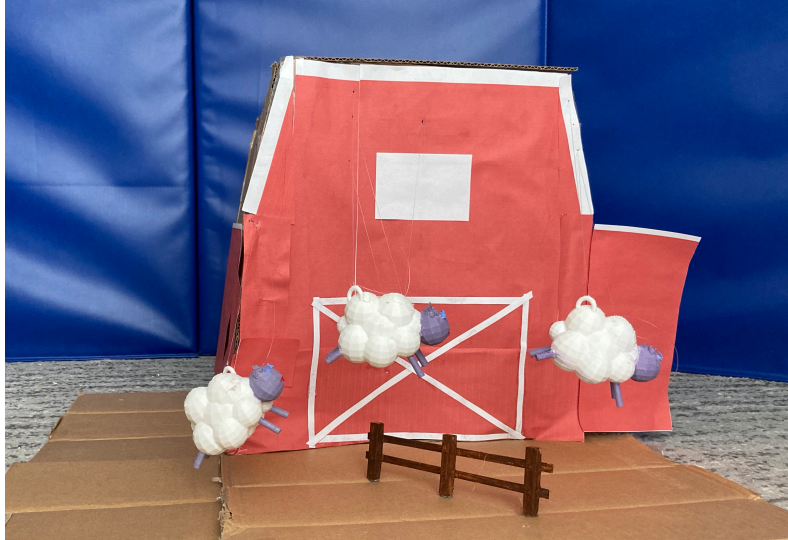


Model from Poly by Google under CC-BY 3.0

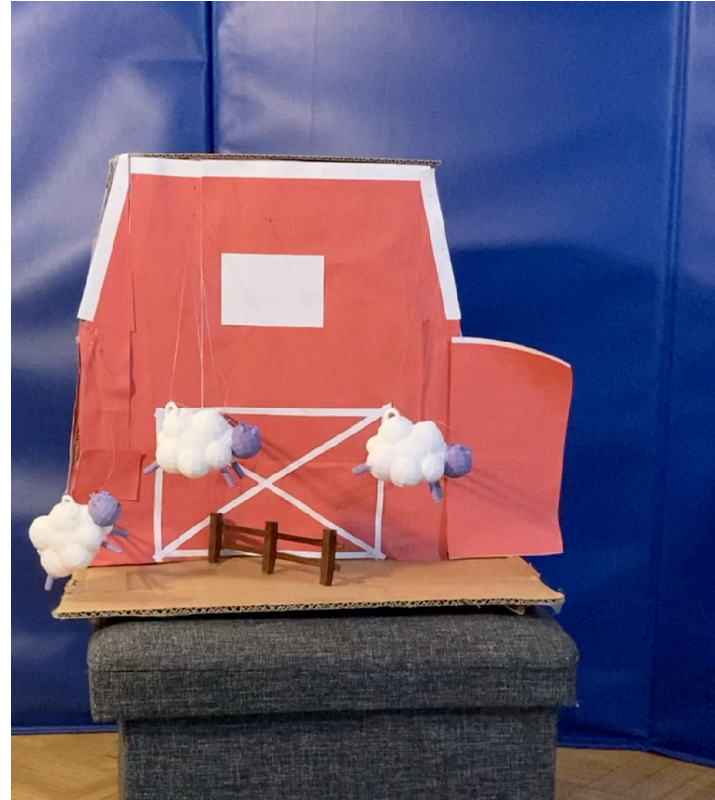
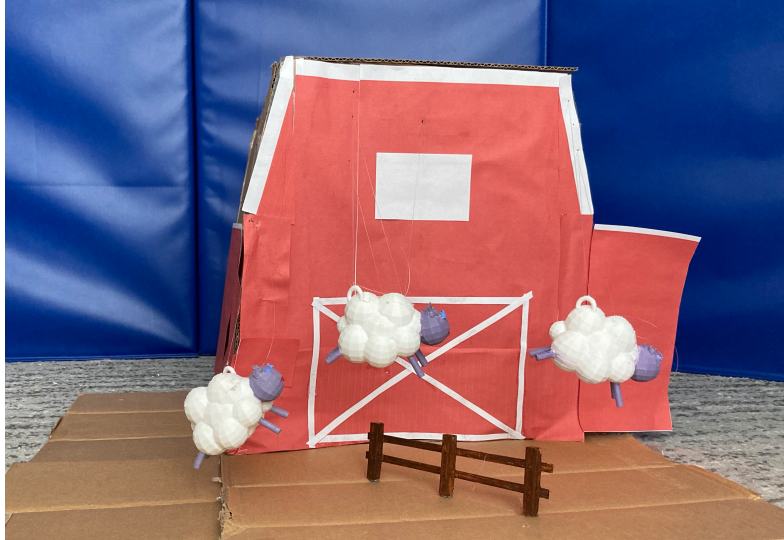
Counting Sheep



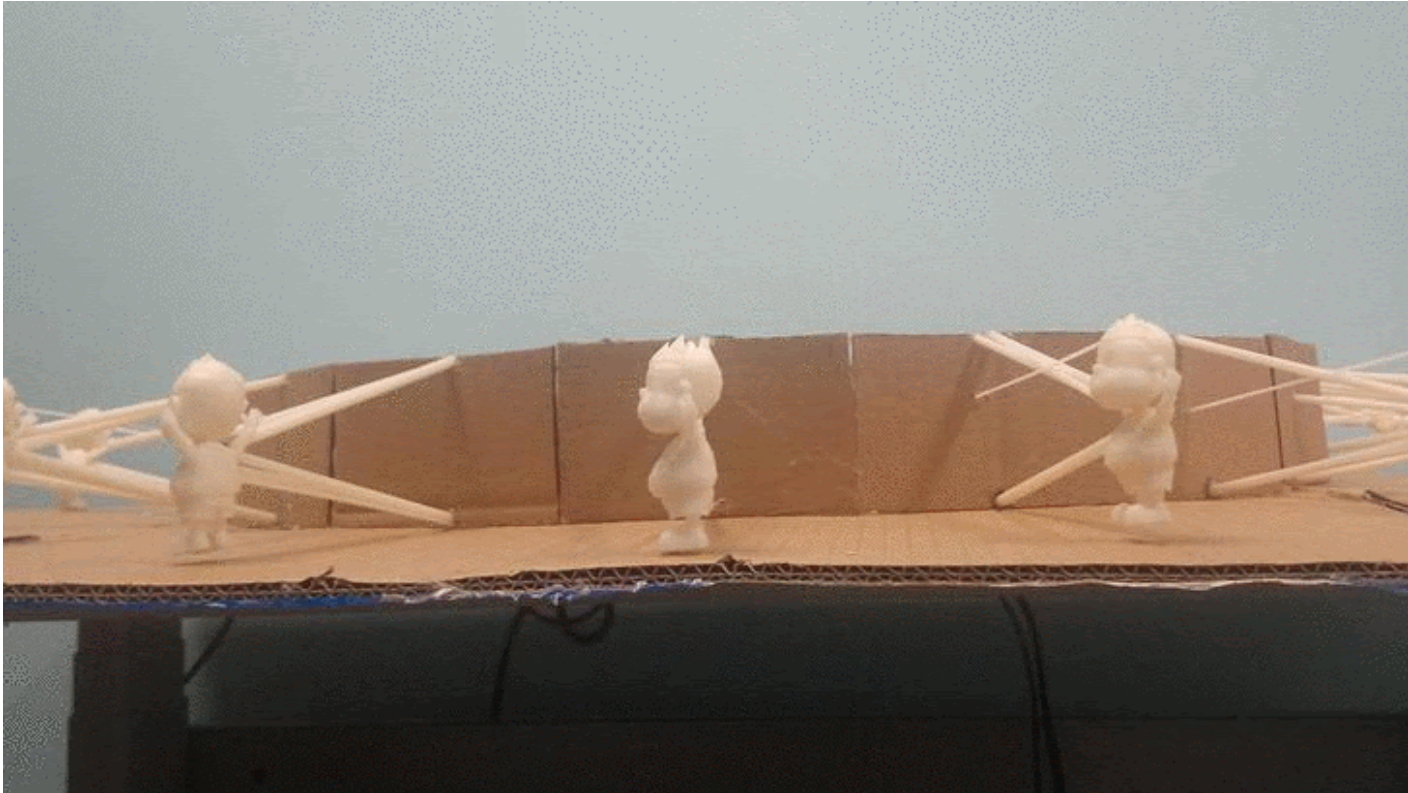
Assembled Wires + Rods



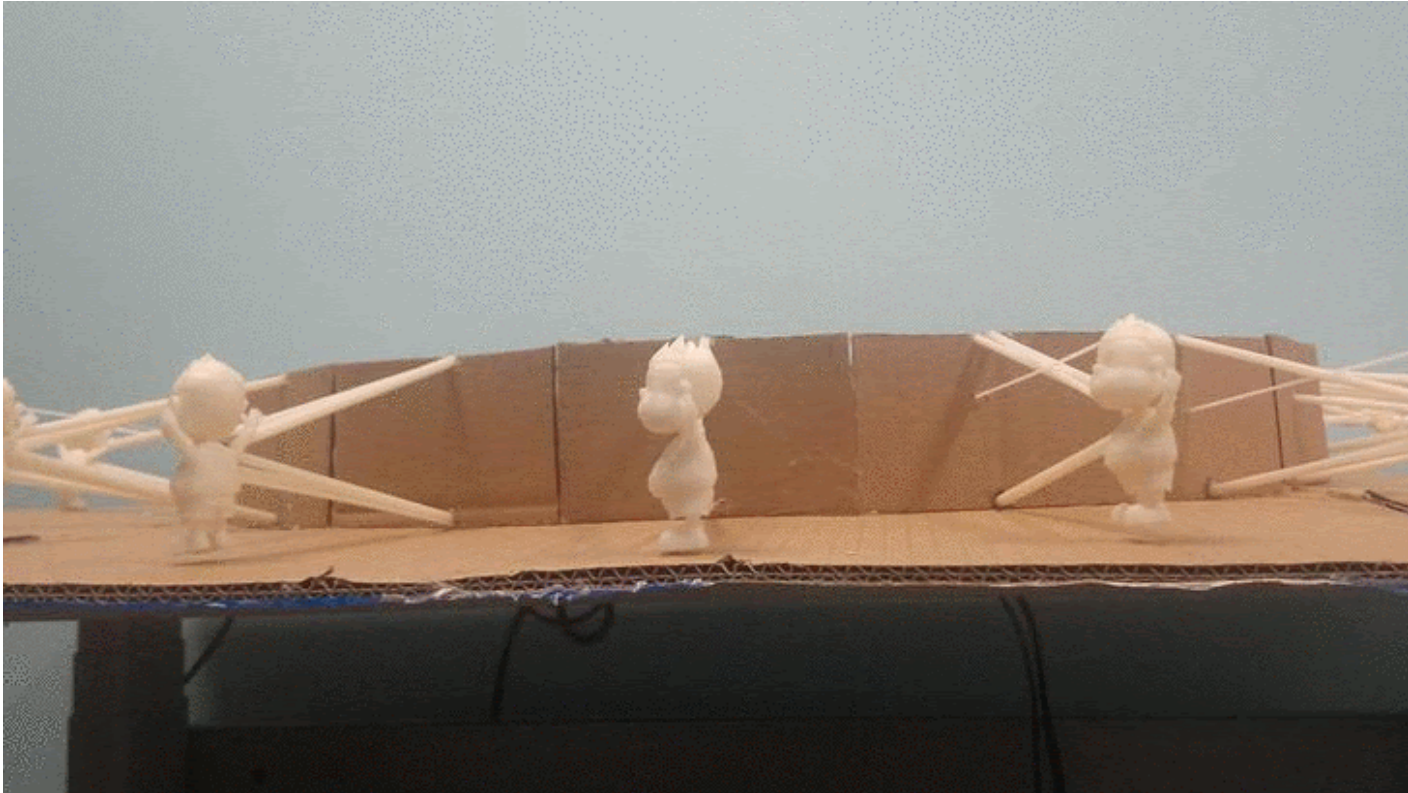
Assembled Wires + Rods



Zoetrope Example



Zoetrope Example





Floating Sculpture Results

Floating Sculpture Results

Enhanced physical stories that have floating components by preserving the illusion of levitation by:

Floating Sculpture Results

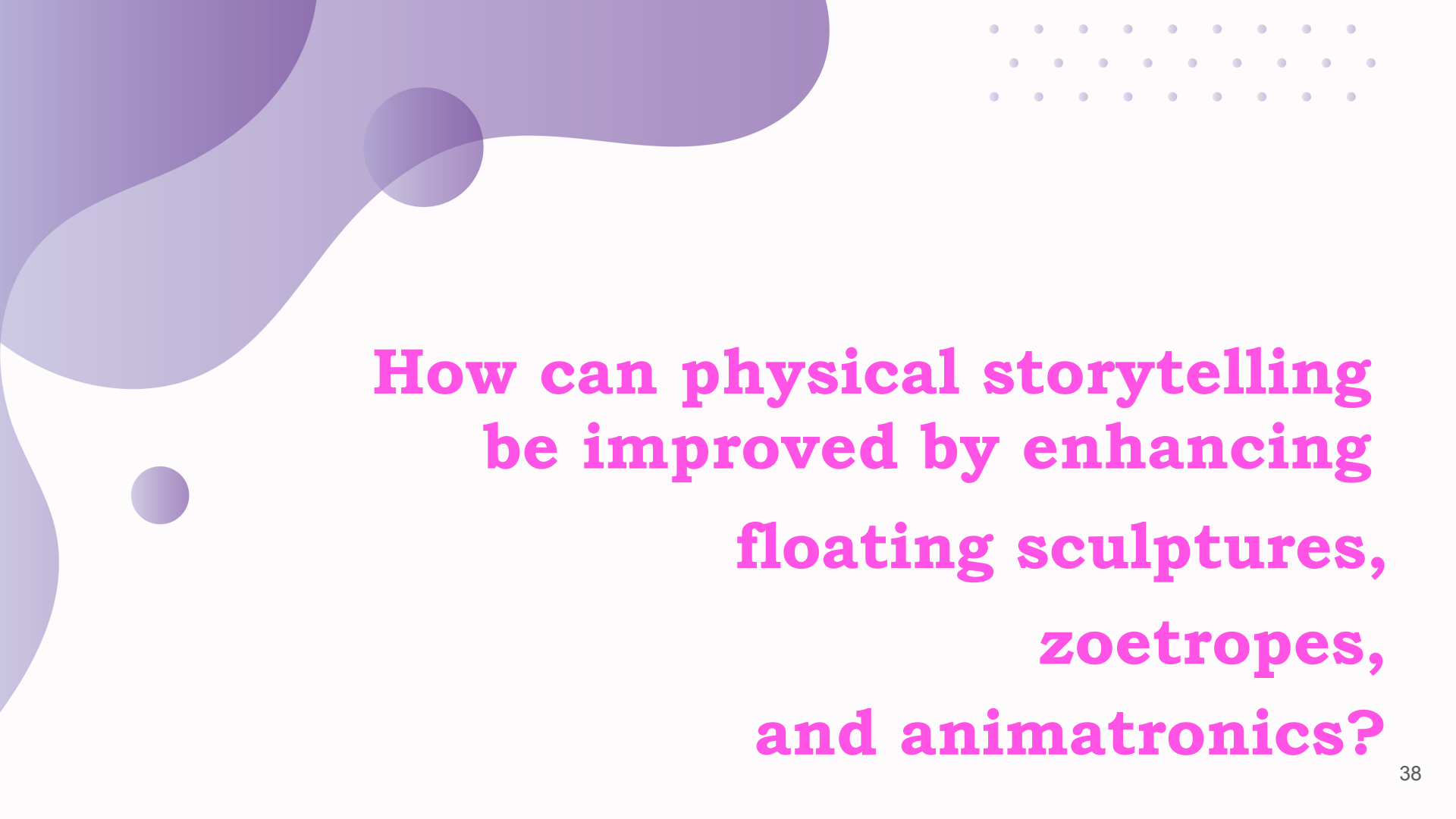
Enhanced physical stories that have floating components by preserving the illusion of levitation by:

