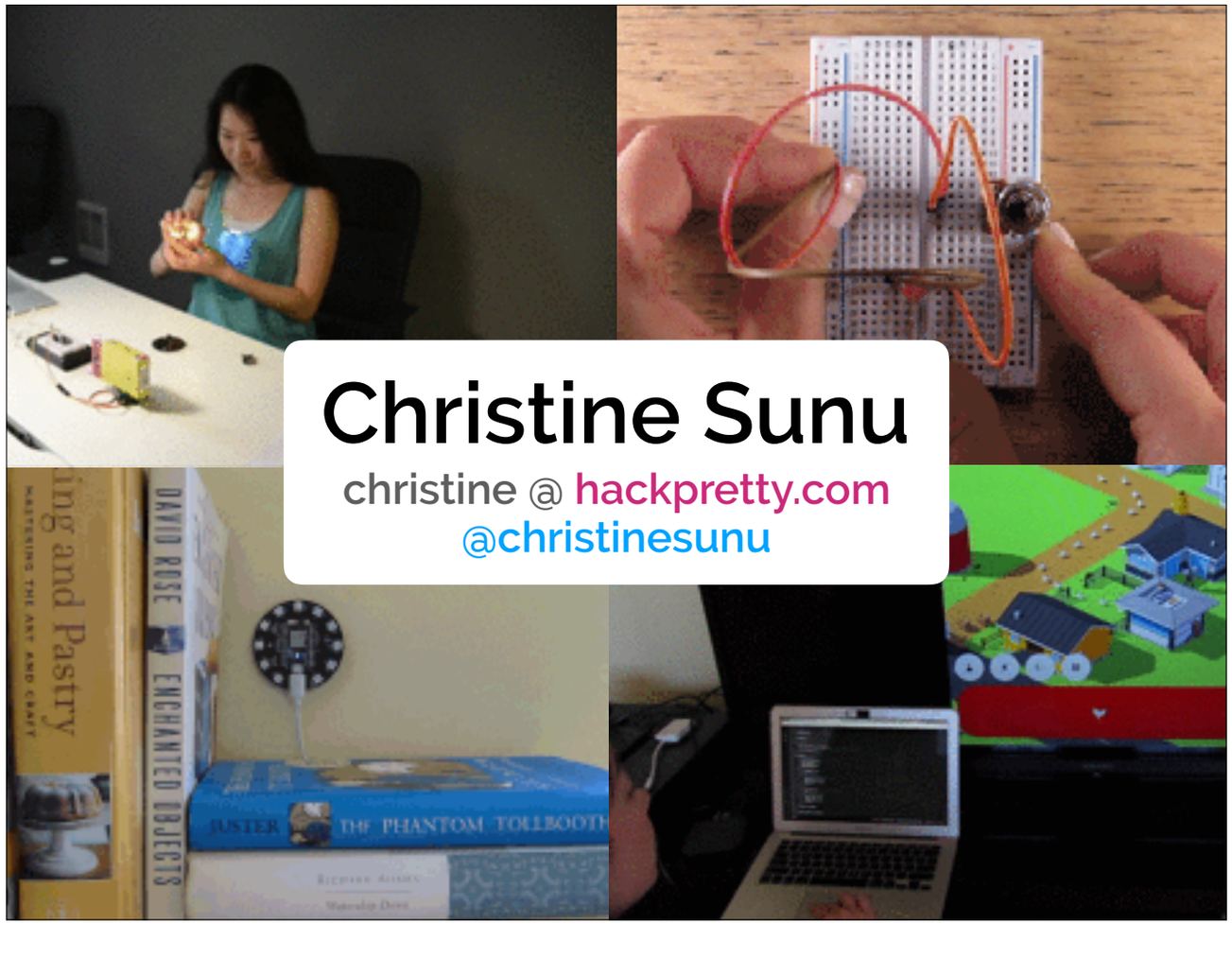
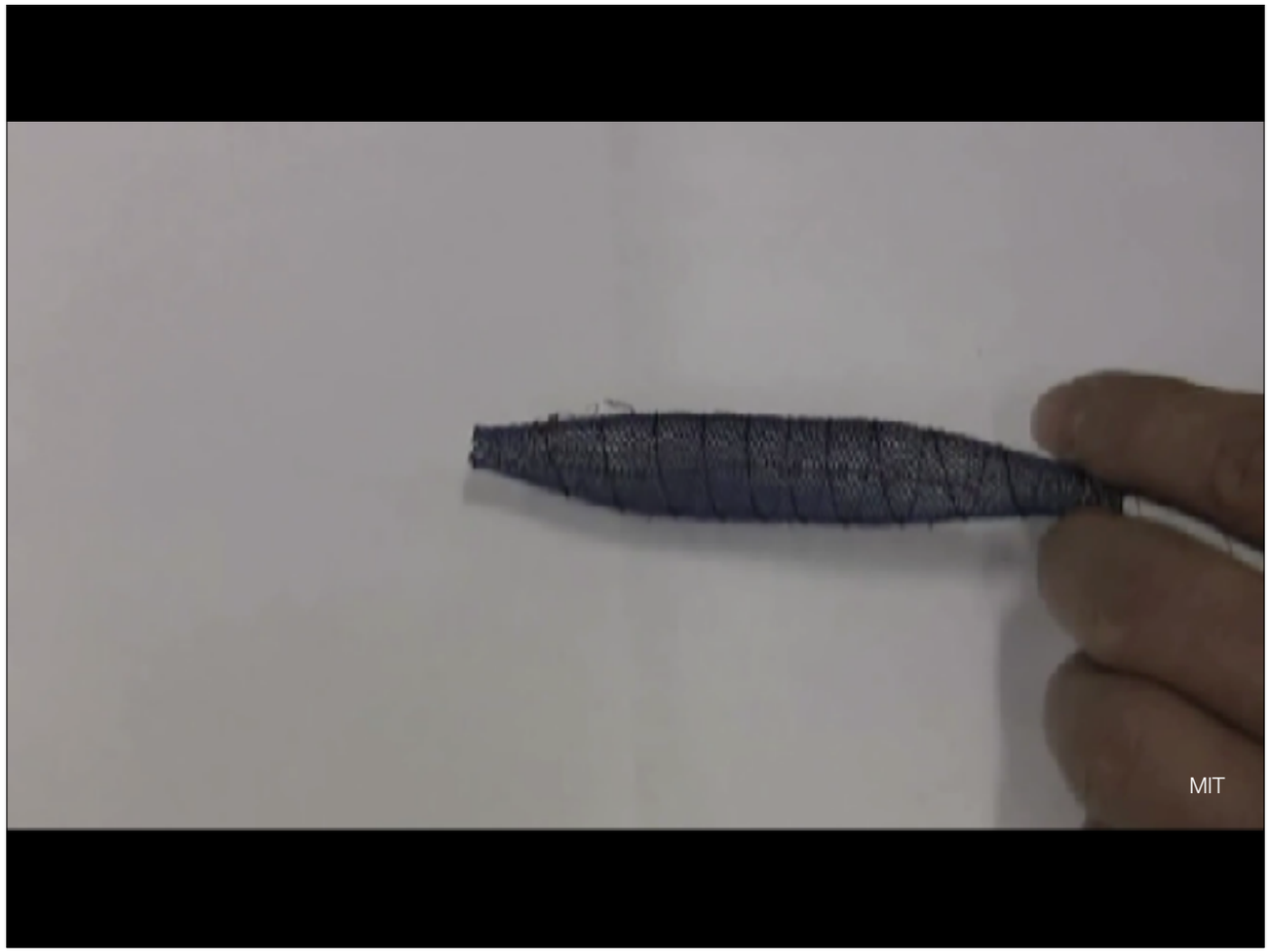


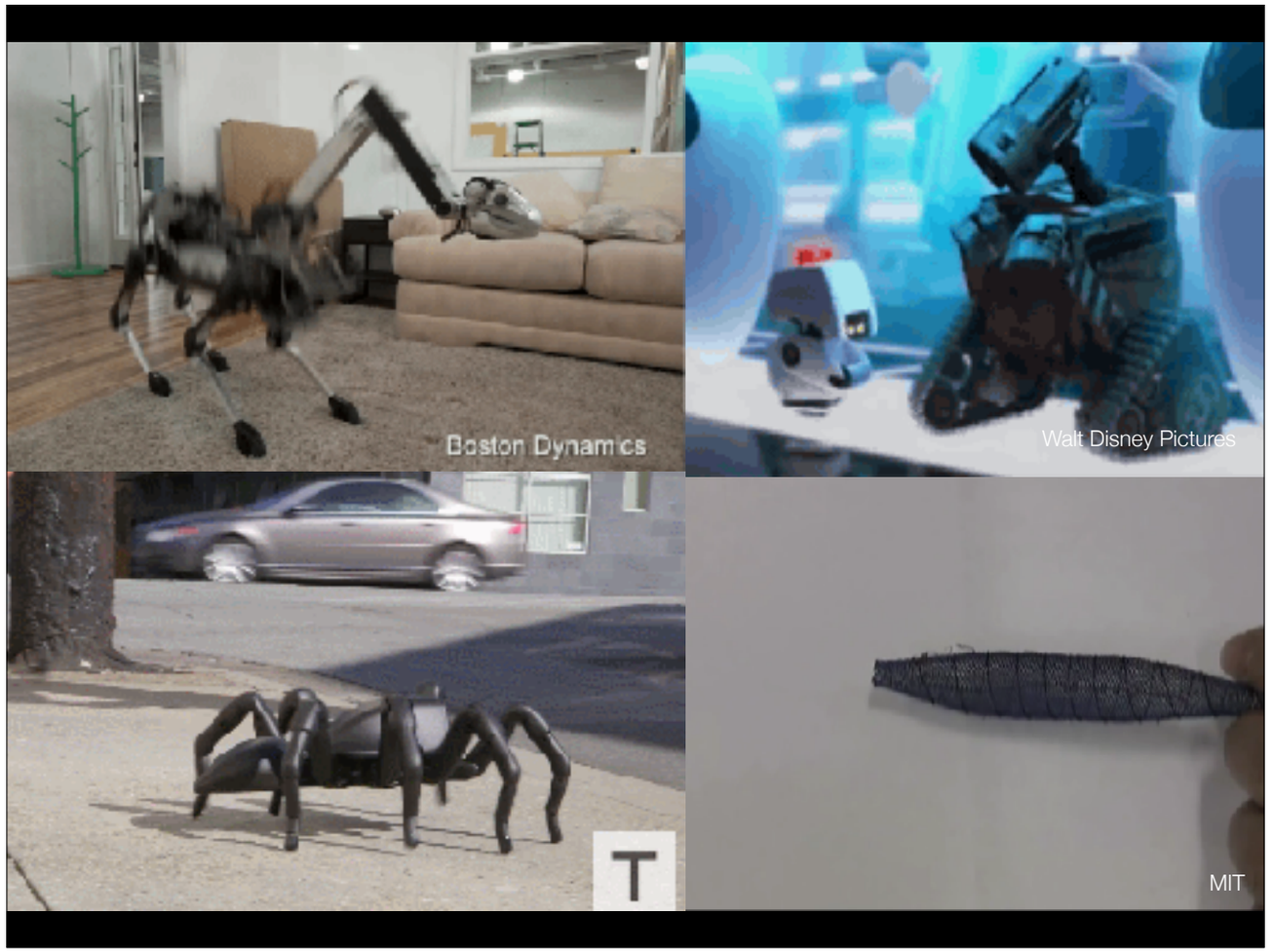
Hi, everyone! I'm Christine. This is me.

I am, like you, a generalist in the awesome, endless learning of electronics and making. I previously ran the **developer community** at Particle and I worked on weird **open-source robots** at BuzzFeed. I currently do freelance product work and post tutorials on electronics and design at hackpretty.com.

Most of my work **focuses on emotive interactivity in physical and digital objects**. I work on getting people to feel living emotions about non-alive objects, whether that's an app or a hardware product or a robot pet. And I've found that the shortcut to getting your user to feel deep emotions— whether that's attachment, care, joy, or fear— is to use biomimicry.



We see **biomimicry in tech news** all the time these days. A lot of technologists focus on biomimicry because it can offer amazing, creative solutions to hard problems. But there’s also another, simpler reason to use it.

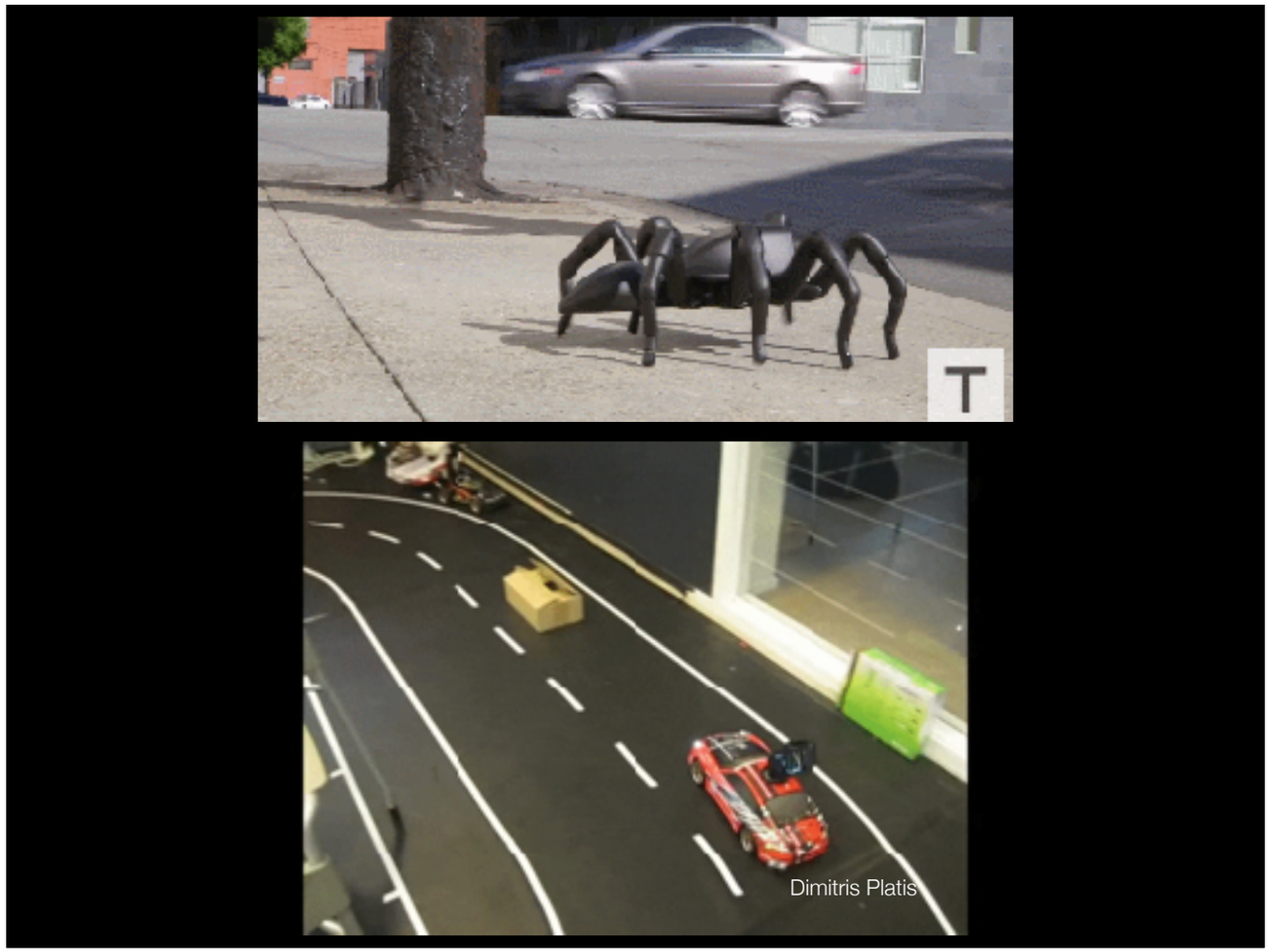


Biomimicry is **fun, funny, crazy, and weird.** It makes us feel something that other, more typical robots don’t.

I mean, let’s face it—

this is funnier than this

And this is cuter than this



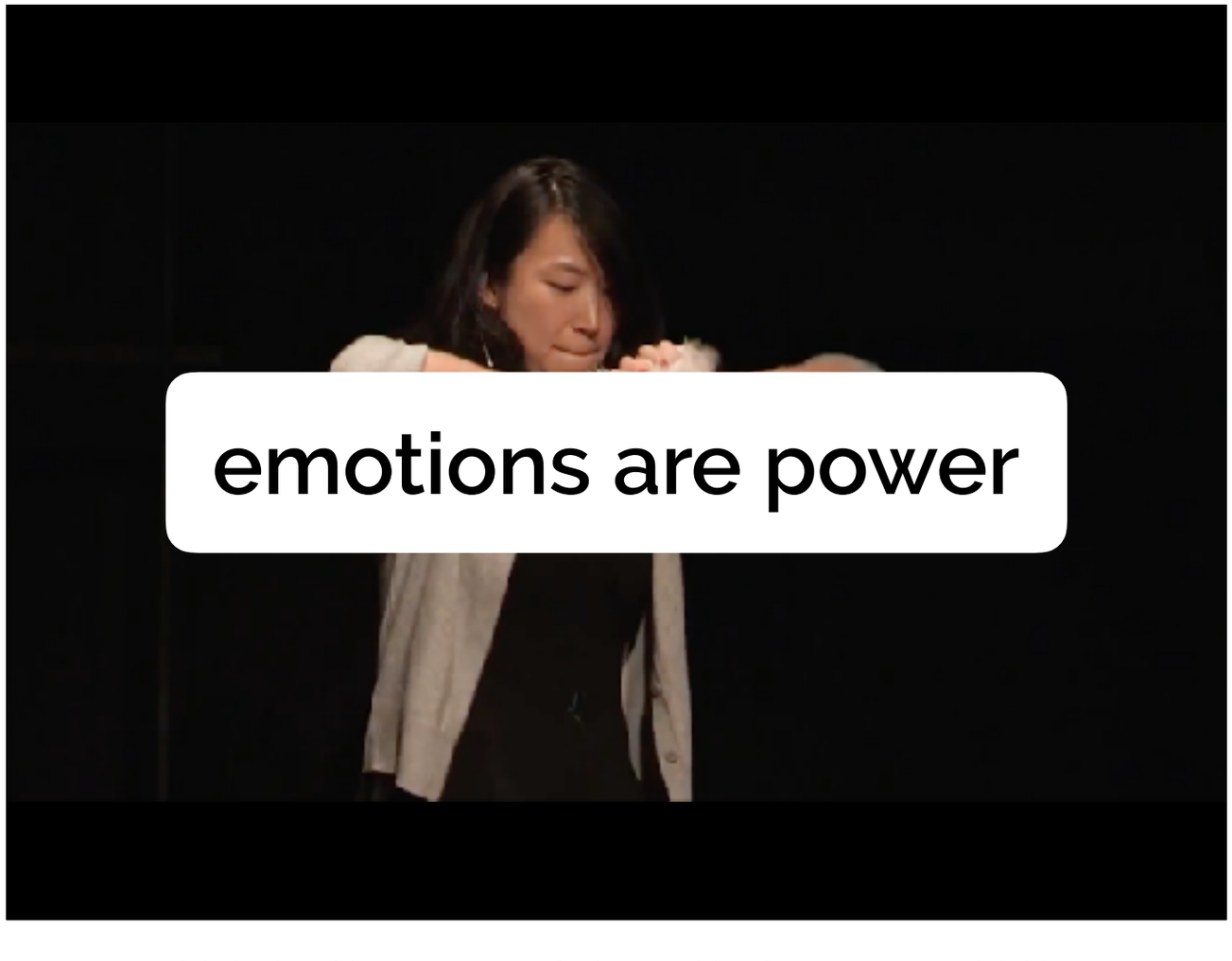
And this is more terrifying than this

We are humans, **evolved to deal with other living things.** So when machines imitate living things, it makes us feel feelings we usually reserve for our animal, insect, and human friends. And that can make us react much more strongly and emotionally to a robotic stimulus. …