1. Devising a concise and **efficient linear program** that extracts a set of supporting rods and wires to hold up objects

Floating Sculpture Results

Enhanced physical stories that have floating components by preserving the illusion of levitation by:

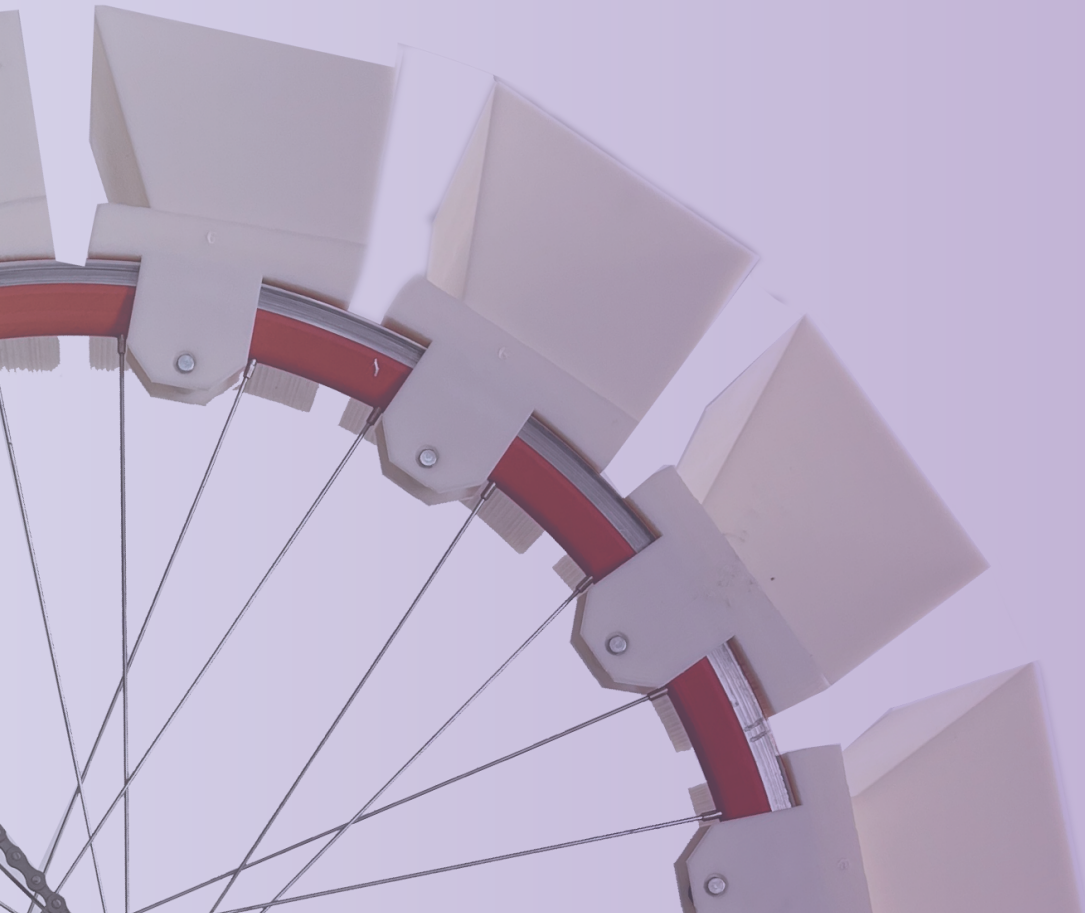
1. Devising a concise and **efficient linear program** that extracts a set of supporting rods and wires to hold up objects
2. Demonstrating that the optimization directly translates to **real world examples**, validating this method through fabrication



**How can physical storytelling
be improved by enhancing
floating sculptures,
zoetropes,
and animatronics?**

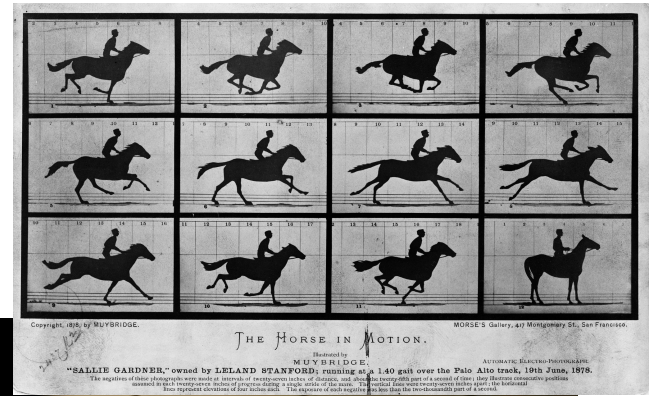


**How can physical storytelling
be improved by enhancing
zoetropes?**

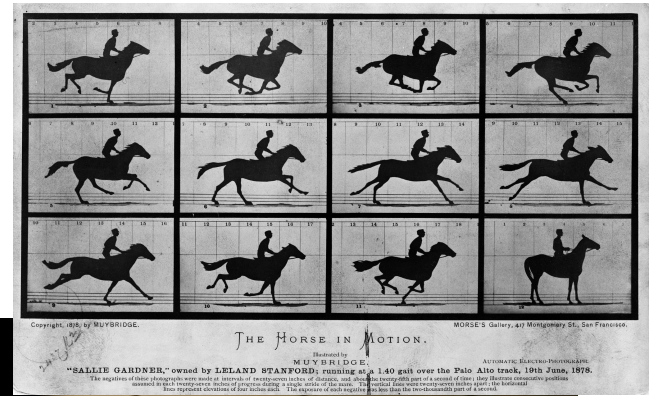


Zoetropes

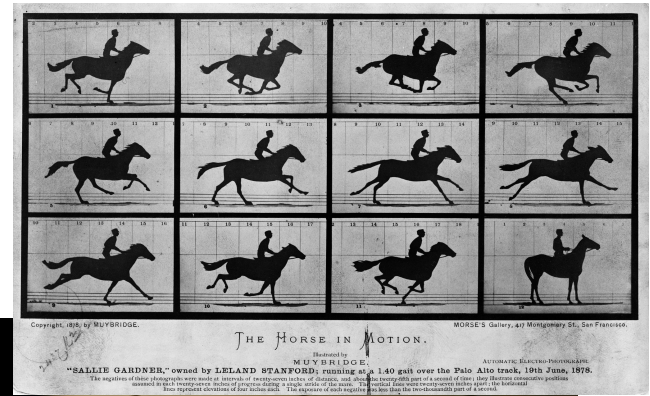
What are zoetropes?



What are zoetropes?

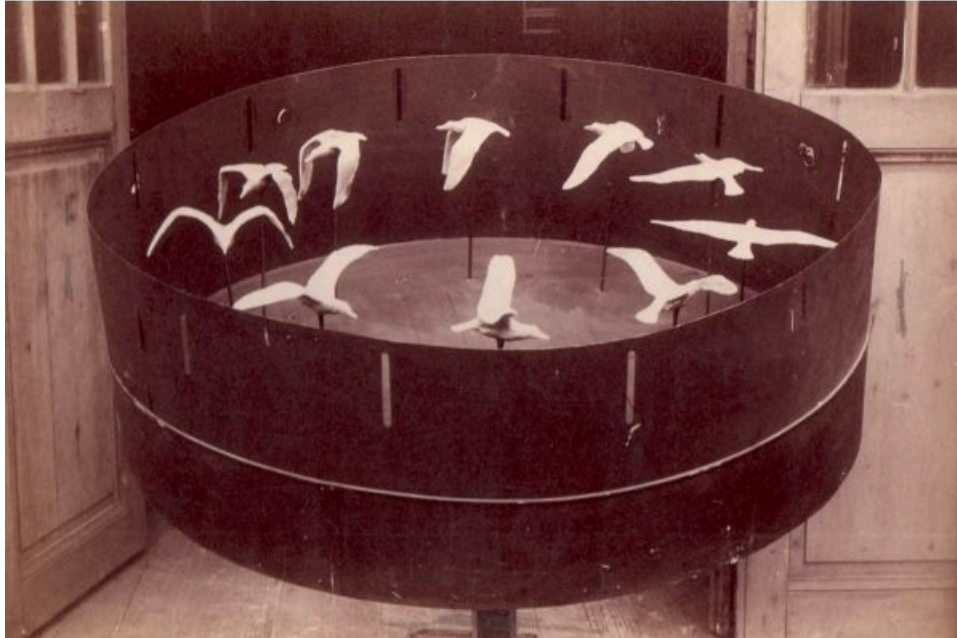


What are zoetropes?



What are zoetropes?

3D zoetropes are not new, this one was made in 1887! 🦅



3D Zoetrope (Étienne-Jules Marey, 1887)

What are zoetropes?

Zoetropes now use strobe lights to create apparent motion.



Feral Fount (Gregory Barsamian, 1996)

What are zoetropes?

Zoetropes now use strobe lights to create apparent motion.



Feral Fount (Gregory Barsamian, 1996)



Limitations of Zoetropes

Limitations of Zoetropes

1. Stories in this format are short and periodic, constrained by the physical nature of a zoetrope



Limitations of Zoetropes

- 1. Stories in this format are short and periodic, constrained by the physical nature of a zoetrope**
- 2. Watching a zoetrope is a passive storytelling experience**

Limitations of Zoetropes

1. Stories in this format are short and periodic,
nature of a zoetrope

2. Watching a zoetrope is a passive storytelling

Interactive 3D Zoetrope with a Strobing Flashlight

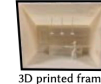
Sarah Kushner
University of Toronto
Toronto, Canada
sak@cs.toronto.edu

Paul H. Dietz
University of Toronto
Toronto, Canada
dietz@cs.toronto.edu

Alec Jacobson
University of Toronto
Toronto, Canada
jacobson@cs.toronto.edu



stepper motor and
timing belt



3D printed frame

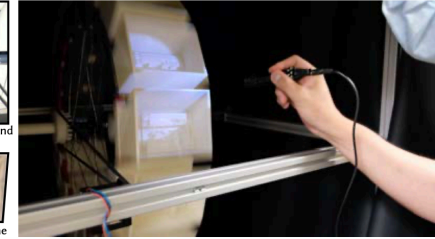


Figure 1: Users can interactively view our bike wheel zoetrope by shining a synced strobe flashlight into the animation.

ABSTRACT

We propose a 3D printed zoetrope mounted on a bike wheel where users can watch the 3D figures come to life in front of their eyes. Each frame of our animation is a 9 by 16 cm 3D fabricated diorama containing a small scene. A strobed flashlight synced with the spinning of the wheel shows the viewer each frame at just the right time, creating the illusion of 3D motion. The viewer can hold and shine the flashlight into the scene, illuminating each frame from their own point of view. Our zoetrope is modular and can have different 16 frame animations substituted in and out for fast prototyping of many cinematography, fabrication, and strobe lighting techniques. Our interactive truly 3D movie experience will push the zoetrope format to tell more complex stories and better engage viewers.

KEYWORDS

animation, 3D printing, zoetrope, fabrication

ACM Reference Format:

Sarah Kushner, Paul H. Dietz, and Alec Jacobson. 2022. Interactive 3D Zoetrope with a Strobing Flashlight. In *The Adjunct Publication of the 35th Annual ACM Symposium on User Interface Software and Technology (UIST '22 Adjunct)*, October 29–November 2, 2022, Bend, OR, USA. ACM, New York, NY, USA, 3 pages. <https://doi.org/10.1145/3526114.3558663>

1 INTRODUCTION

Zoetropes are an old but powerful animation device defined by a sequence of images or figures around a spinning cylinder. They can be seen as not only a precursor to traditional film, but also as an equally effective, however limited, storytelling medium.

In the late 19th century, the photographer Eadweard Muybridge popularized the zoetrope and brought it to public audiences in what might be the first ever movie “theatres,” where viewers could pay to see a short periodic animation of animal locomotion. The limitations of this format are that it is 1) non-interactive and it 2) only allows for short repetitive looping stories. In this demo, we approach problem 1) by introducing a novel interactive element.

Zoetropes have already been exhibited in the graphics and HCI communities [Koutaki 2019], [Tokota and Hashida 2018], [Sano et al. 2010], [Miyashita et al. 2016]. Typically zoetropes are a passive experience, analogous to regular movie watching. Our zoetrope installation lets users take a more active role in consuming this new media by providing them with the power to light the scenes how