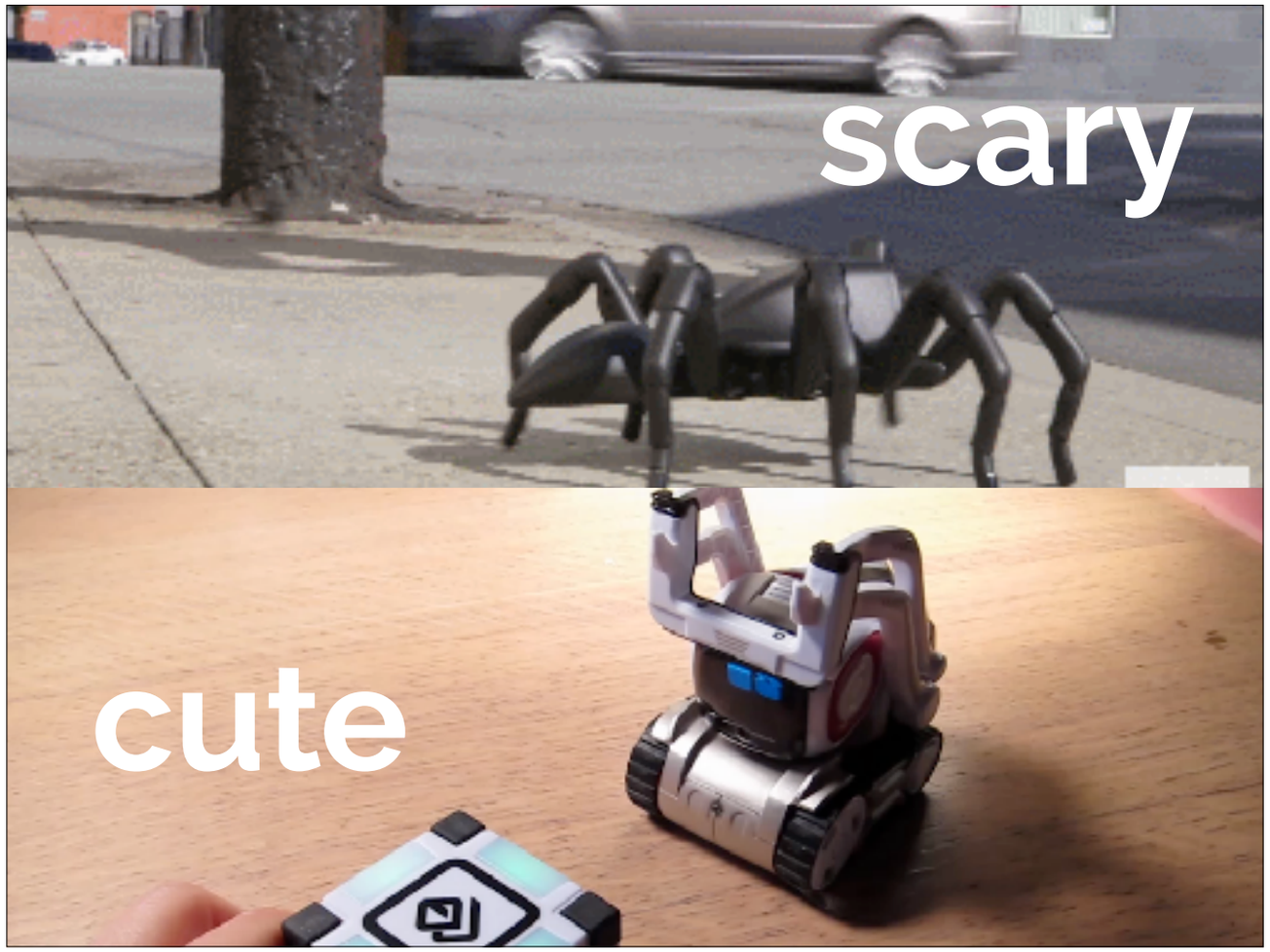
The power of the emotions we feel when we see something else we think is alive can be **overwhelming**. I was talking about emotive biomimicry a few months ago at an event in san francisco, and I showed people this little bot. I carried him around the whole time, while I discussed how you make your bots fake being alive. And then at the end:

[video of worm breakage]

Now I think they added the applause at the end there because I’m pretty sure I walked off stage to horrified gasping followed by total silence. People were very affected by the worm being killed even though **they were told it was a robot,** the **entire talk was about the illusion** they were experiencing at that very moment, and I had the words **“this is a robot”** projected on the screen behind me. A cognitive scientist came up to me after the talk and told me that even though she knew everything I was doing, she still cried when I snapped the worm in half.



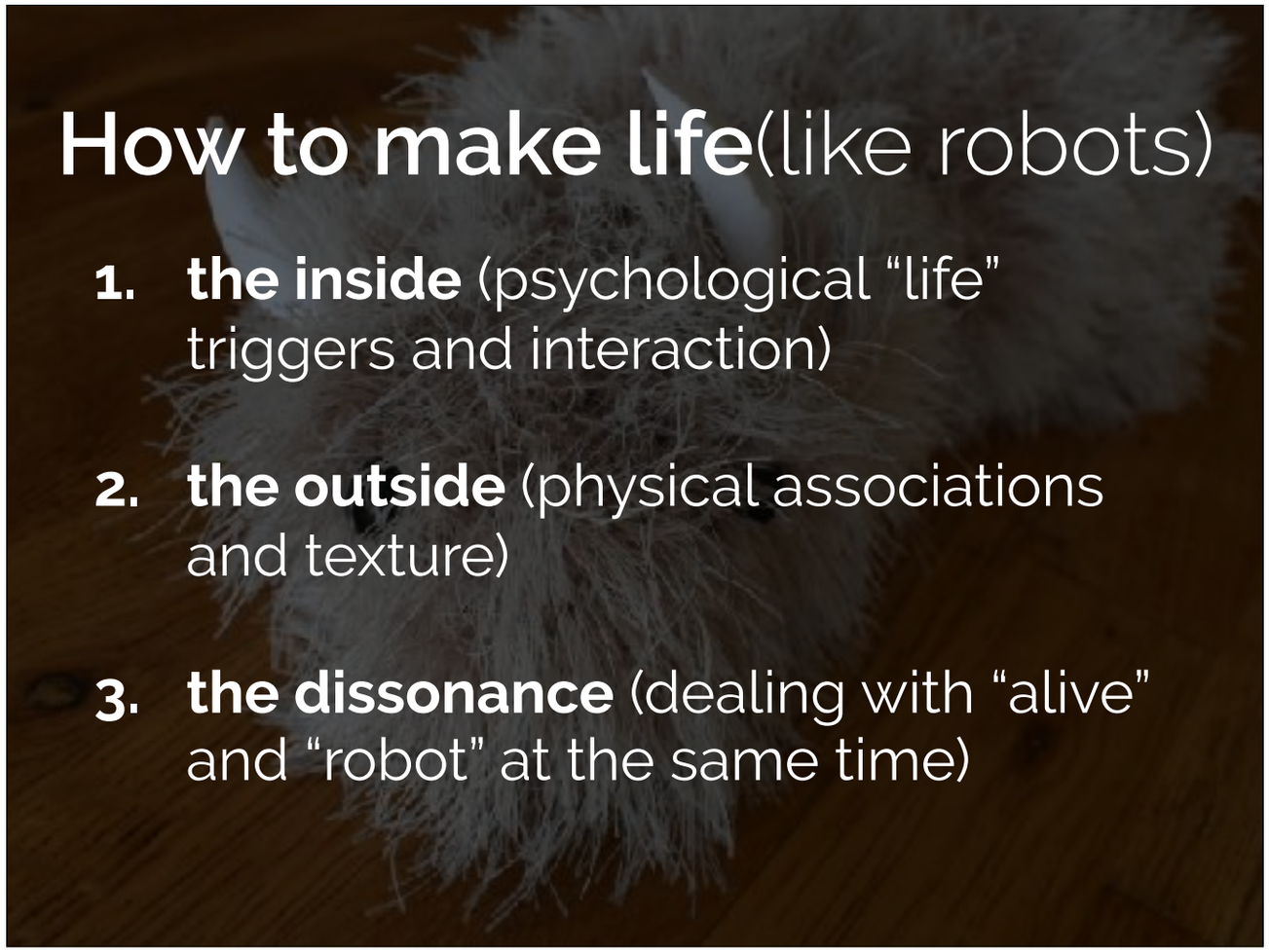
Which goes to show that human emotions are powerful. And making your users feel something is a very powerful thing.



Feelings are important. Feelings guide the perception of your product, they guide clicks on buttons like subscribe, and like, and add to cart. They guide user experience.

Biomimicry is a very powerful shortcut to feelings, and so it becomes very useful in product design, or even in weekend hacking projects. As users, we are more likely to do a task if we feel genuinely good when we do it or genuinely bad when we don’t. Feelings can make an uncomfortable bot feel more comfortable. They can make an unprecedented new technology slide into your life like you never knew you lived without it.

So the question isn’t, “Will adding biomimicry to my hack or product make people feel something more about it, or make it more usable” the question is, “How do I do it effectively, and how do I get the feeling and experience I want my users to have?”



The answer has to do with a lot of factors that go into the human perception of life, as well as a lot of physical associations with appearance, texture, and movement.

There’s also another issue, which is that biomimicry by robots does have its limitations. No matter how alive it seems, no matter how attached we are, we technically know it is a robot. Recognizing that is actually an important part of designing a convincing and easy to use interface.

the inside
(psychological “life” triggers and interaction)

Let’s start with this. The inside. Not just of your robot, but of your users minds.

Your users are human. If you understand the way humans perceive life with empathy, it’s much easier to get people really attached to your bot, app, or interface.

I’m going to go over this a bit on the quicker side, but the basic idea is this: Living things need. We need food, water, a big box of resistors from aliexpress. We also need other living things. We have societies based around our need for each other, to be near each other, to fight and conquer each other, to help and love and care for each other. We are constantly on the lookout for other living things, and whether they are likely to help or hurt us.

And when we’re looking for life, we’re looking for something that seems like us. Something that has evidence of need.

Need starts with purpose, so I often start with that, too. Like us, a lifelike robot should be happy when it fulfills its purpose or upset when it can’t.

So the Fur Worm’s purpose was to not die while being crushed onstage at a conference. If it was in danger of failing its purpose, it would act very very uncomfortable. It was really consistent in struggling, and struggling more to show greater danger and discomfort. This alone was pretty convincing.

^ This is Cozmo, by Anki

But as you can imagine, if something reacts the exact same way every time, we start classifying it as not alive. You start to see the hand inside the puppet.

And this is a point about emotions, because often times our emotions can feel completely random to us, so when building an emotional robot that humans will relate to, you have to recreate the sense of random inconsistency that humans actually feel. We're not exclusively frustrated when something bad happens.

^ This is Cozmo, by Anki

We’re sometimes going to be skeptical, sometimes angry, to varying degrees, and sometimes we’re just sad. It’s different every time, depending on our situation and mood and so many other factors.

It’s especially good if you can create random reactions that are convincing in their emotional expression but remain fully unpredictable. And that’s possible with simpler bots.

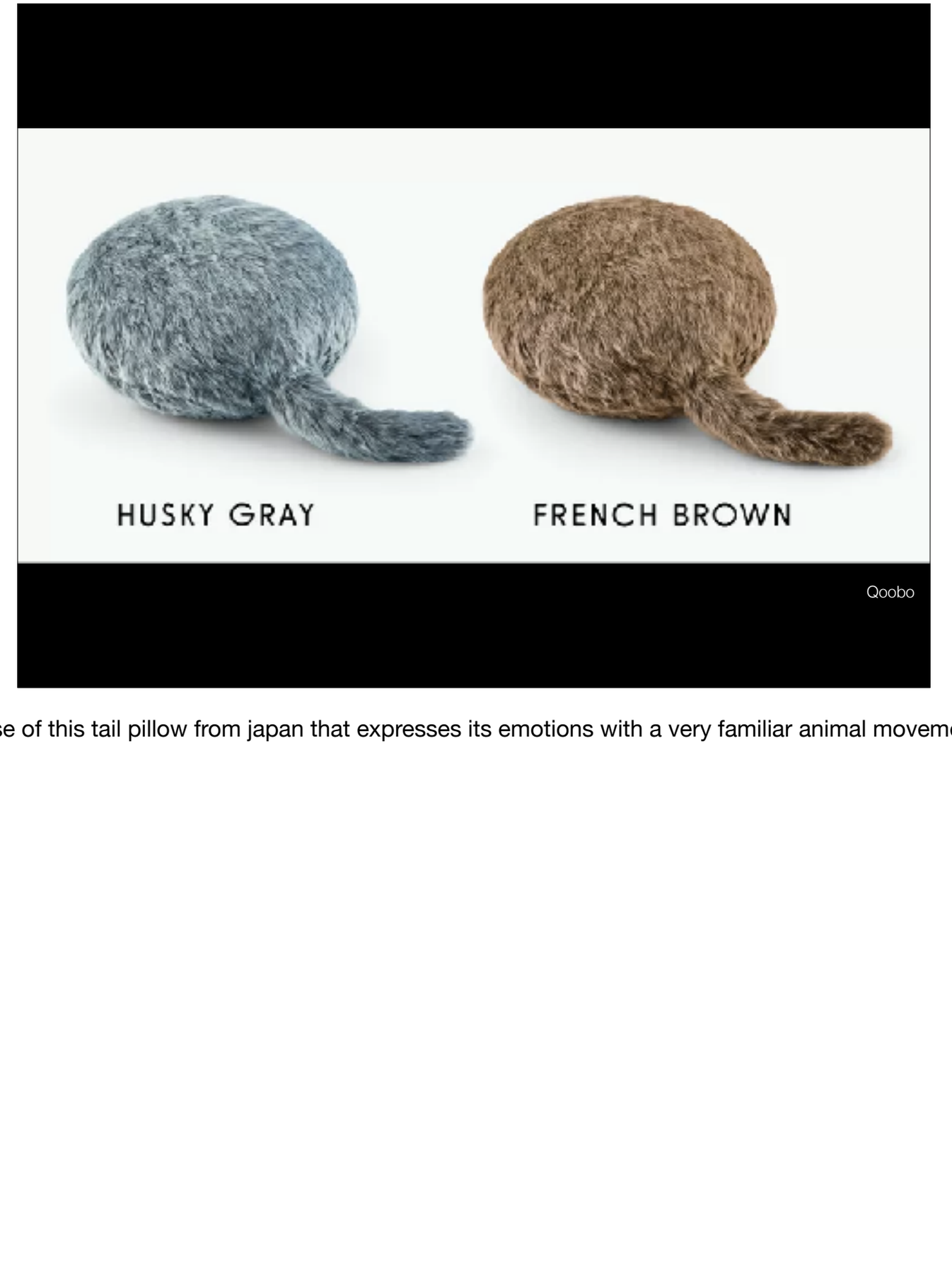
When uncomfortable, the fur worm never twitched predictably. Although the speed and amplitude of his animation increased with his increased discomfort, the degree of increase, the number of twitches, and the sounds he produced were a result of random noise. Not even I could predict them, which made him into a lifelike illusion that a lot of times convinced even me, and I’m the person who wrote the code.

So making a robot that appears to have needs is pretty effective, especially when coupled with the appearance of random, full-ranging reactions.

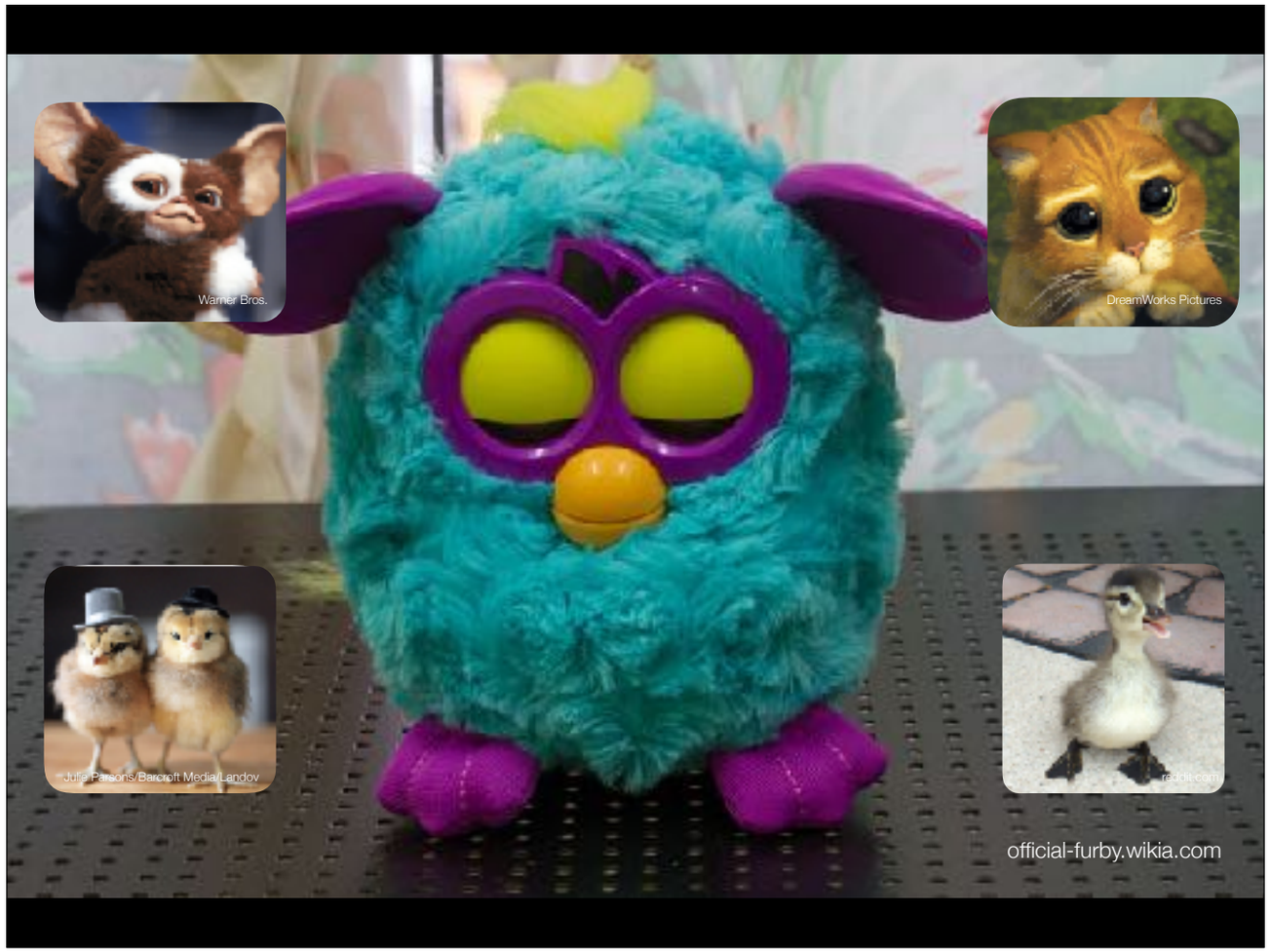
the outside
(physical associations and texture)

But of course, there’s also a lot that goes into the external part of biomimicry that takes the psychological elements and solidifies them.

In terms of outward appearance, I find it is better to mimic combinations of creatures rather than a specific critter. Trying to look like a known lifeform often creates expectation that are hard to fulfill. What you're really trying to do is handpick associations people have with known creatures, real and fictional, and put them together into a critter that optimally represents what you want your audience to feel.