Interactive 3D Zoetrope with a Strobing Flashlight

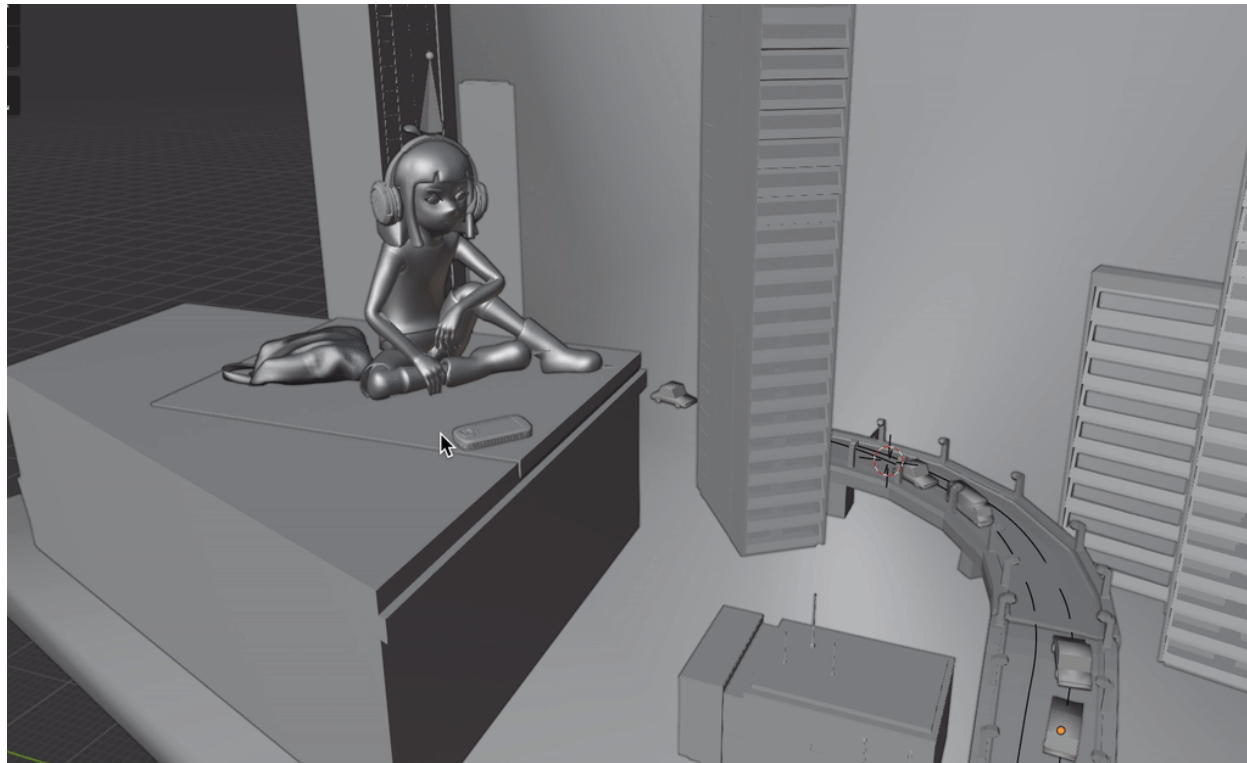
Kushner, Dietz, Jacobson

UIST Demos 2022

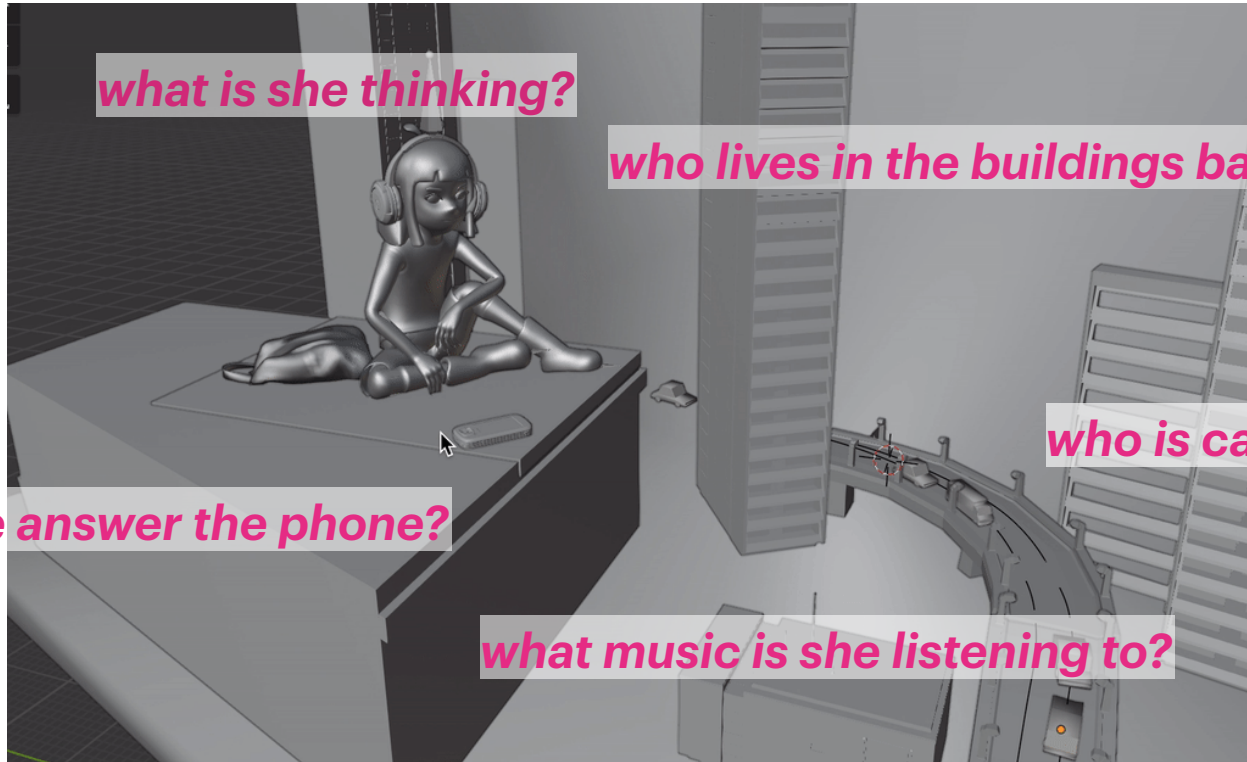
Limitations of Zoetropes

- 1. Stories in this format are short and periodic, constrained by the physical nature of a zoetrope**
- 2. Watching a zoetrope is a passive storytelling experience**

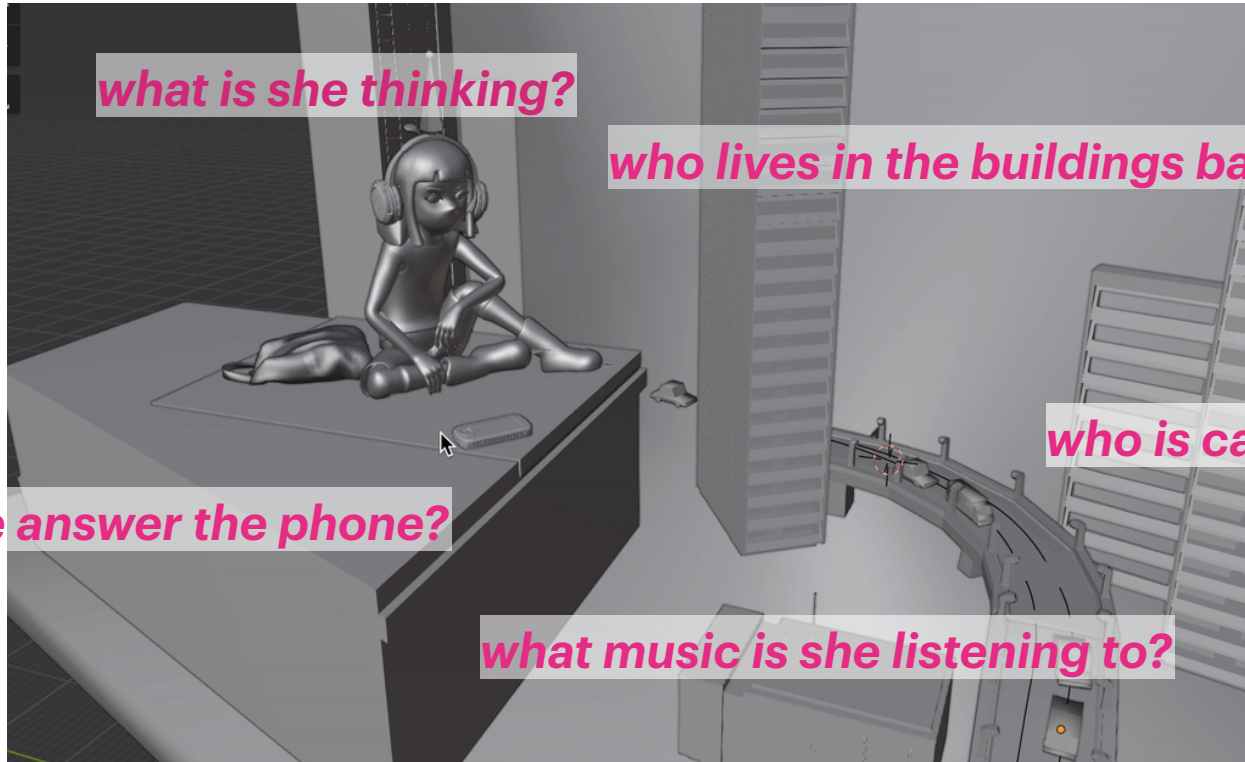
How can we create a more compelling story?



How can we create a more compelling story?

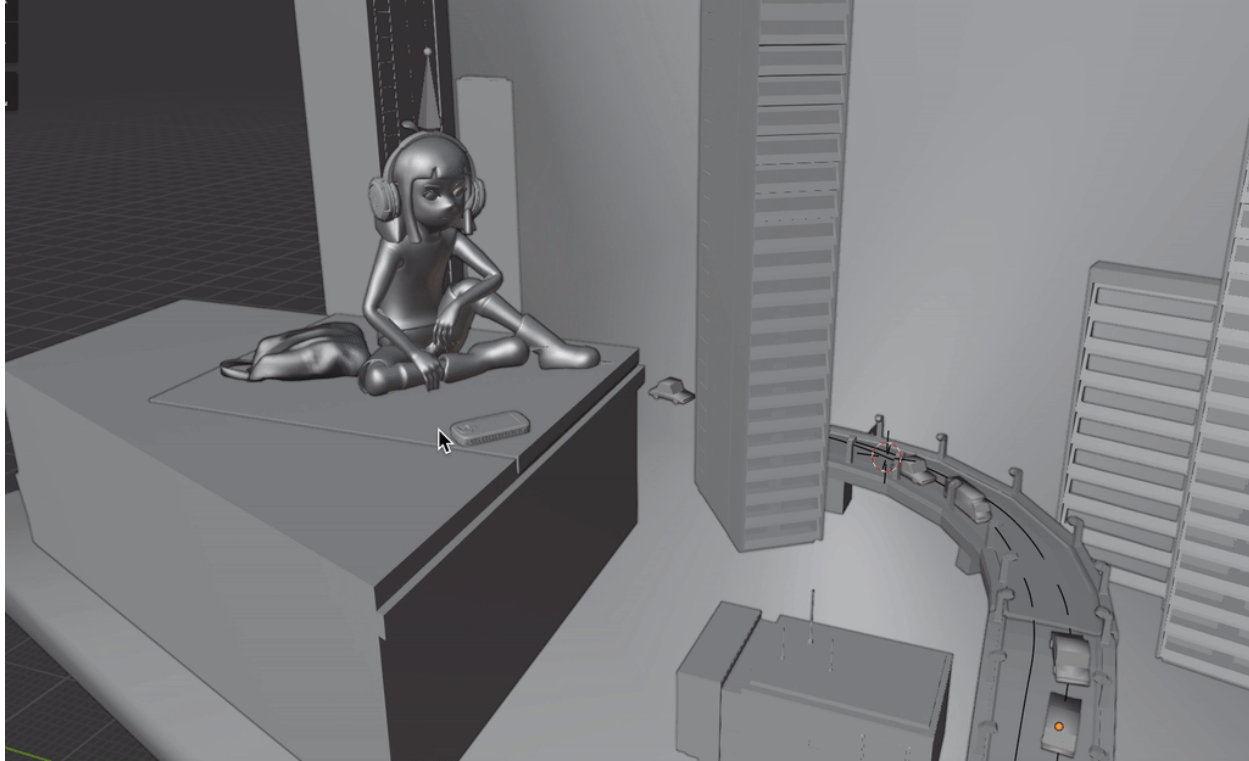


How can we create a more compelling story?

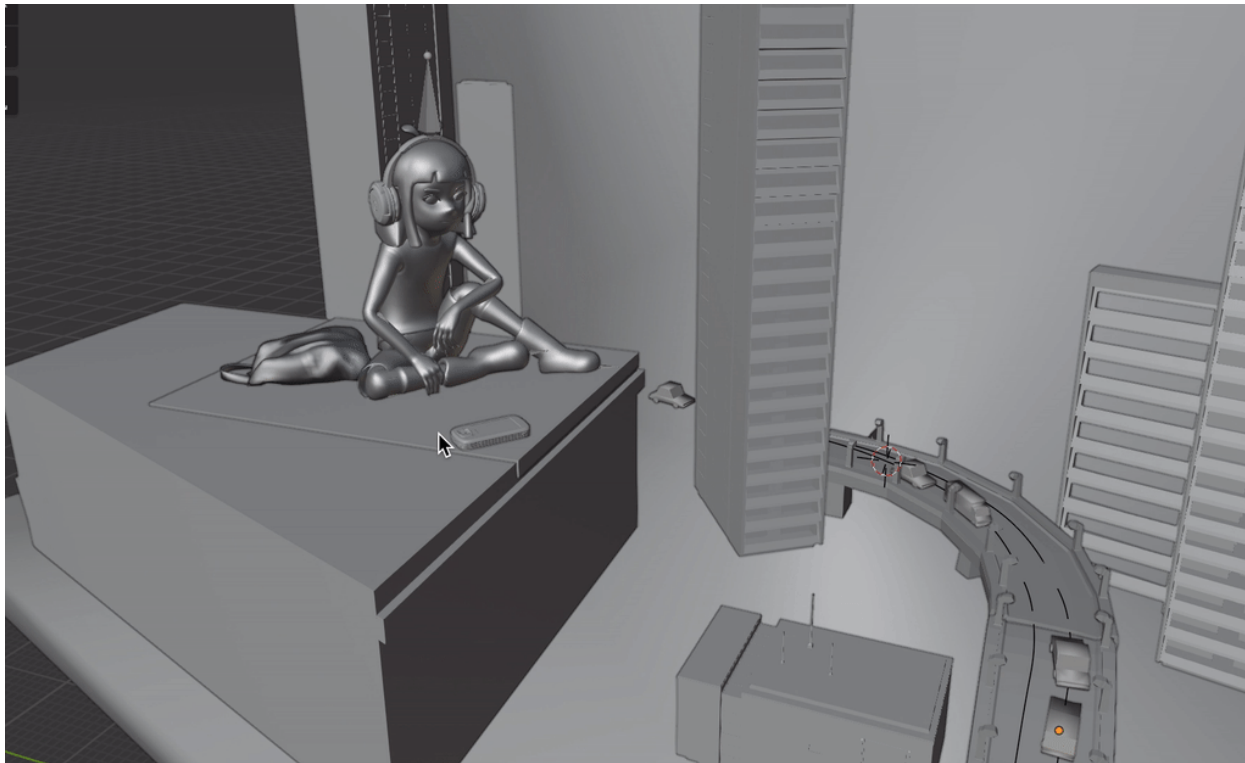


Who is this girl and what is her life like in this moment?

Who is this girl and what is her life like in this moment?



Who is this girl and what is her life like in this moment?



Can we answer those questions using audio?



Zoetropes Research Goals

Zoetropes Research Goals

- 1. Augment zoetropes so that more complex stories can be told**

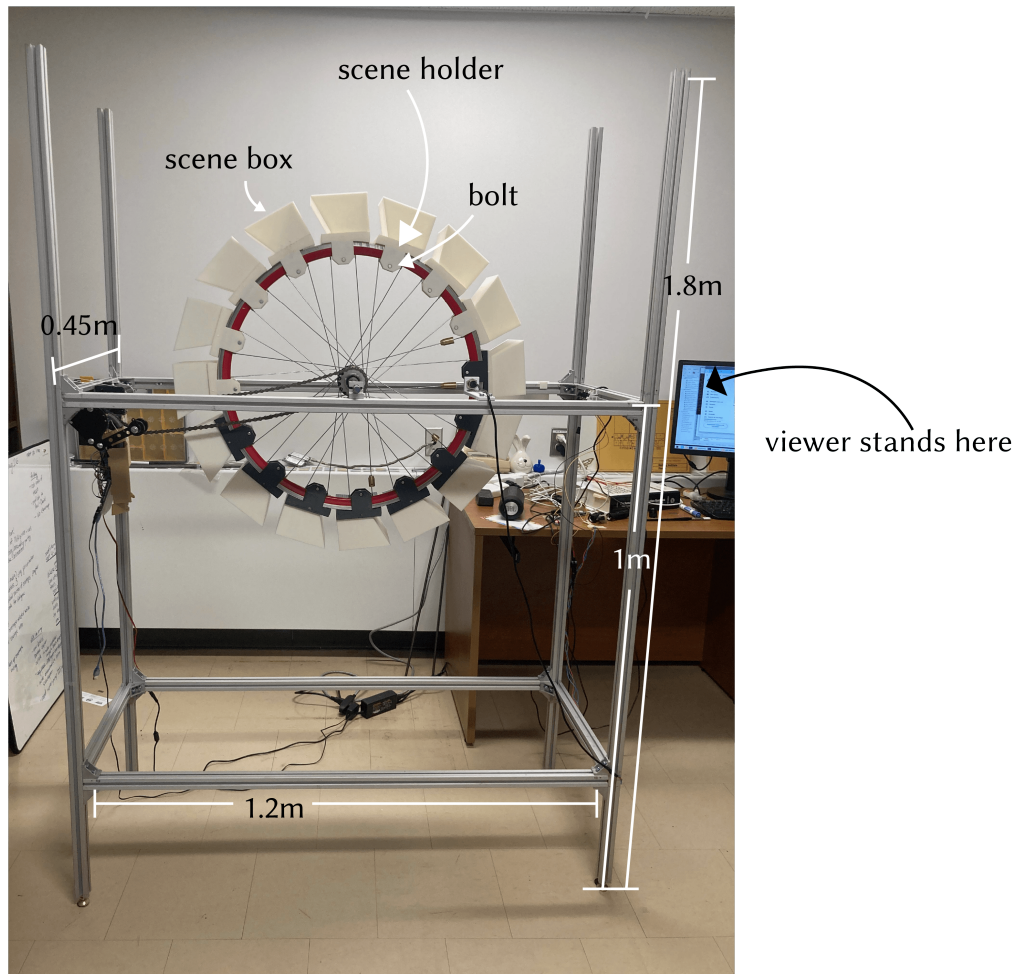
Zoetropes Research Goals

- 1. Augment zoetropes so that more complex stories can be told**
- 2. Reveal hidden elements in a scene to engage the viewer in a more immersive experience...**

Zoetropes Research Goals

- 1. Augment zoetropes so that more complex stories can be told**
- 2. Reveal hidden elements in a scene to engage the viewer in a more immersive experience...**
using interactive audio components

How?