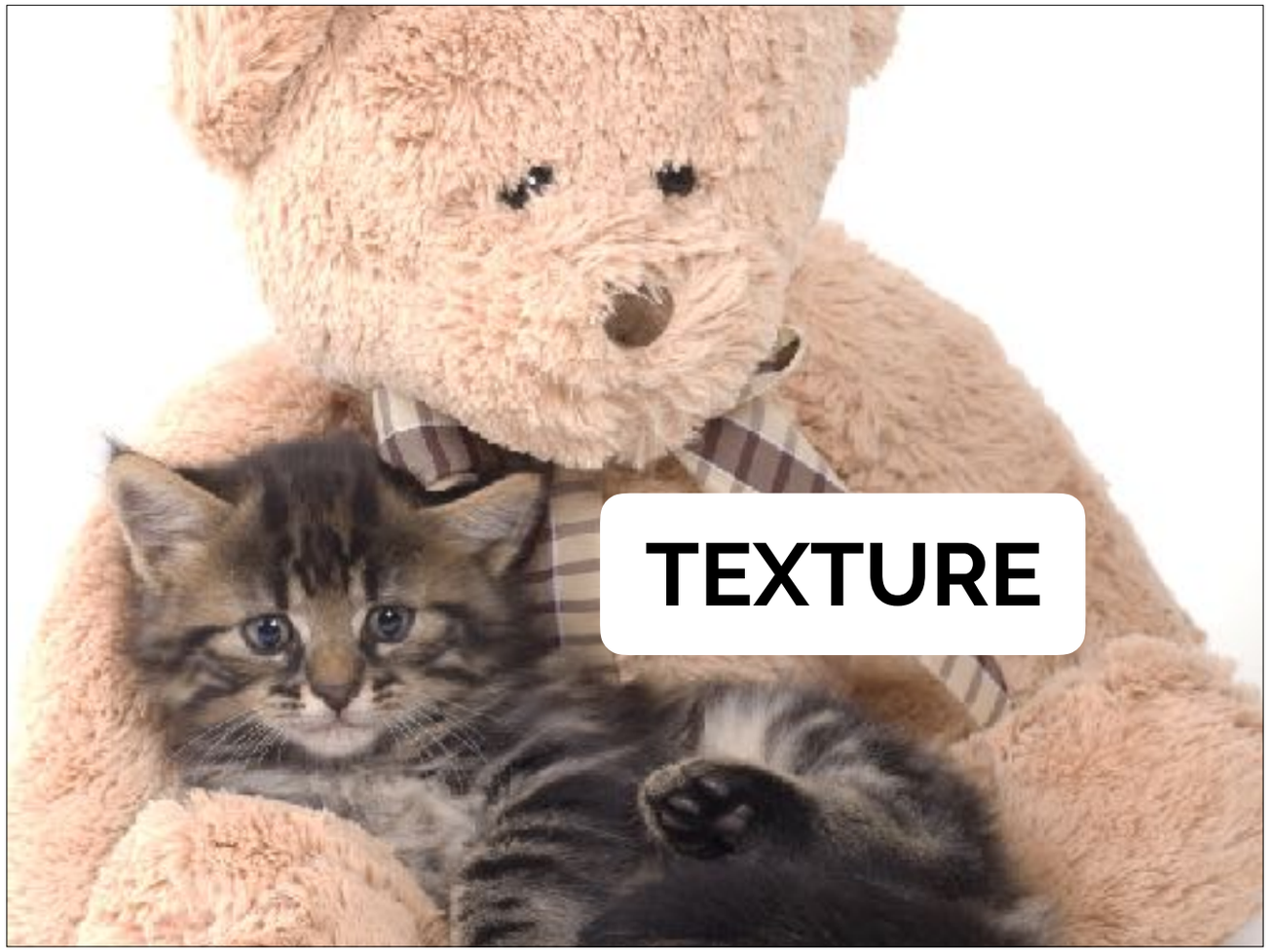
You can go really simple, like in the case of this tail pillow from japan that expresses its emotions with a very familiar animal movement. This can be really effective.



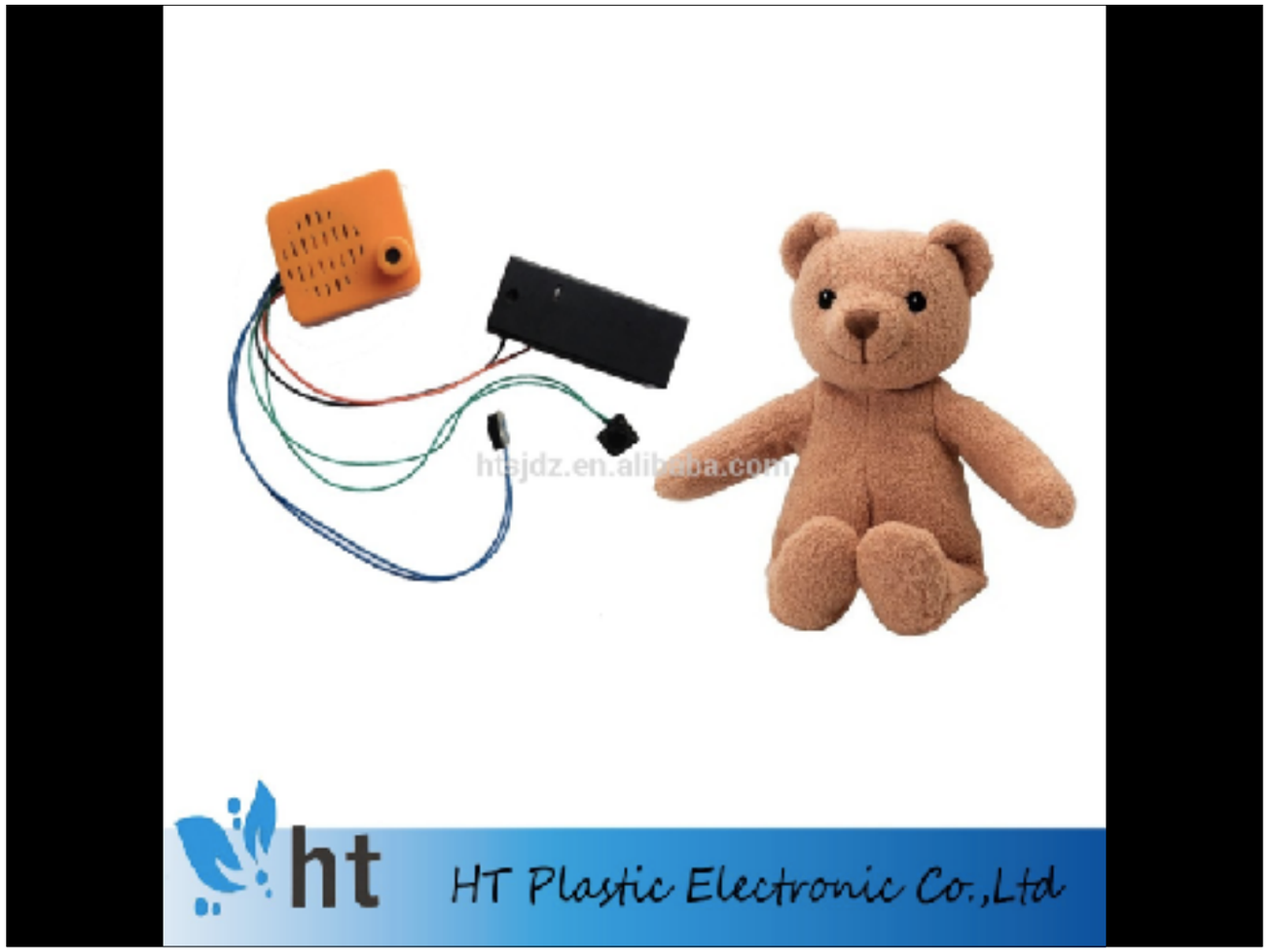
You can also go big, and mix a lot of emotions together. So in this case, a big mess of slightly alien cuteness. But associations are a double-edged sword. People will draw associations from things you didn’t mean to put in. You can get very close to all the cute associations, and then with one hardware choice--

—ruin all the work you just did.

Associations serve to support the story of your bot. Should it make people feel good? Should it scare them? Should it scare some but not others? You have to handpick the right ones and avoid the ones you don’t want.



Texture becomes a very important part of this. And this isn’t just the basic covering, because something that is soft on the outside doesn’t necessarily feel “right” as a living thing when you touch it.



Feeling a big box of electronics inside even the most charming exterior will take your lifelike critter from magic to robotic in the span of a single hug.

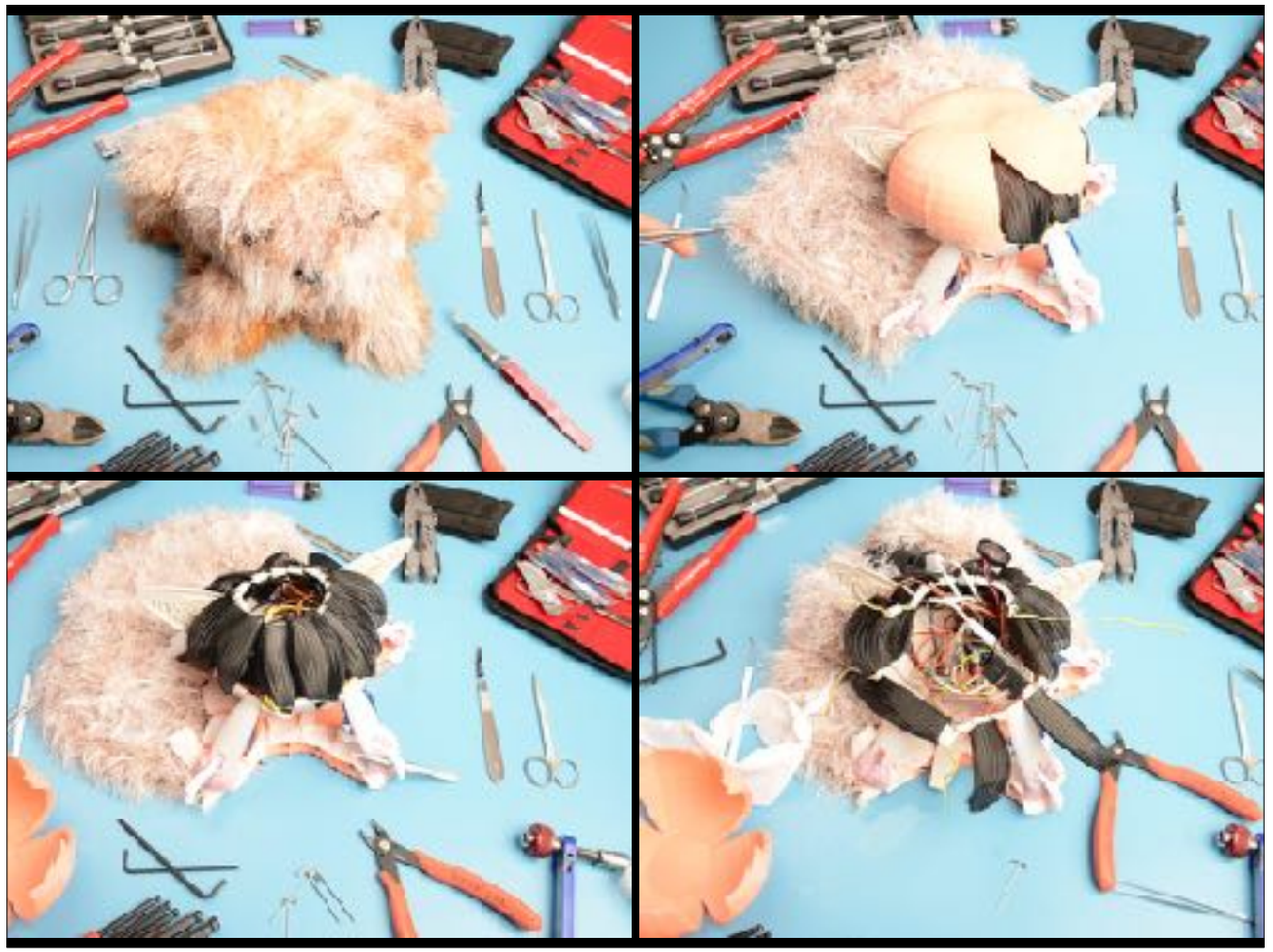
If you’ve got something that is meant to seem alive, it should feel alive, through and through. And a lot of times this means not only associations with the appearance of the bot, but also physical layers of biomimicking elements.

The inside matters. The skeleton you create can be felt. And when you make layers in actual imitation of biology, it can make your critter look and feel really right. This is Burbles the Starfish Cat, from my Starfish Cat Human Discomfort experiment. Some of you met Burbles here at Supercon last year. He does a number of cute things to try and make you pick him up, and then when you do he mewls in distress and reaches out with his little cat claws,

until he detects bare skin using the IR thermometers on his terrifying mouth base, at which point he tries to suckle you with a gross pneumatic motor I bought from China.

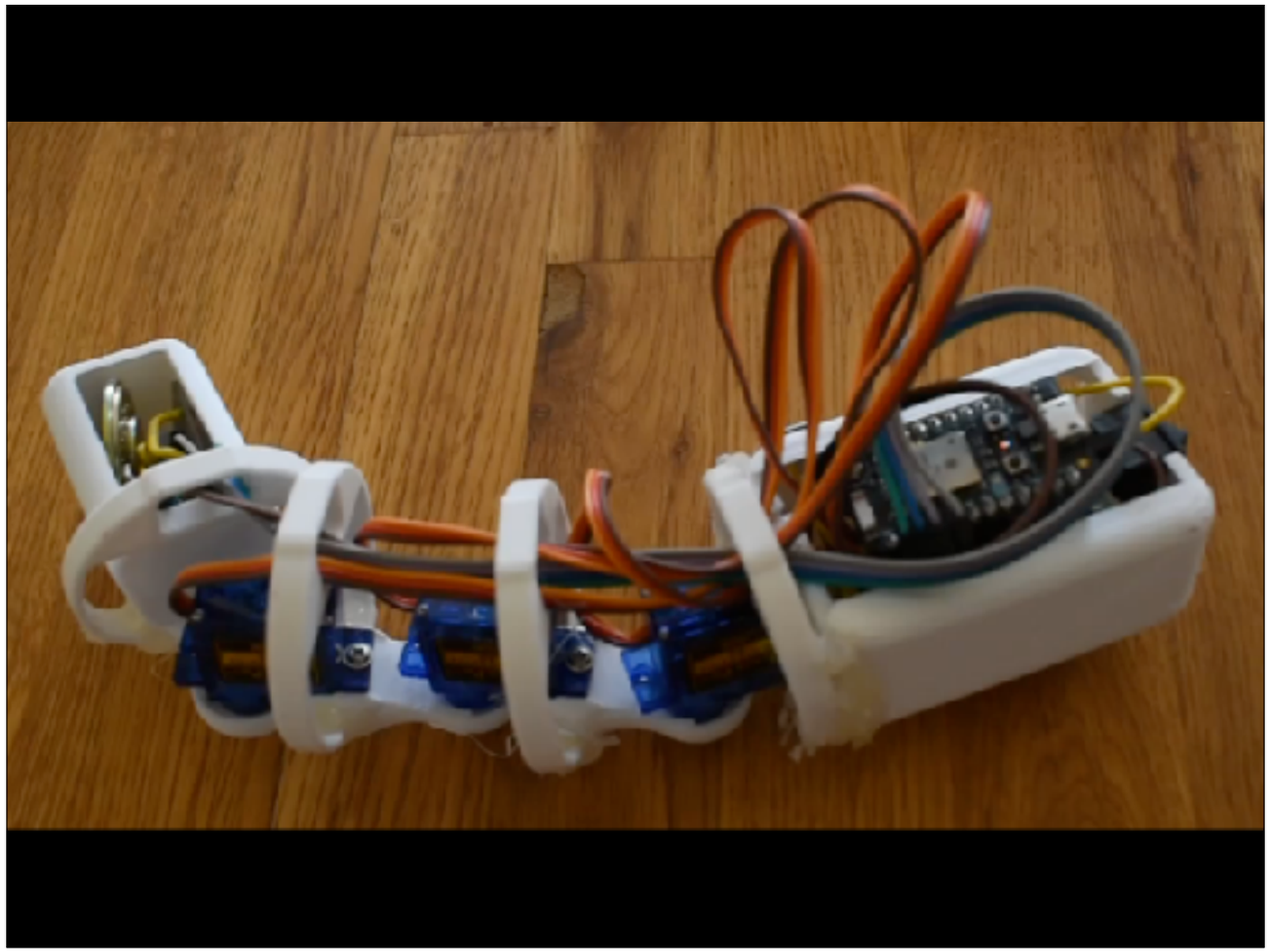
Burbles was meant to feel unnervingly alive to max people out on simultaneous pity and discomfort. So I had to layer in a structure that would protect his electronics while also feeling sort of biological and muscular.

And if you’re trying to imitate biological layers, it actually does help a lot to do layers.

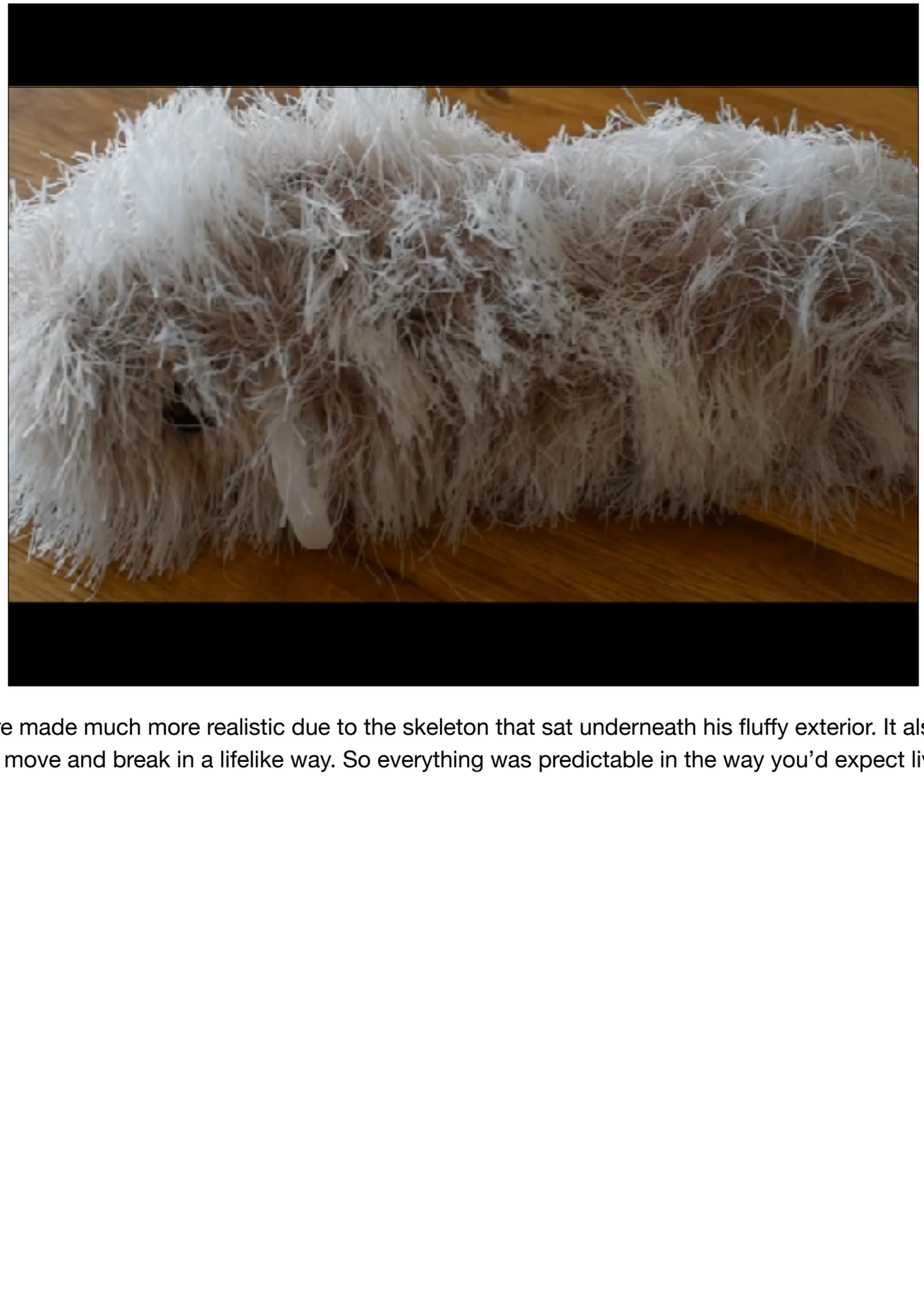


So I came up with a layered structure with cartilaginous bones, springy wire wrap “muscle,” and a thin layer of subcutaneous silicone, ending in a fluffy, pet-able exterior woven from feathery yarn.