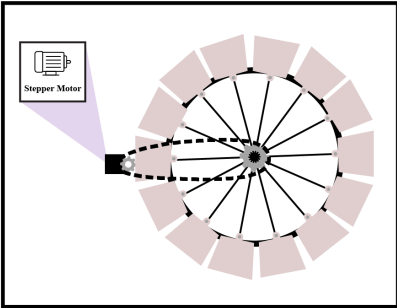
How?



viewer stands here

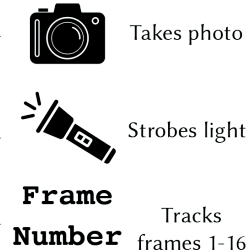
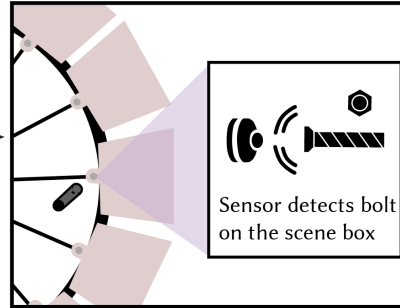
Control loop

Motor Spins Wheel



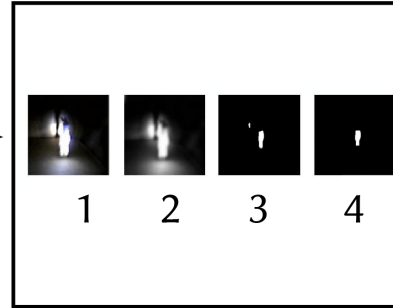
- Ramps up to full speed
- Tensioner on bike chain
- Wheel balanced with spoke weights

Trigger Light



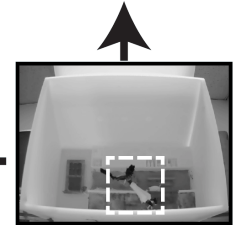
Frame Number Tracks frames 1-16

Process Frame



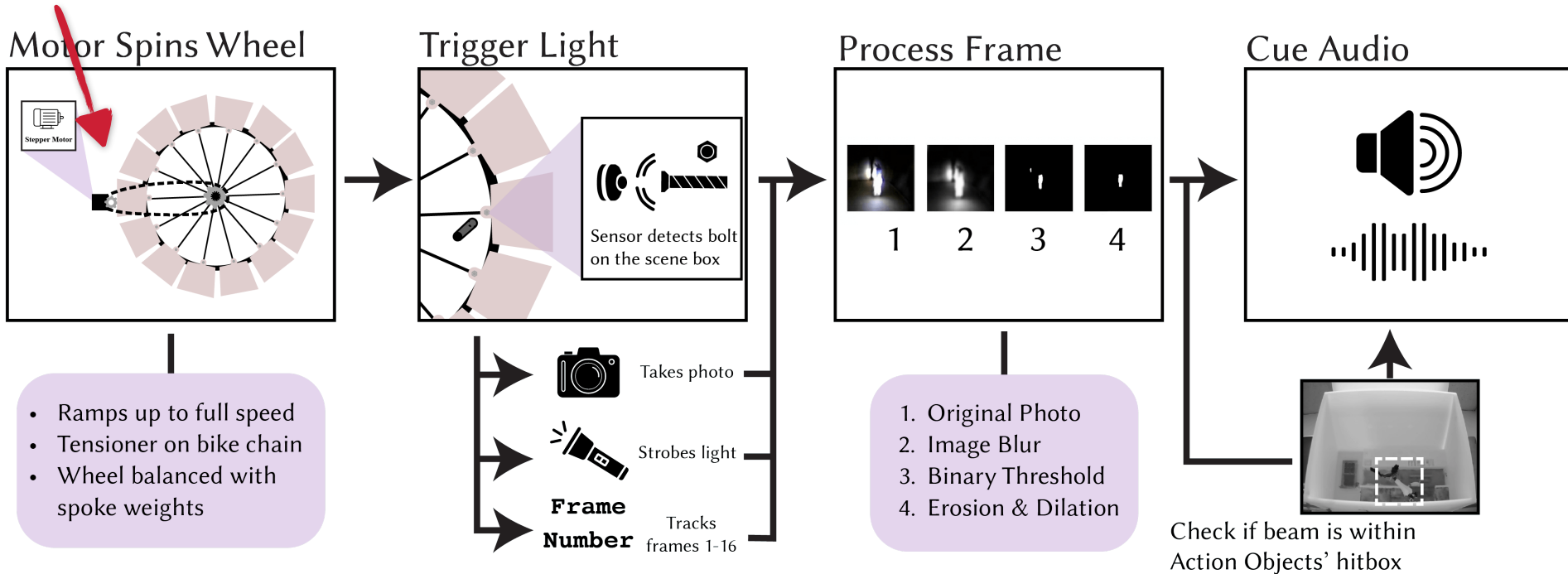
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3. Binary Threshold
4. Erosion & Dilation

Cue Audio

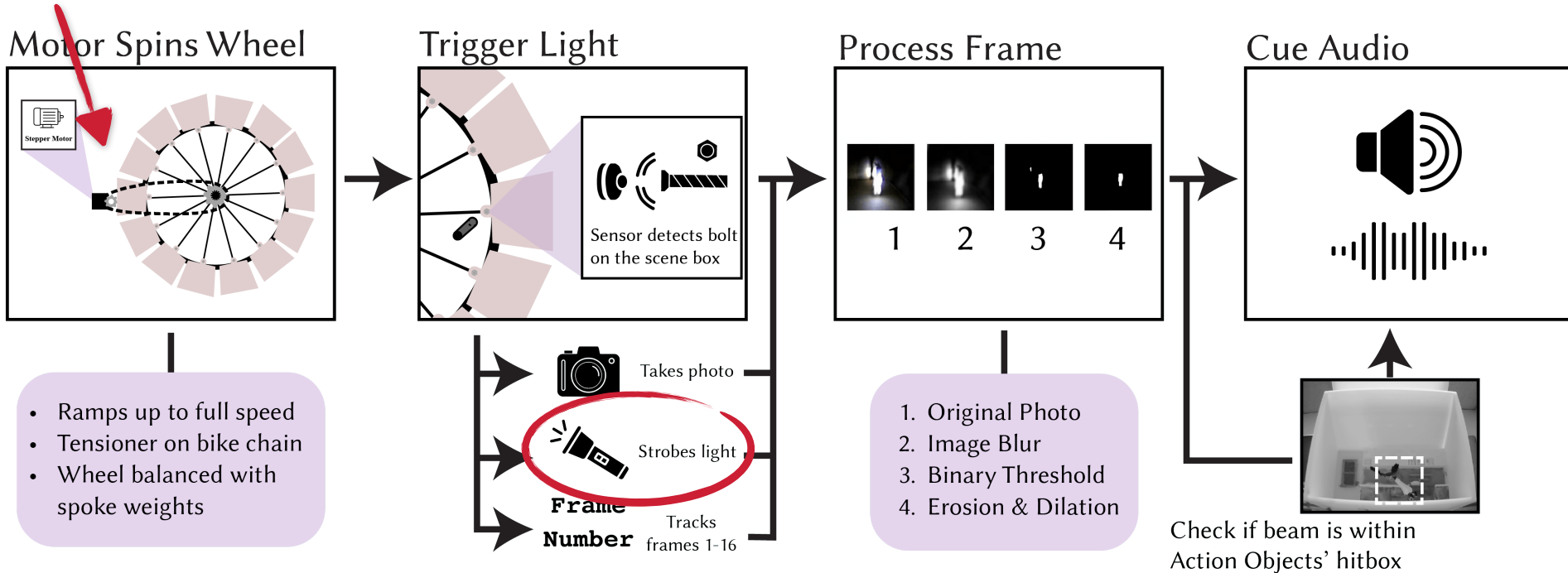


Check if beam is within Action Objects' hitbox

Control loop

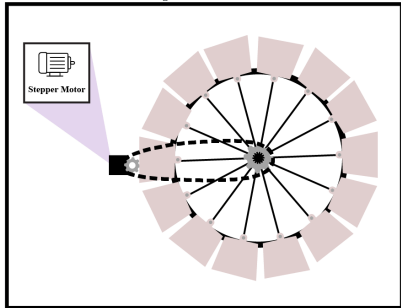


Control loop



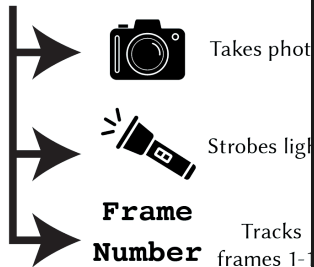
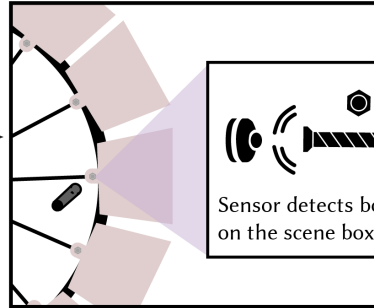
Control loop

Motor Spins Wheel



- Ramps up to full speed
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- Wheel balanced with spoke weights

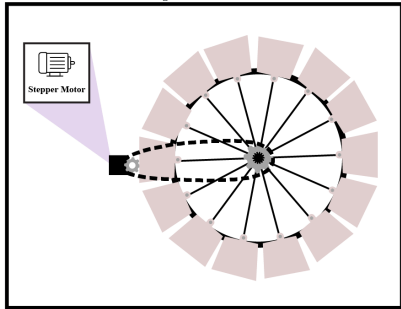
Trigger Light



Action Objects hitbox

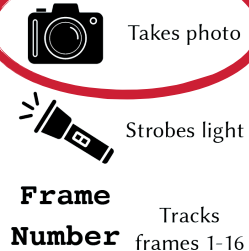
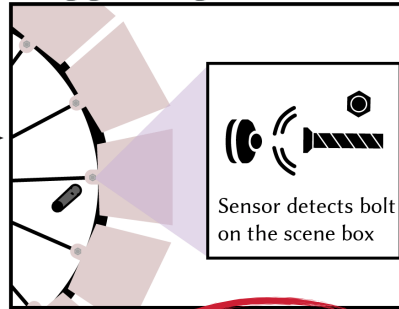
Control loop

Motor Spins Wheel

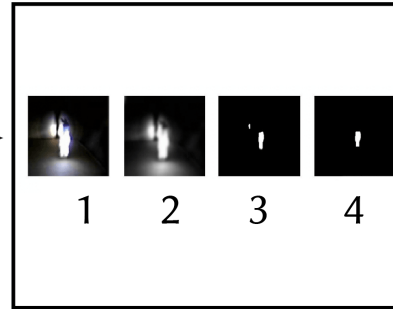


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Trigger Light

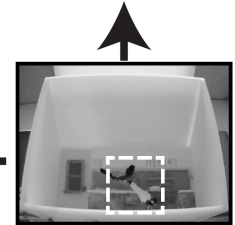


Process Frame



1. Original Photo
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3. Binary Threshold
4. Erosion & Dilation

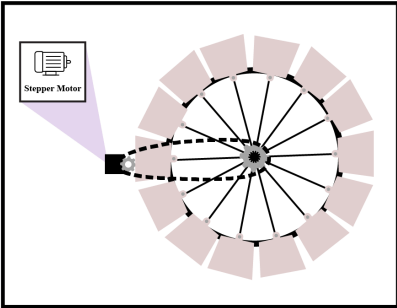
Cue Audio



Check if beam is within Action Objects' hitbox

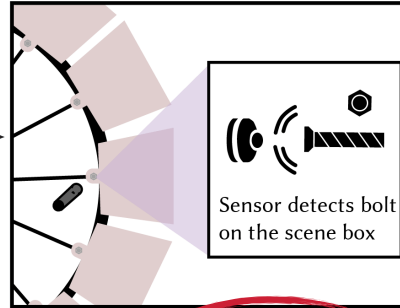
Control loop

Motor Spins Wheel



- Ramps up to full speed
- Tensioner on bike chain
- Wheel balanced with spoke weights

Trigger Light



Takes photo

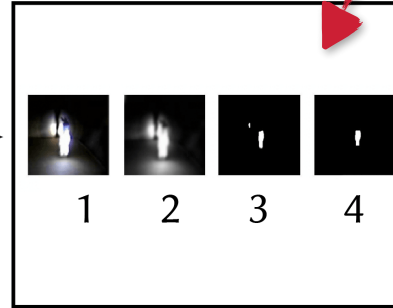


Strobes light

Frame Number

Tracks frames 1-16

Process Frame



1. Original Photo
2. Image Blur
3. Binary Threshold
4. Erosion & Dilation

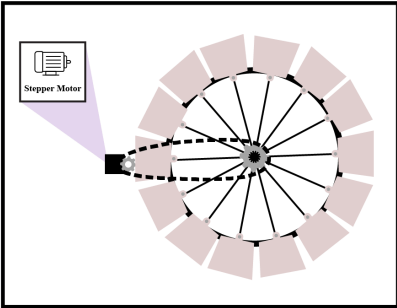
Cue Audio



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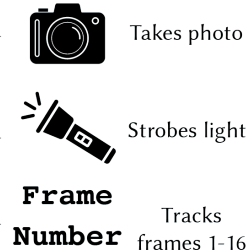
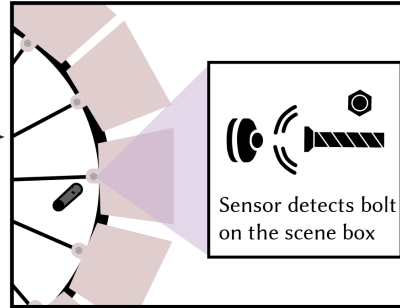
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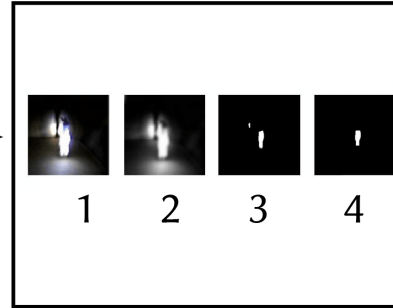


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Trigger Light

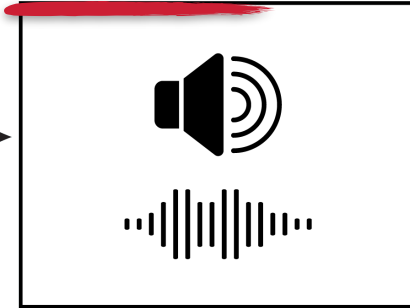


Process Frame



1. Original Photo
2. Image Blur
3. Binary Threshold
4. Erosion & Dilation

Cue Audio



Check if beam is within Action Objects' hitbox

City girl animation



City girl animation



City girl animation



Action Object: cars

City girl animation



City girl animation



City girl animation



City girl animation



Action Object: cell_phone

City girl animation



City girl animation



City girl animation





Zoetrope Results



Zoetrope Results

We designed a device and method that enriches zoetrope stories by:

Zoetrope Results

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- 1. Letting the viewer **explore the scene** with a strobing flashlight**

Zoetrope Results

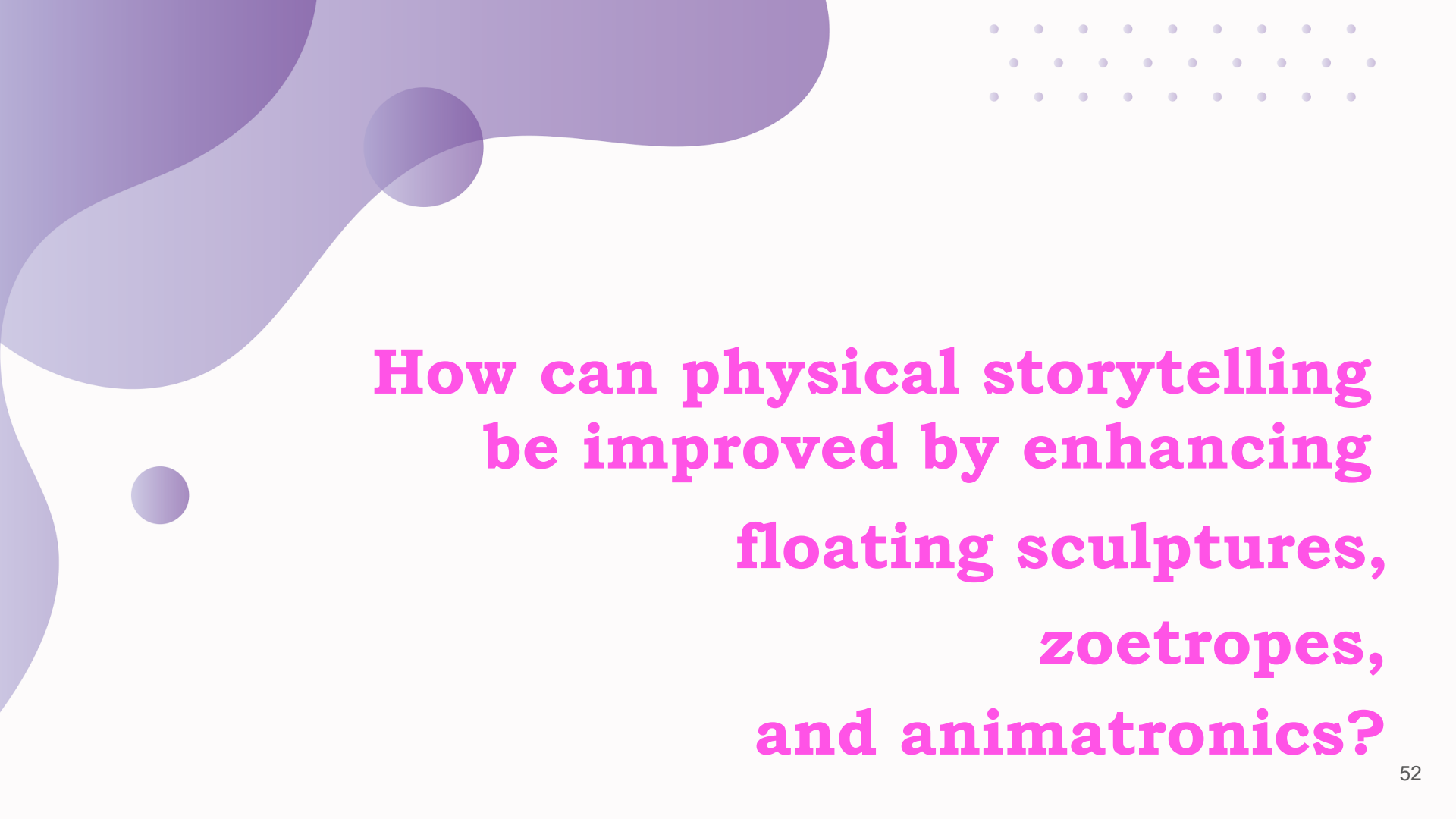
We designed a device and method that enriches zoetrope stories by:

- 1. Letting the viewer **explore the scene** with a strobing flashlight**
- 2. **Triggering audio** when the viewer looks at action objects**

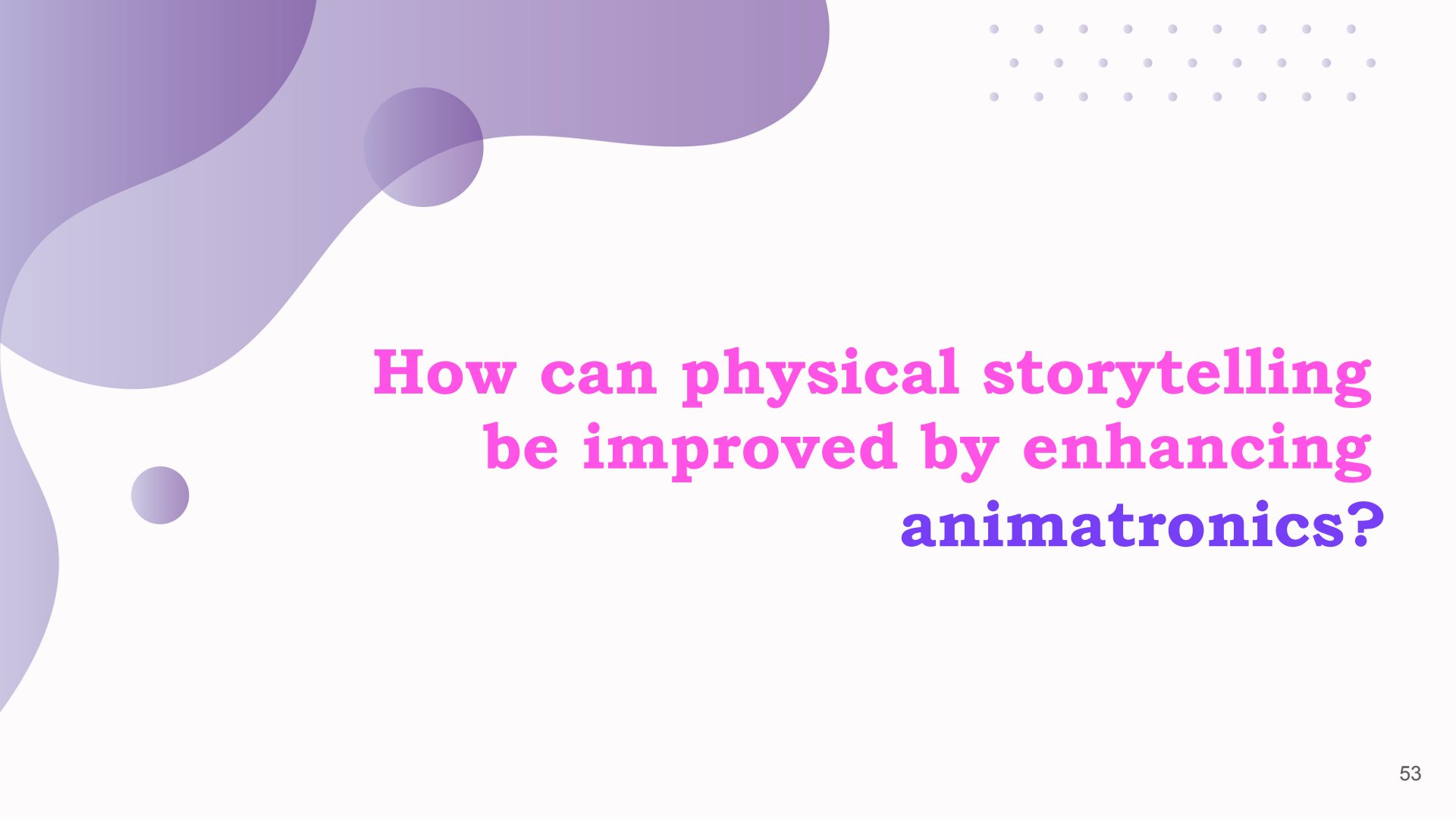
Zoetrope Results

We designed a device and method that enriches zoetrope stories by:

- 1. Letting the viewer explore the scene with a strobing flashlight**
- 2. Triggering audio when the viewer looks at action objects**
- 3. Allowing multiple versions of the story to be told**



**How can physical storytelling
be improved by enhancing
floating sculptures,
zoetropes,
and animatronics?**



**How can physical storytelling
be improved by enhancing
animatronics?**

Animatronics

A top-down photograph of two children sitting on a blue patterned surface, likely a rug, and drawing on white paper. The child on the left is wearing a grey sweater and a black cap, and is holding a blue marker. The child on the right is wearing a dark green hoodie with a white logo and dark pants, and is holding an orange marker. There are various drawing supplies like markers and paper scattered around them. The image has a semi-transparent purple overlay on the left side where the text is located.

What are animatronics?



Great Moments with Mr. Lincoln, 1964



Chuck E. Cheese



Jordan's Furniture Store



Pirates of the Caribbean, Disney World 55

What are animatronics?



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What are animatronics?



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Mr. Lincoln, 1964



Jordan's Furniture Store

Papertronic Puppets: Teaching STEM and Storytelling Through Creative Construction

Sarah Kushner, John Kanji, Paul H. Dietz, Daniel Wigdor
Dynamic Graphics Project Lab, Dept. of Computer Science
University of Toronto
Toronto, ON Canada
{sarah.kushner, john.kanji, paul.dietz, daniel.wigdor}@dgp.utoronto.edu

Abstract—This innovative practice full paper finds that storytelling through animatronics can offer a combination of creativity and engineering in order to engage students in an inquiry-based approach to STEM learning. Animatronics is the art and science of bringing a story to life through robotic puppetry. Typically reserved for trained engineers with ample resources, animatronics can be an expressive yet inaccessible medium. We aim to allow students to write, create, and perform an animatronic story, learning valuable technical skills along the way. Our study, which took place over the course of eight weeks, investigates the use of our Paper Animatronics Kit in a Grade 2 and Grade 6 classroom, following the progression of their creative writing, animatronic building, and mentoring processes. We present results of our qualitative analysis of student and teacher interviews and group discussions.

Index Terms—K12, Creativity, Communication skills, Problem solving, Student experience

I. INTRODUCTION

Stories are the medium by which we decode the human experience. Storytelling has been discussed in the context of education as a way of cultivating imagination, empathy, and reflection of the world [1]. Through writing and performing, students build a literacy of storytelling which lays the foundation for deeper, more complex engagement with the world.

Animatronics is the art and science of building physical robotic puppets to bring a story to life with sound and motion. Animatronic shows have become a fun and popular attraction in theme parks, restaurants, and museums, ever since one of the first presentations to the public, Walt Disney's life-size animated Abe Lincoln at the 1964 New York World's Fair. This expressive practice is a unique combination of creativity and STEM (science, technology, engineering and math), which makes it a useful tool to engage students in both storytelling and robotics.

However, this expressivity comes with a high barrier to entry, and the medium is typically accessible only to trained engineers with ample resources. To help lower this barrier and make animatronics accessible to a wide range of ages, abilities, and socioeconomic status, we introduce an affordable yet versatile Paper Animatronics Kit for K-6 students to create papercraft puppet shows. The design of our kit is informed by the "critical making" movement established by thinkers such as Ratto and Garnett to describe the process of creating

artifacts to explore and understand social and cultural issues, blending engineering, design, art, and social sciences [2], as well as Ratto's idea of "tinkerability," which he defines as "a playful, exploratory, iterative style of engaging with a problem or project" [3]. Critical making and tinkerability are not focused on the product of the making but the process of getting there which acts as a way for the maker to explore the world. By centering storytelling and the creative process, and allowing open-ended exploration with the technology, we aim to empower student agency and voice. Our kit thus uses an inquiry-based approach that taps into students' genuine curiosity about the world to solve problems, scaffolding the technical elements while allowing them to tinker and inject their creativity and identity.

Our contributions are as follows:

- A Paper Animatronics Kit for K-6 students
- An in-classroom user study with Grade 2 and 6 students to evaluate the suitability of our kit
- Qualitative analysis of teacher and student interviews and group discussions

In this paper we describe the components of our kit in more detail, present the findings of our study, and end with key implications of using our animatronics kit in elementary classrooms.

II. RELATED WORK

A. STEAM, and the Creativity Gap

Of central importance to us is the so-called "creativity gap," defined as "an incongruity between the ostensible value educators place on creativity and its absence in schools" [4]. The creativity (or creative participation) gap manifests in education in a variety of ways: the removal of creativity from "academic" subjects and its partitioning into separate arts programs, and the chronic underfunding of said programs [5], but also inequality of access to experience, skills, and tools required to flourish creatively in an era of digital media [6].

Emerging as an augmentation to the interdisciplinary field of STEM, STEAM aims to address the creativity gap by integrating the Arts into STEM education, emphasizing creative and design thinking as well as problem solving [7]. But this approach has been problematized by some, such as

Papertronic Puppets: Teaching STEM and
Storytelling Through Creative Construction
Kushner, Kanji, Dietz, Wigdor
IEEE Frontiers in Education 2024

Attractions 360°

Pirates of the Caribbean, Disney World 55



Animatronics Research Goals

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Make the art and science of animatronics more accessible to non-experts such as children and teachers with no technical experience by:

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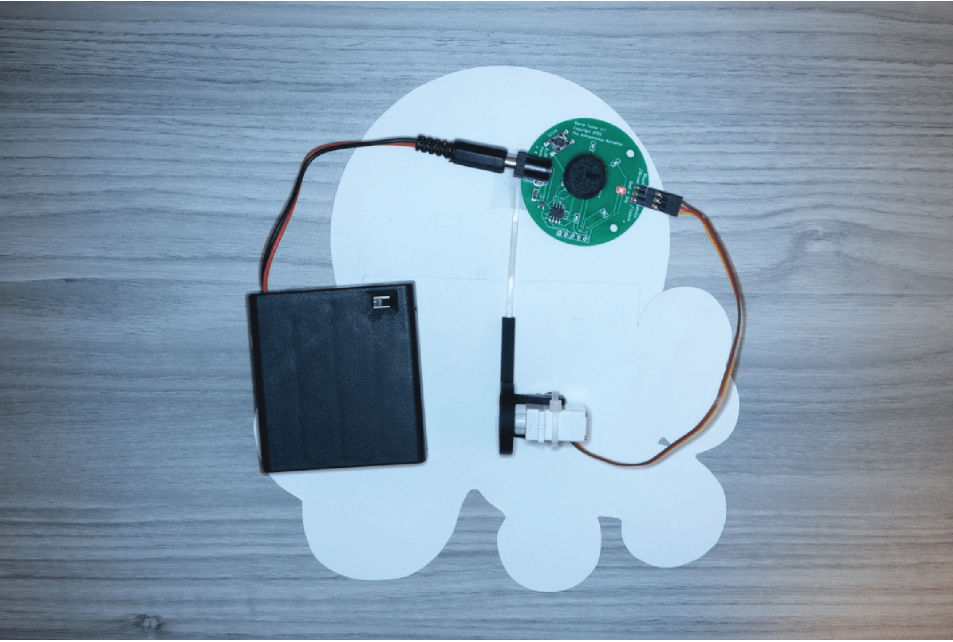
- 1. Creating an affordable yet versatile animatronics kit**