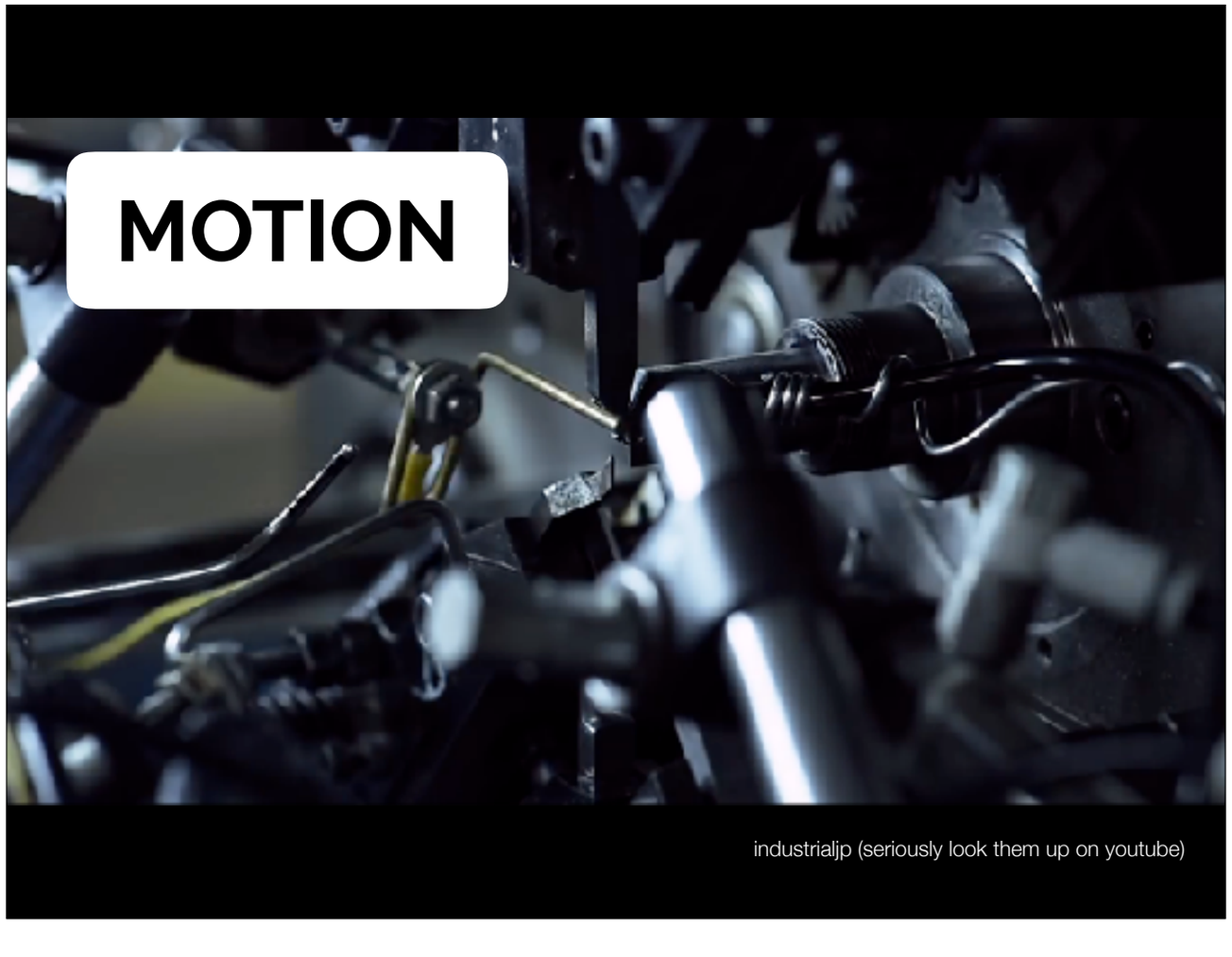
The effect of the layers was really profound to see. It went a long way to making people react strongly to holding Burbles, and hugging him, and handling him gently, and comparing him to their dogs, and thinking he was, well, kind of alive.



The same thing happened with the Fur Worm. It’s definitely spooky to see him without skin, but what skeleton isn’t spooky?

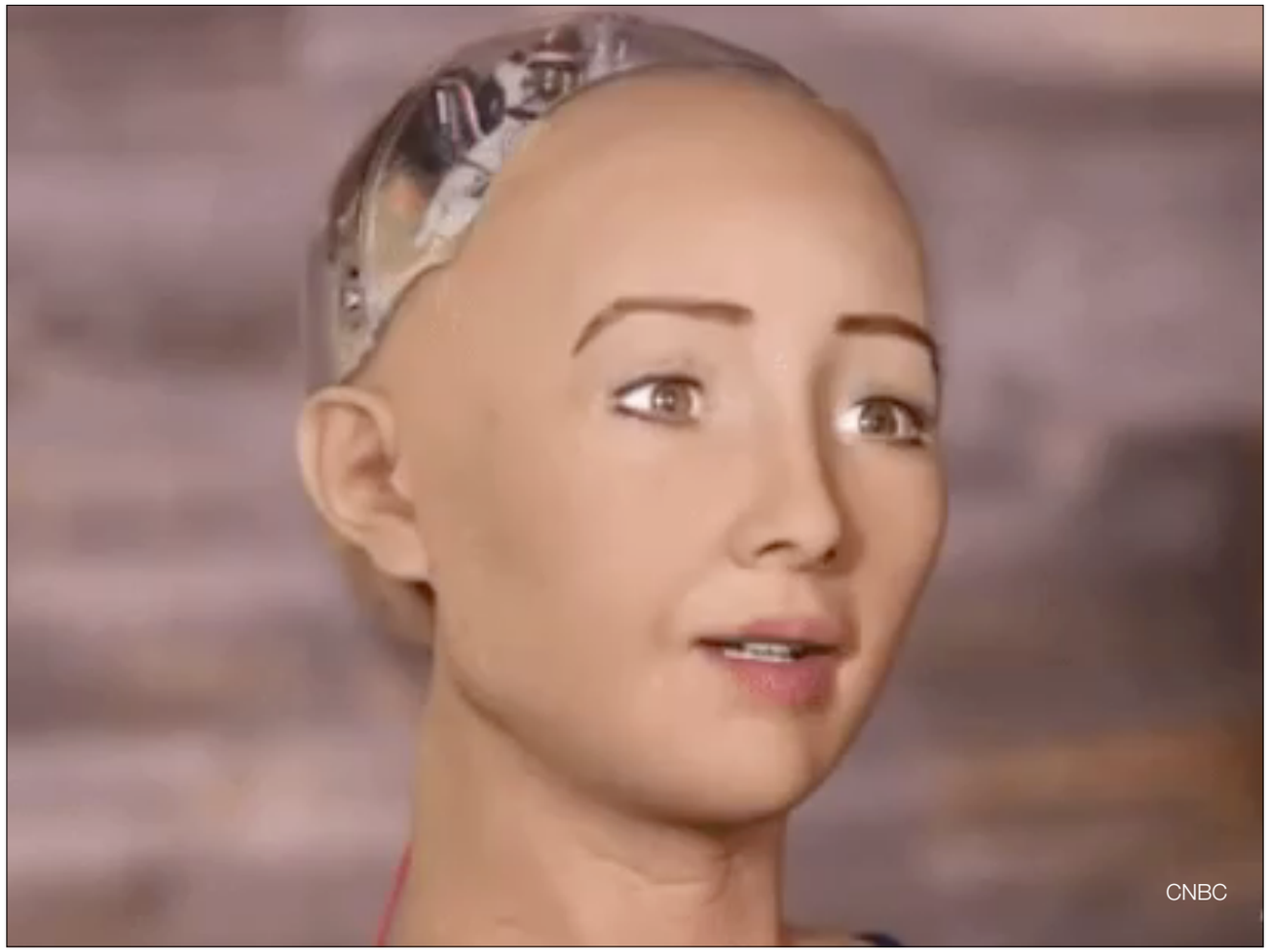


The movements I put into the worm were made much more realistic due to the skeleton that sat underneath his fluffy exterior. It also made him a lot stronger, and allowed me to create a creature that would both move and break in a lifelike way. So everything was predictable in the way you'd expect living things to be, not robots.



industrialjp (seriously look them up on youtube)

And as long as we’re on the topic, let’s talk about about motion. Motion is a huge part of life, and without convincing motion we’re not really going to be able to build convincingly lifelike robots.

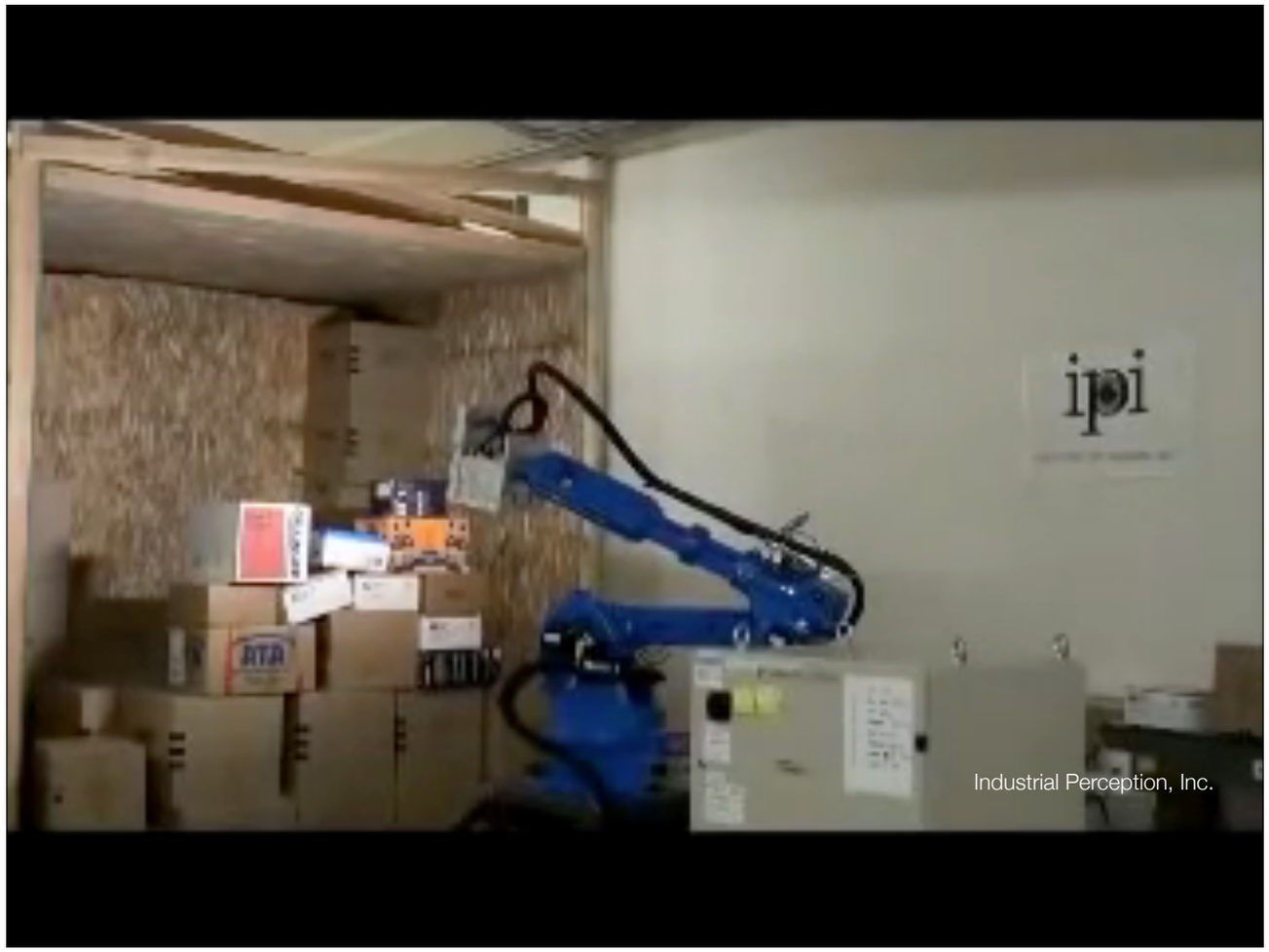


A real-looking robot with halting or unpredictable movement puts us squarely in the uncanny valley, and is generally creepy.