Animatronics Research Goals

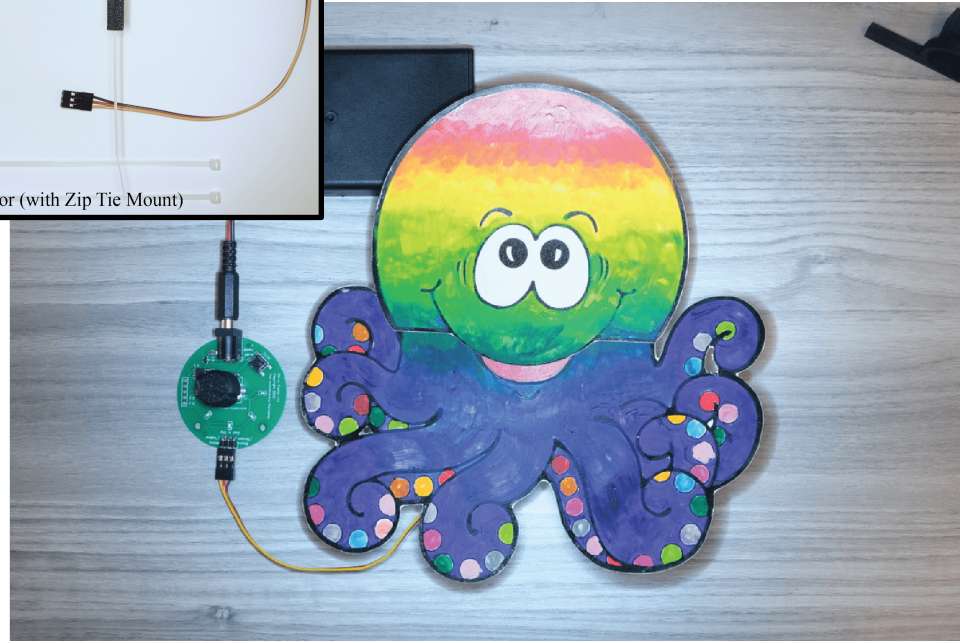
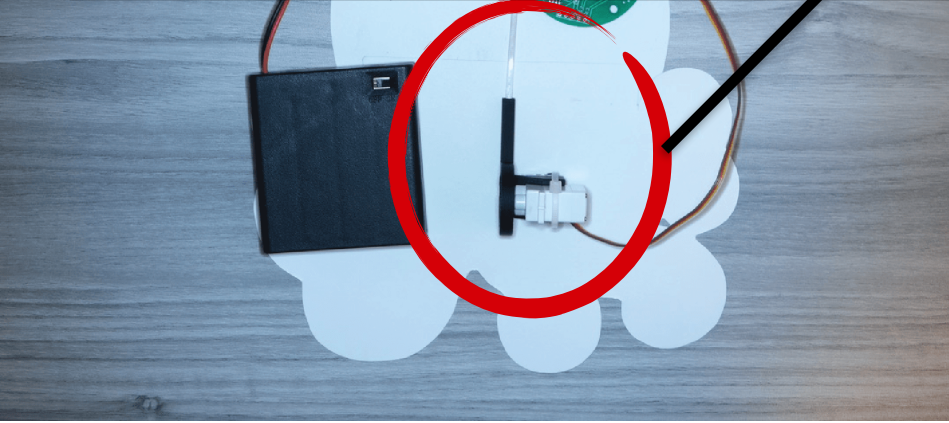
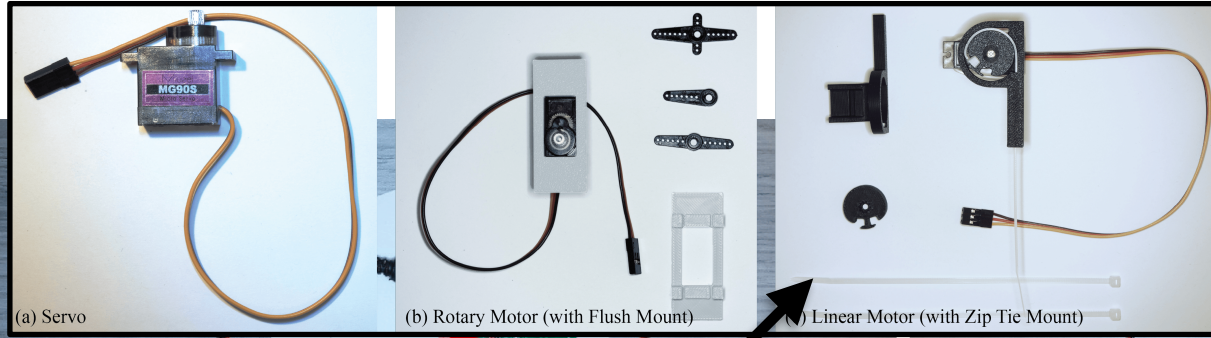
Make the art and science of animatronics more accessible to non-experts such as children and teachers with no technical experience by:

- 1. Creating an affordable yet versatile animatronics kit**
- 2. Running workshops that teach K-12 students STEM skills while doing creative tasks**

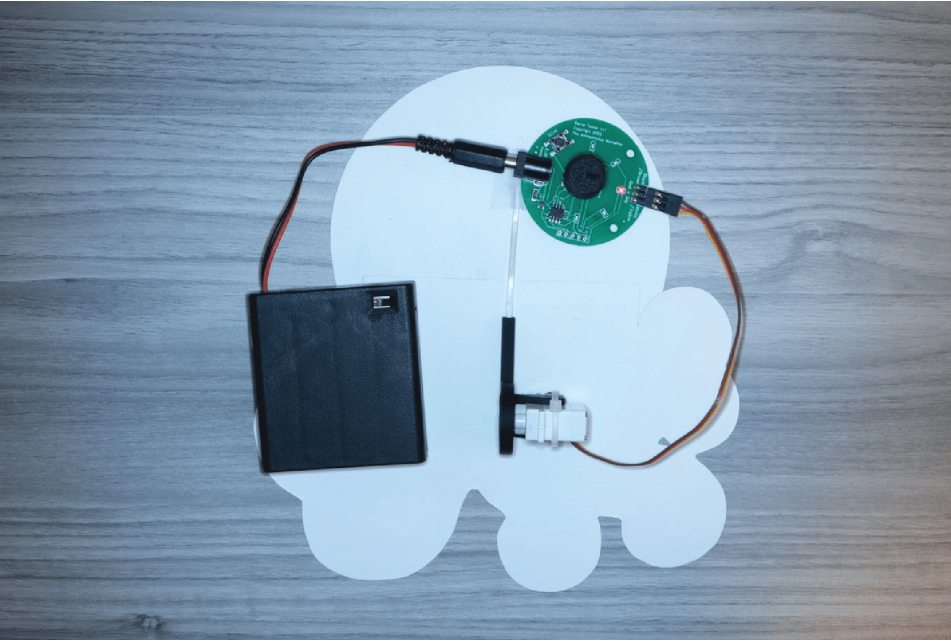
Animatronics Kit



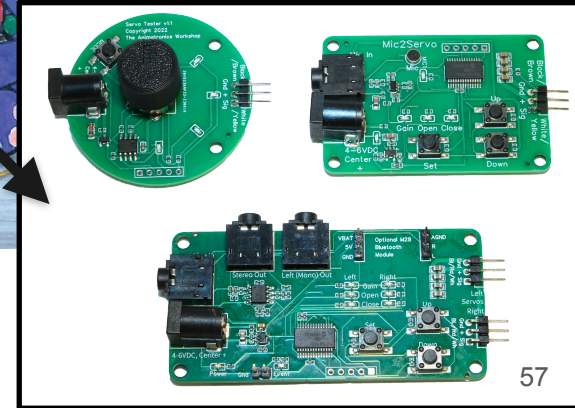
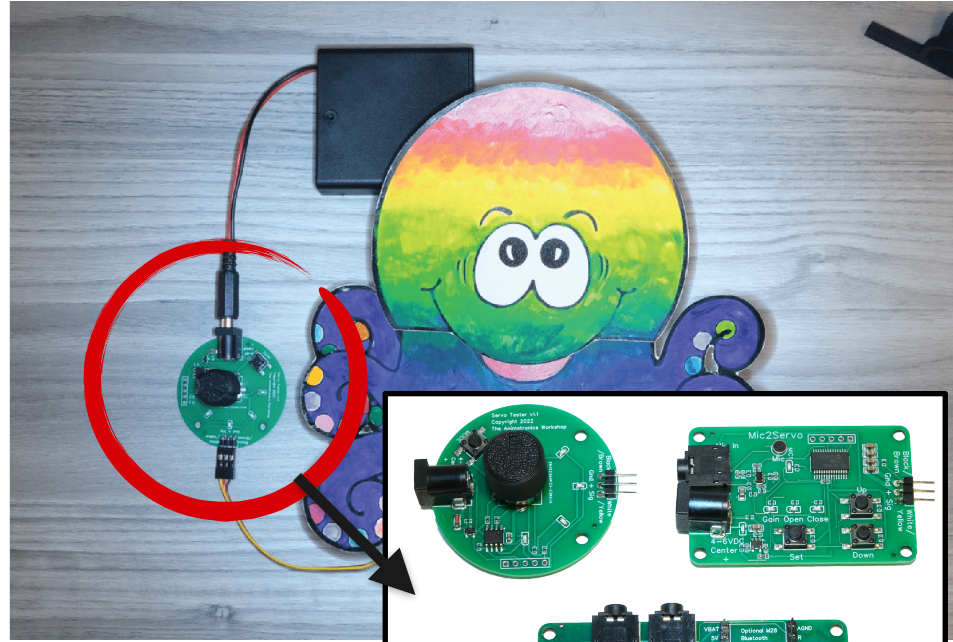
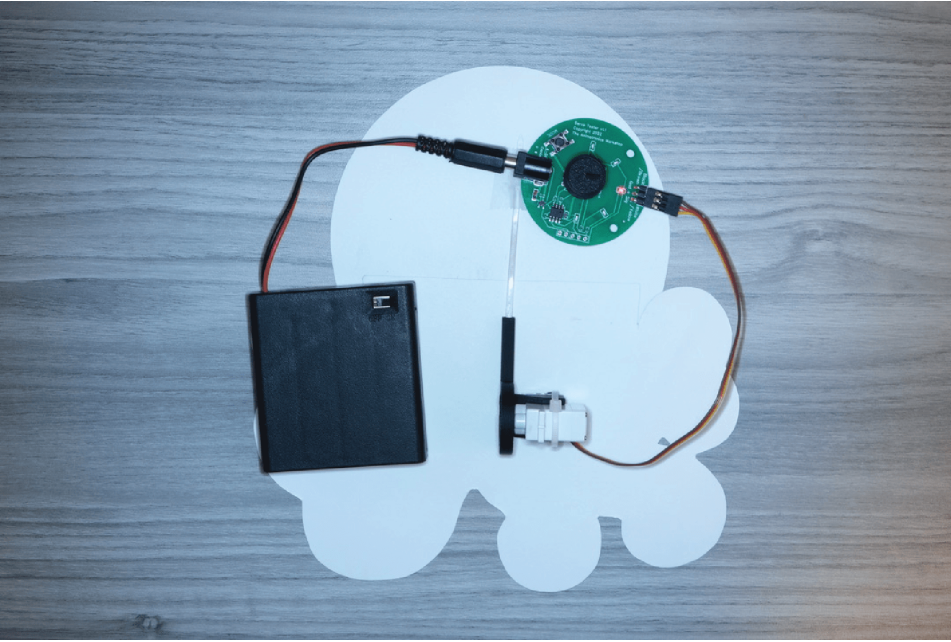
Animatronics Kit



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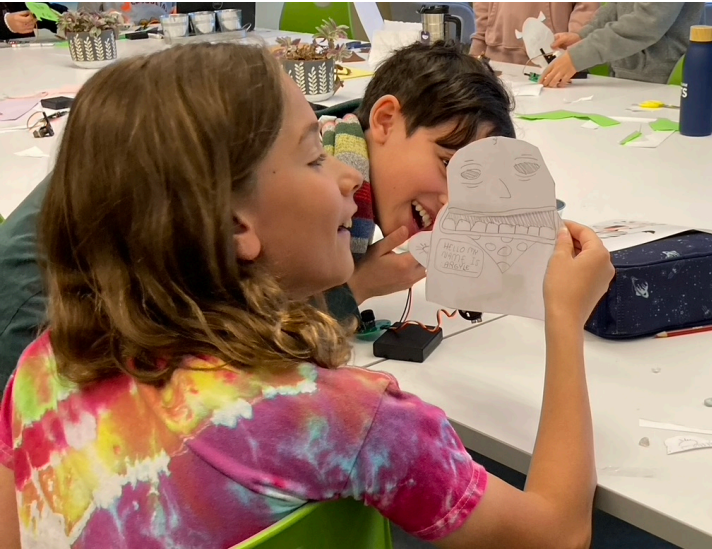
Animatronics Kit



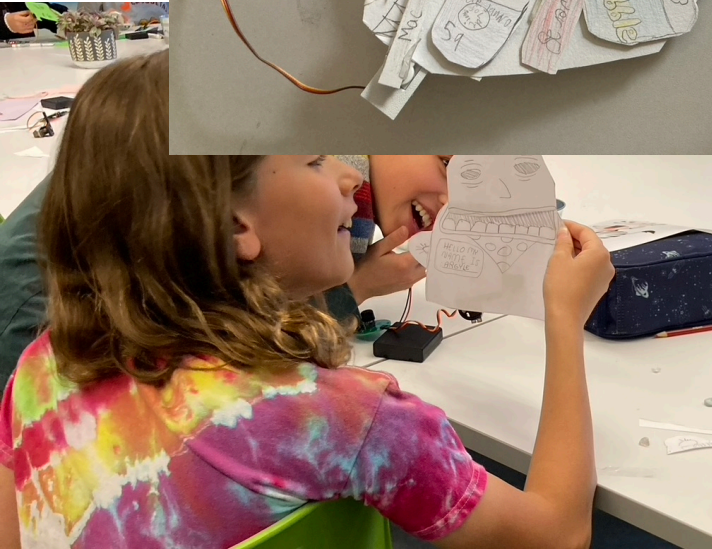
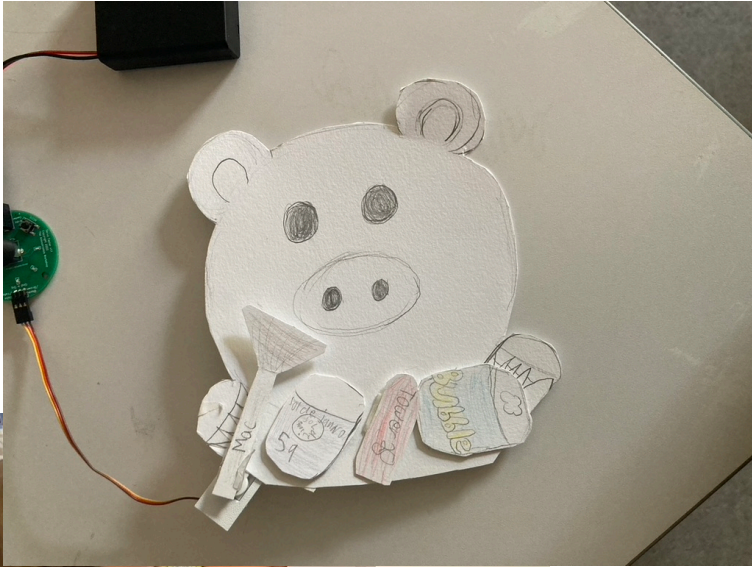


Creativity + STEM

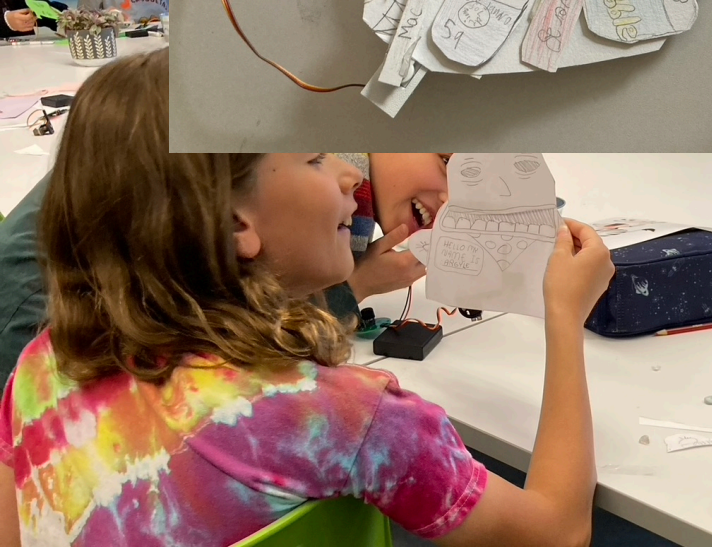
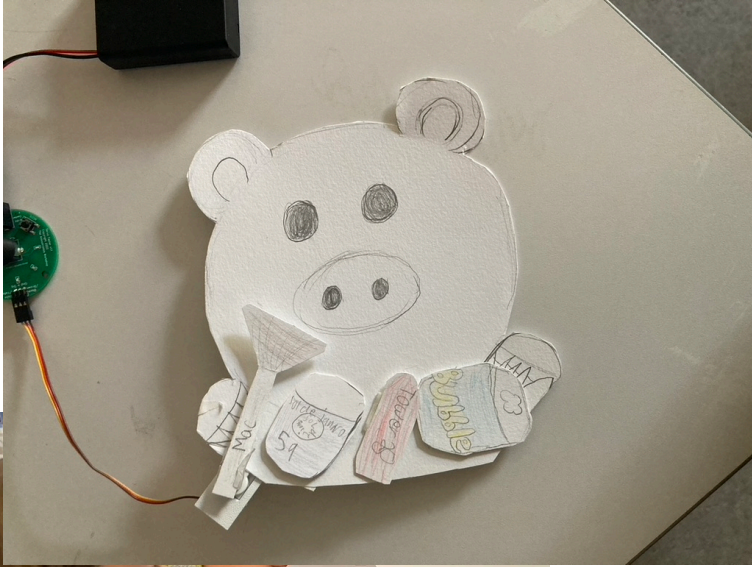
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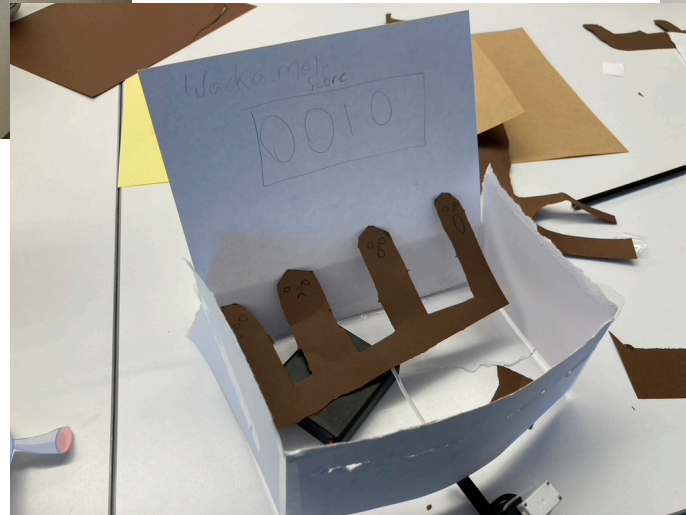
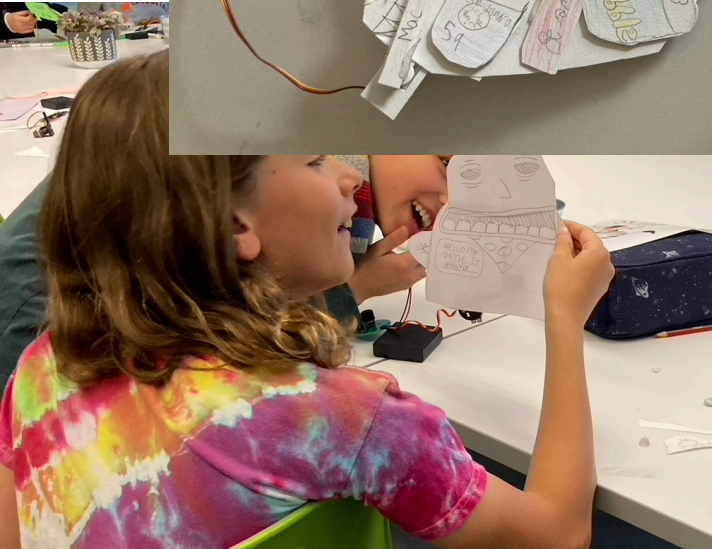
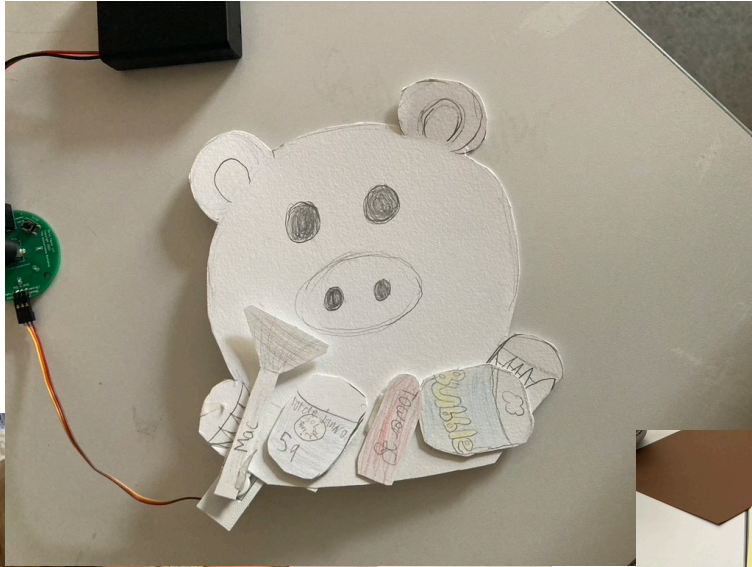
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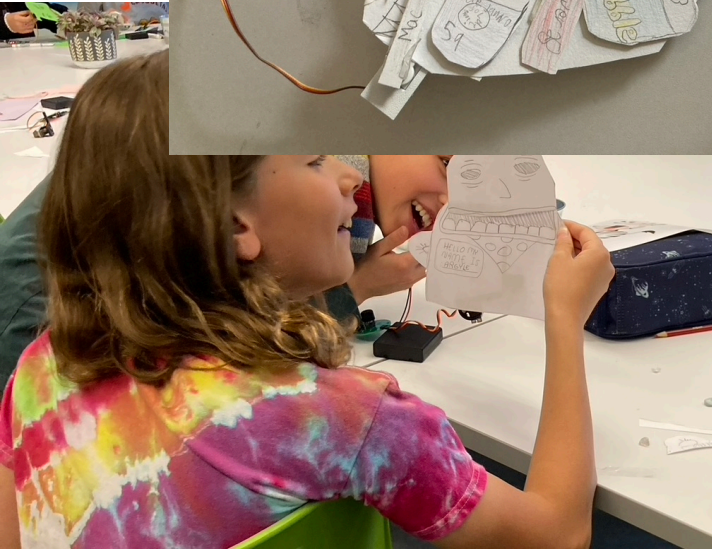
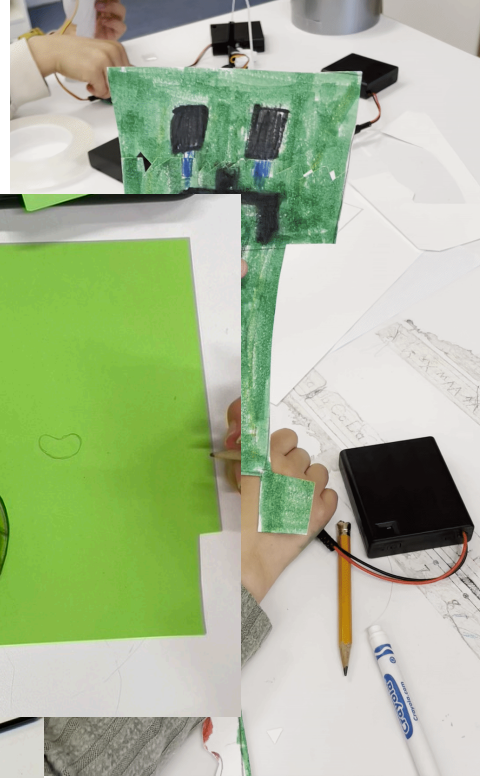
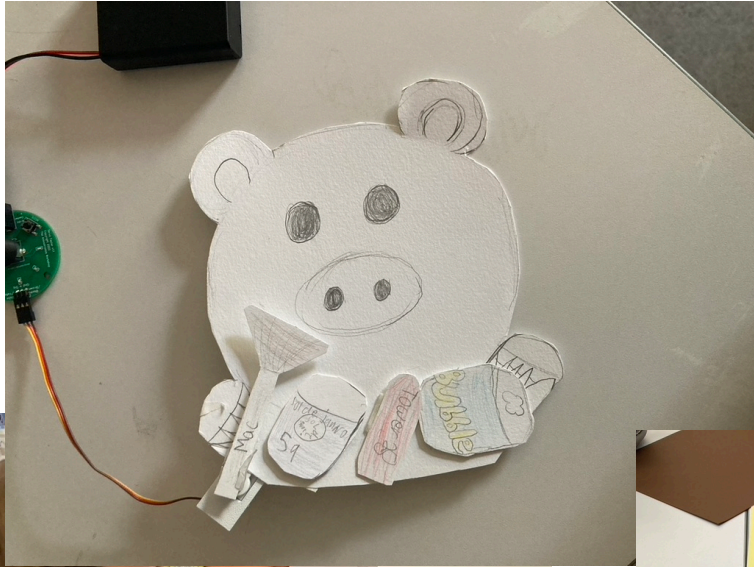
Creativity + STEM



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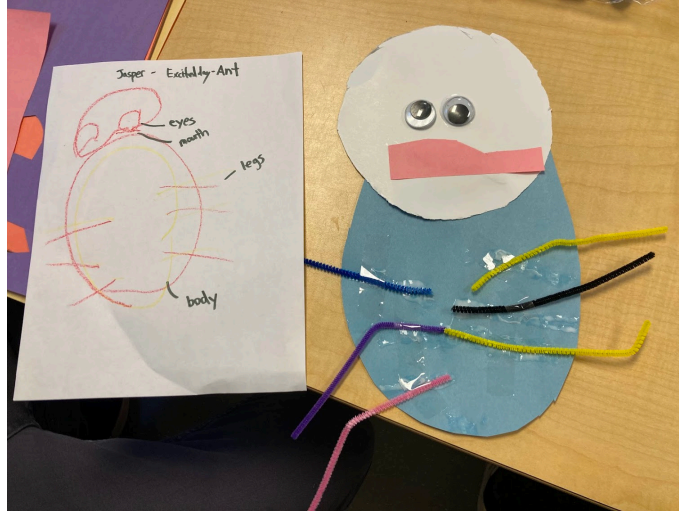
Creativity + STEM





Challenge level, age groups, and tech teachers

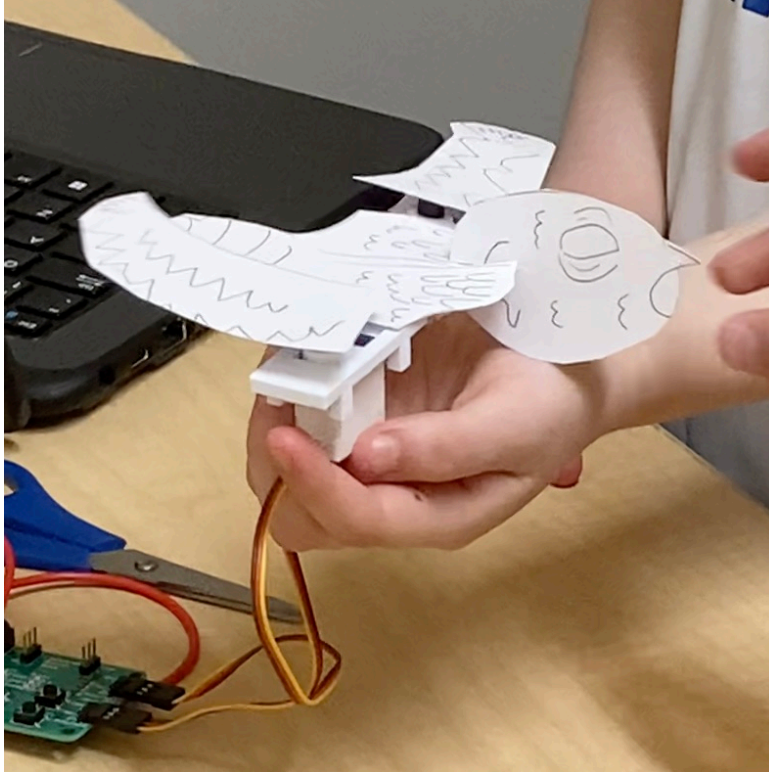
Challenge level, age groups, and tech teachers





Challenge level, age groups, and tech teachers

Challenge level, age groups, and tech teachers



Challenge level, age groups, and tech teachers

WIZ
Learner

Classrooms

My Cores

Discovery

Profile

Logout

All Your Unlocked Levels

Review your unlocked levels, units and tasks!

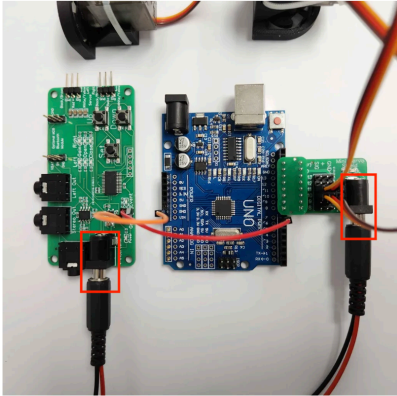
Unit 3

<

Tasks 3

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Unit: Mission 3: Buzzing Bees - Task: Buzzing Bees Instructions



Show QR Code

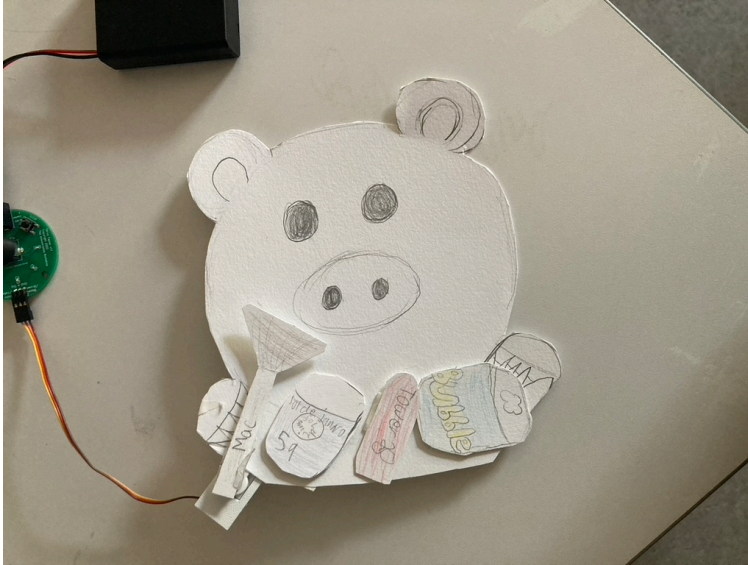
Mentoring





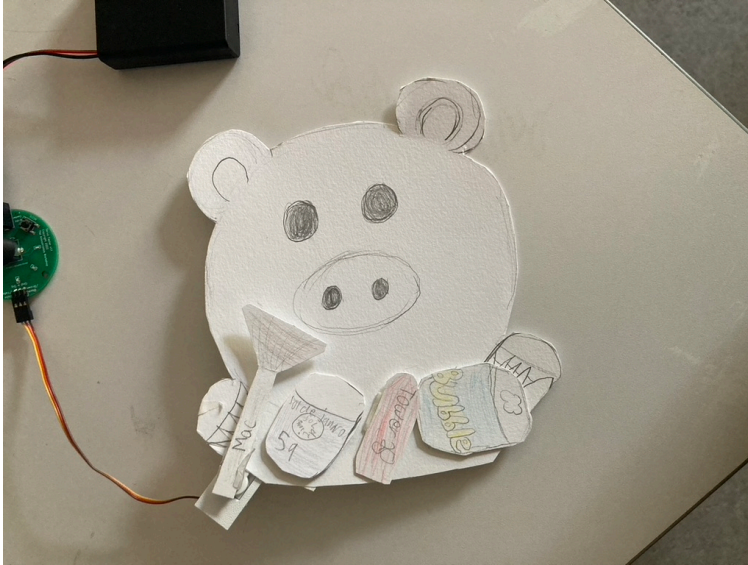
Mentoring

Mentoring



Grade 2 makeup brush swinging

Mentoring



Grade 2 makeup brush swinging

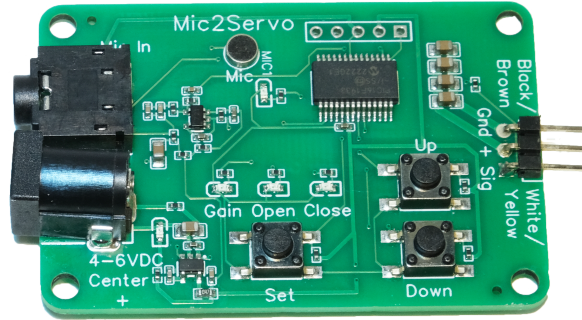
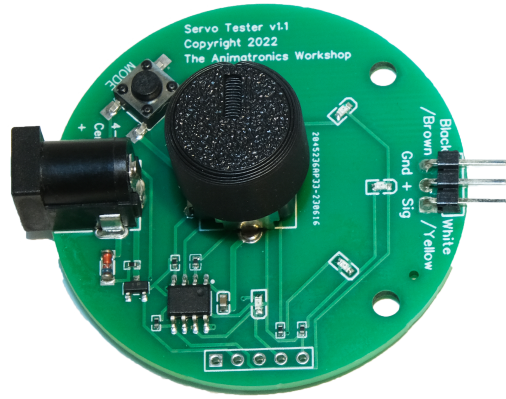


Grade 6 axe swinging

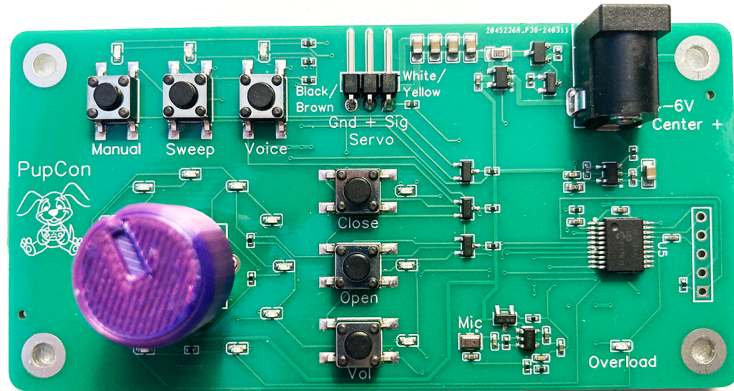


Kit + Classroom Evaluation

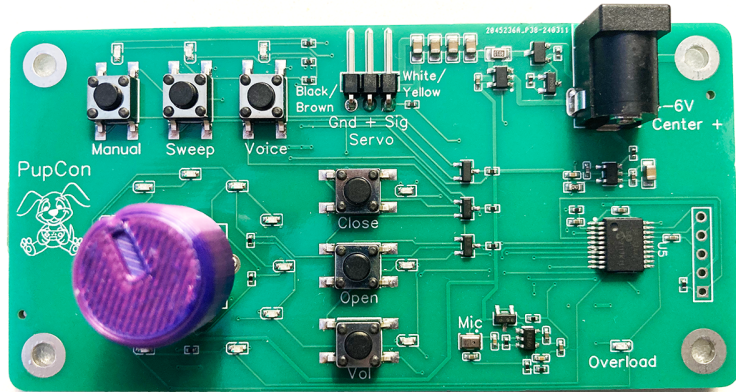
Kit + Classroom Evaluation



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Animatronics Results

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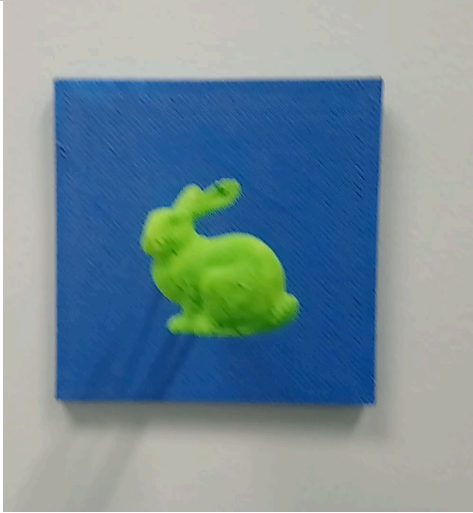
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- 1. Combining STEM with creative tasks engages students**
- 2. Tradeoff between difficulty and teacher's constraints**
- 3. Mentoring in animatronics tasks benefits mentors and mentees**
- 4. Kit allowed students to create paper animatronic puppets and can be improved**

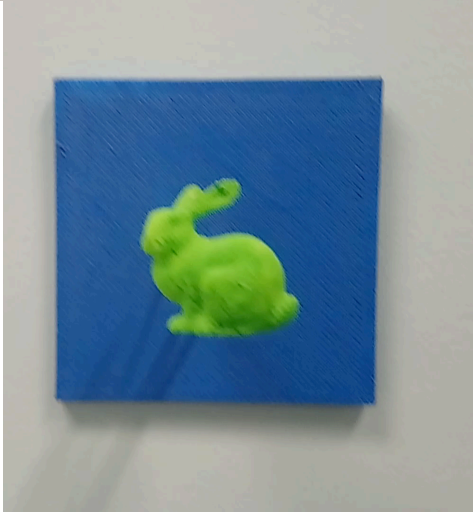
Conclusion

Physical storytelling in 3 mediums



Floating Sculptures

Physical storytelling in 3 mediums



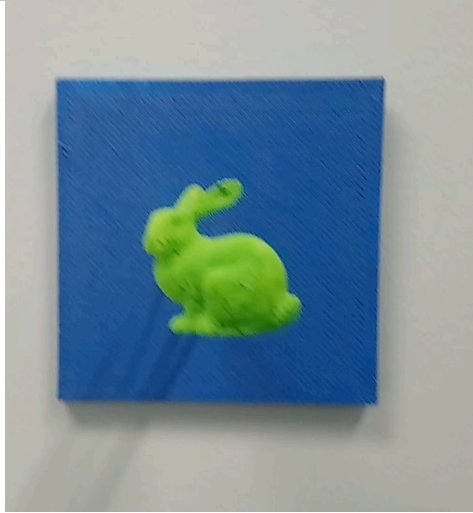
Floating Sculptures

Physical storytelling in 3 mediums

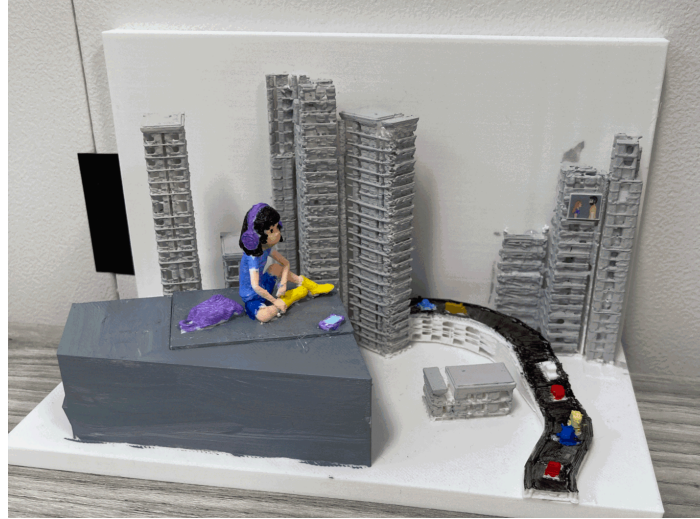


Floating Sculptures

Physical storytelling in 3 mediums

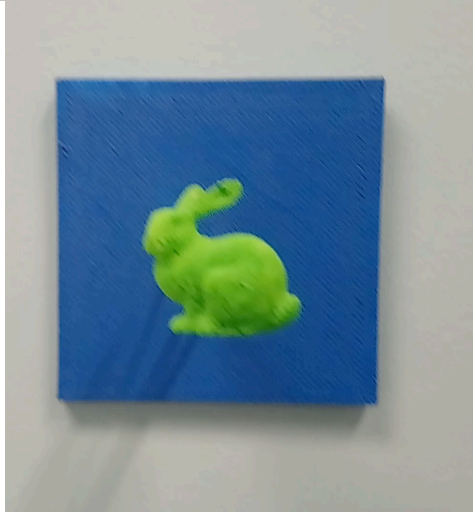


Floating Sculptures

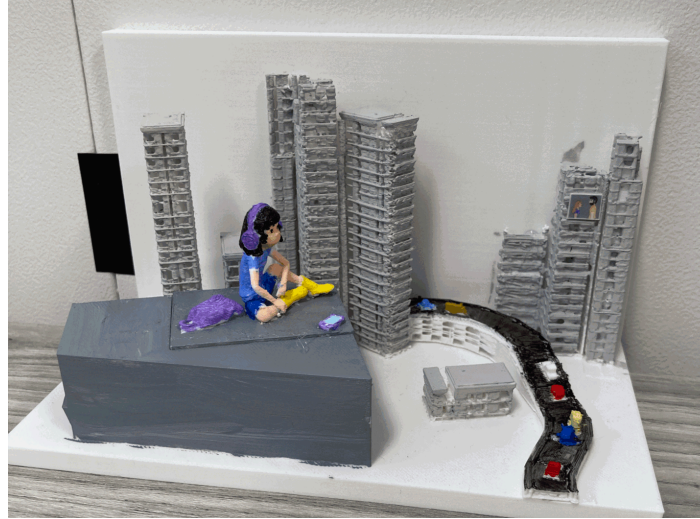


Zoetropes

Physical storytelling in 3 mediums

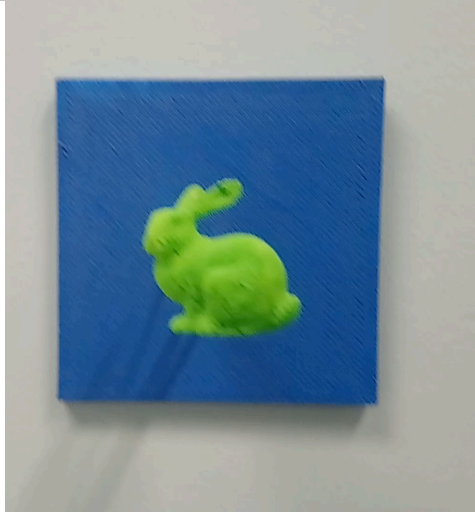


Floating Sculptures



Zoetropes

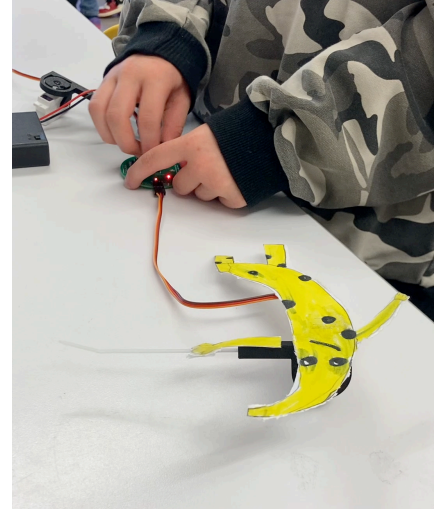
Physical storytelling in 3 mediums



Floating Sculptures

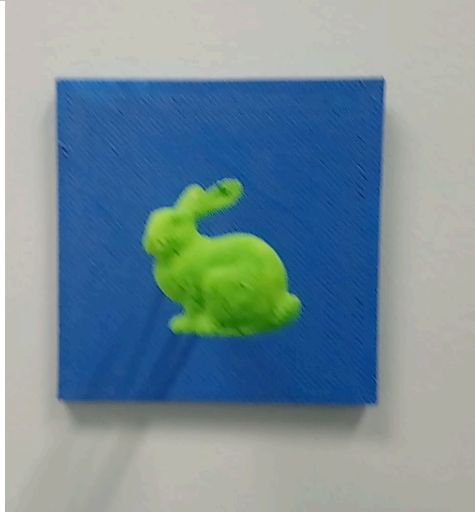


Zoetropes



Animatronics

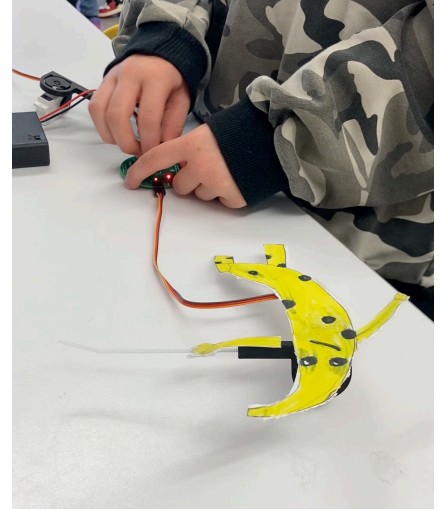
Physical storytelling in 3 mediums



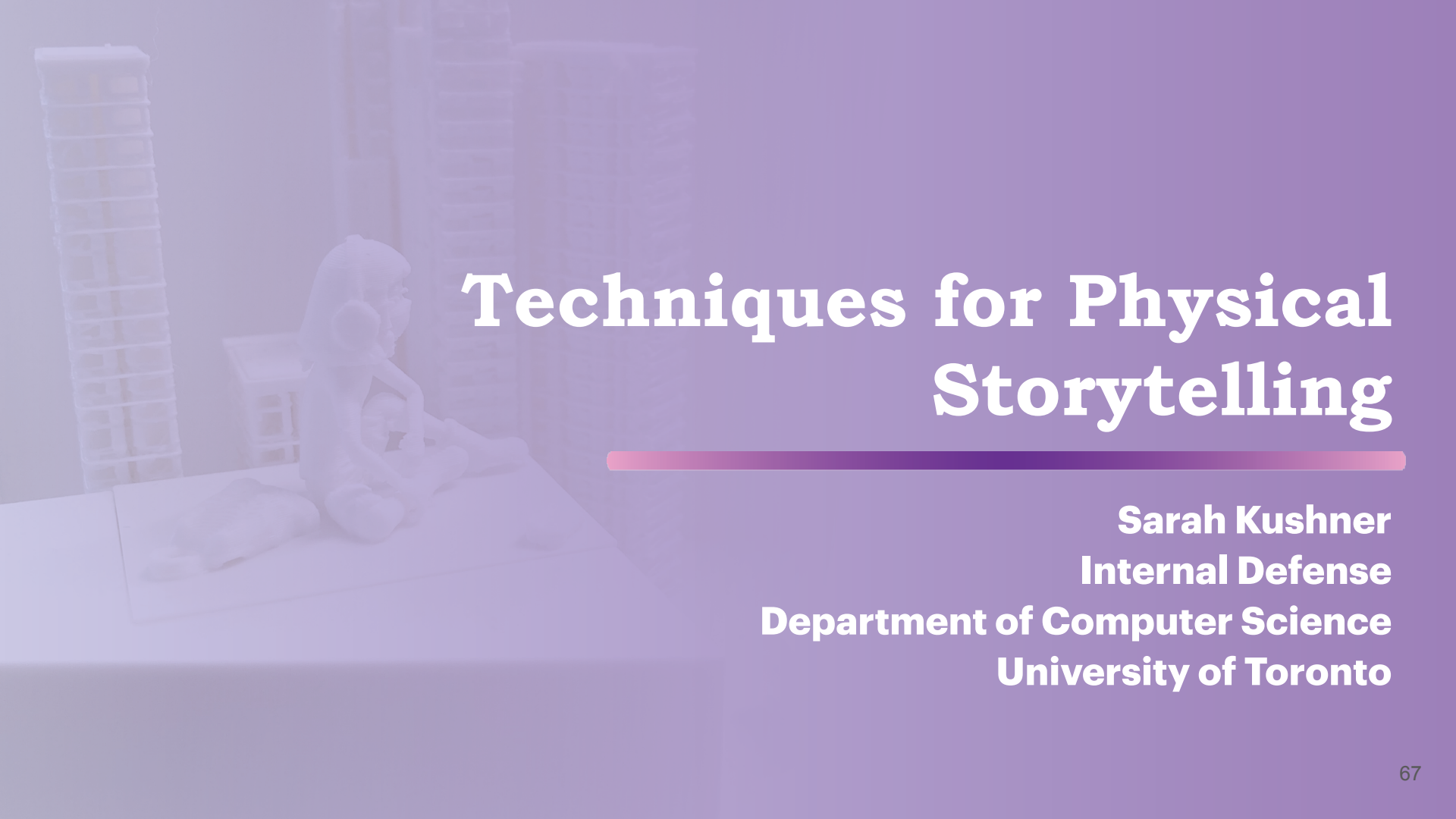
Floating Sculptures



Zoetropes



Animatronics



Techniques for Physical Storytelling

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