Robots are binary. And binary motion— where we go from 0 to 100 in the blink of an eye— is seen as starkly robotic. No movement, then movement. Resting, to pre-determined action.

Animals don’t do that. We accelerate into motion to be safe as we move from place to place. We slowly ramp up and experiment and we seek out the exact right movement with our ungainly limbs. We also use motion as a modem for expression-- we portray emotion and uncertainty with the speed and acceleration of our movement.

So if you want to trick someone into thinking something is alive, using motion, then you’ve got to get away from this,

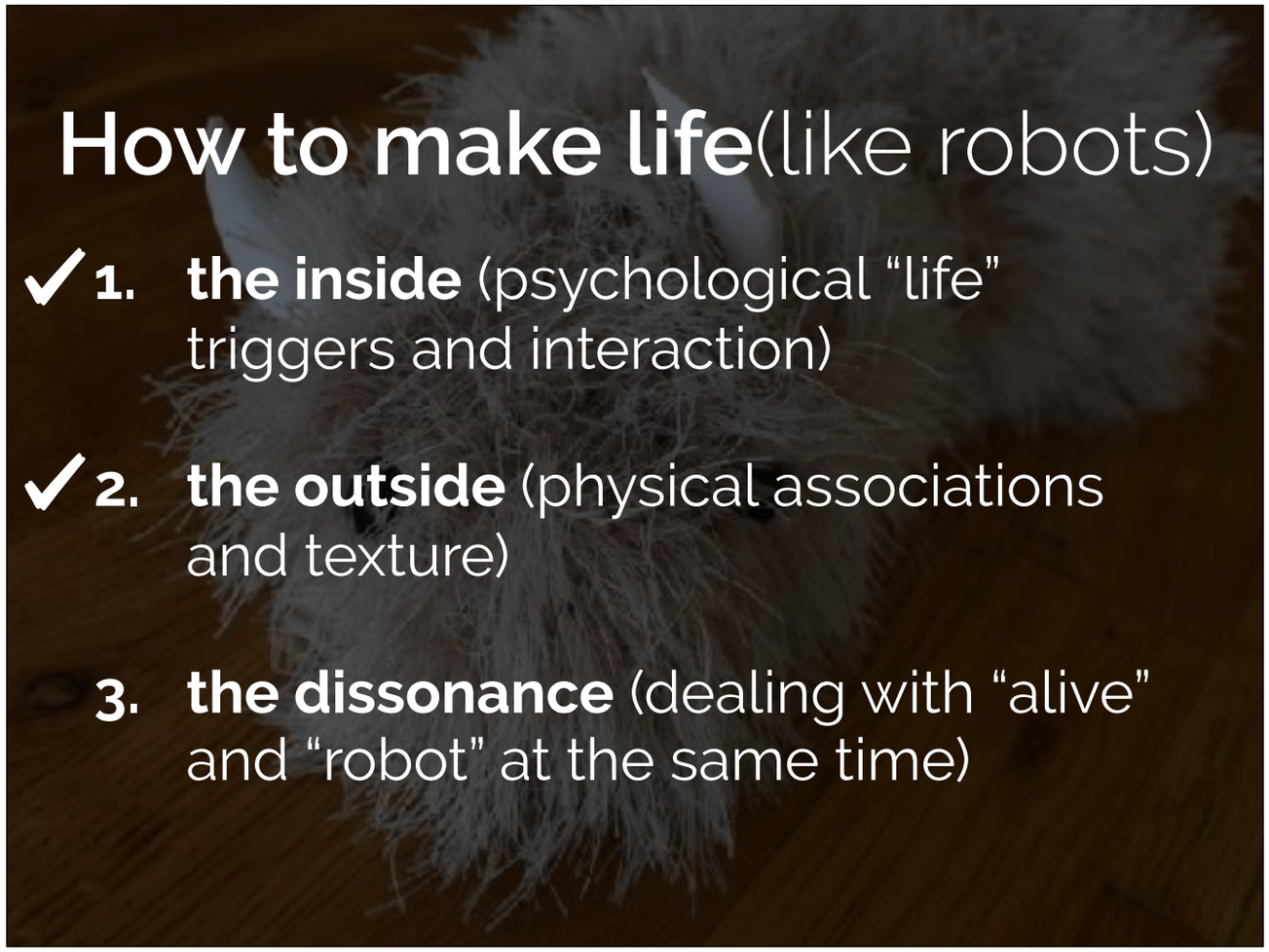


and go towards this. This about acceleration. Adding a particular acceleration profile can create something that feels very evocative, very expressive, and even alive.

This is a robot programmed for acute expression using acceleration. But even on a small scale, acceleration makes a difference in the perception of life.

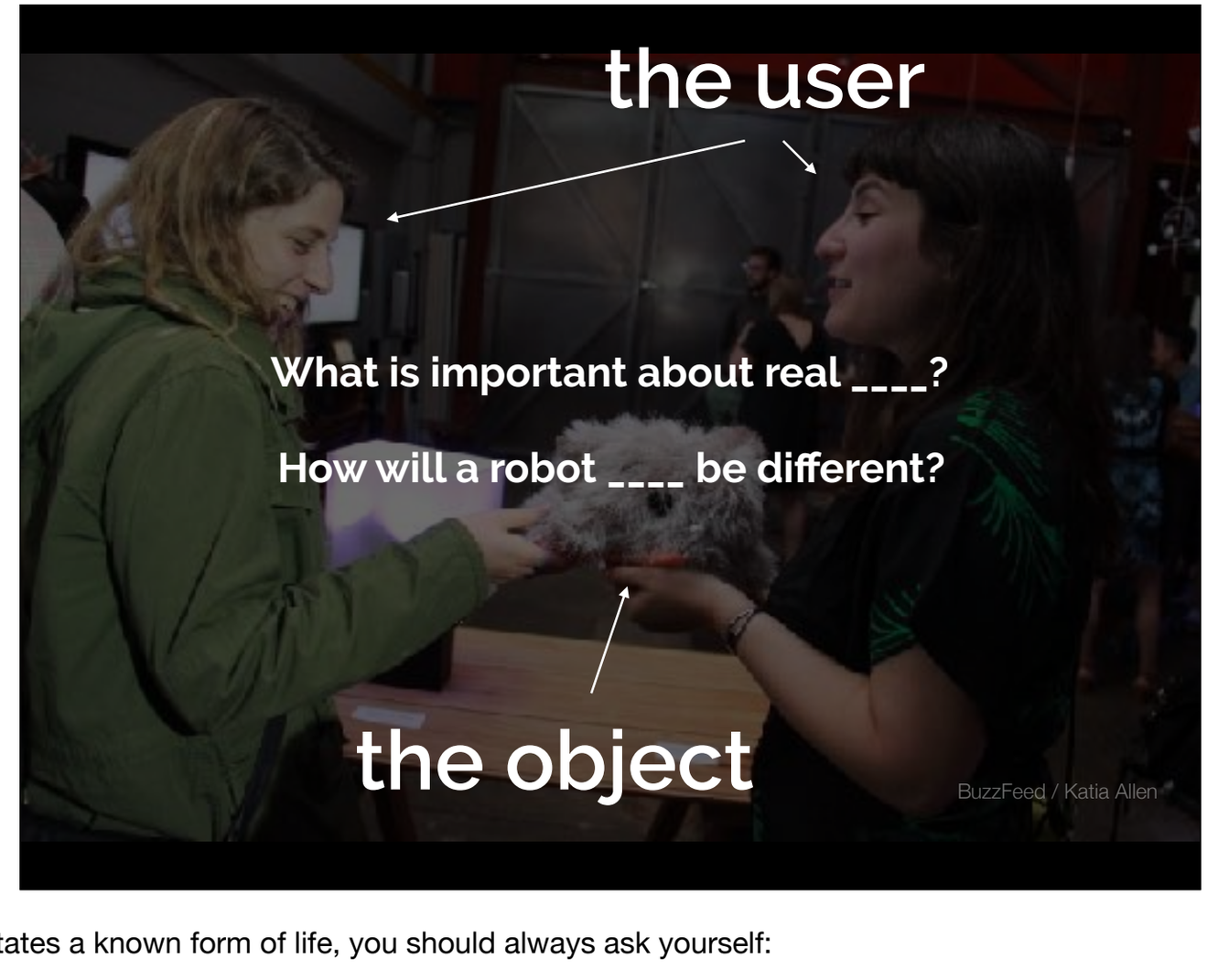
While building one of my bots, I did an experiment where I showed one servo doing binary motion and the other slowly accelerating. One of my labmates told me that to her, one of them seemed pretty typical as robots went, and the other she was pretty sure was going to kill her in her sleep.

So motion matters, both in the instant perception of life and in the creation of robotic “expressions” that feel lifelike.



Okay so that pretty much takes care of, a few of the basics on how to make something appear lifelike using biomimicry and human factors. But when building lifelike interfaces, we have to consider that in the end, a robot is a robot, and that is a fundamentally different relationship than that between humans and living things. And that’s actually kind of great, and not a disadvantage at all, as long as you account for it.

Because no matter what we do to make a robot more lifelike, it is always going to be a robot. We know it is a robot when we design and build it, and consumers know it is a robot when they buy it and power it up. So the relationship between humans and cats is going to be fundamentally different than that between humans and cat robots.

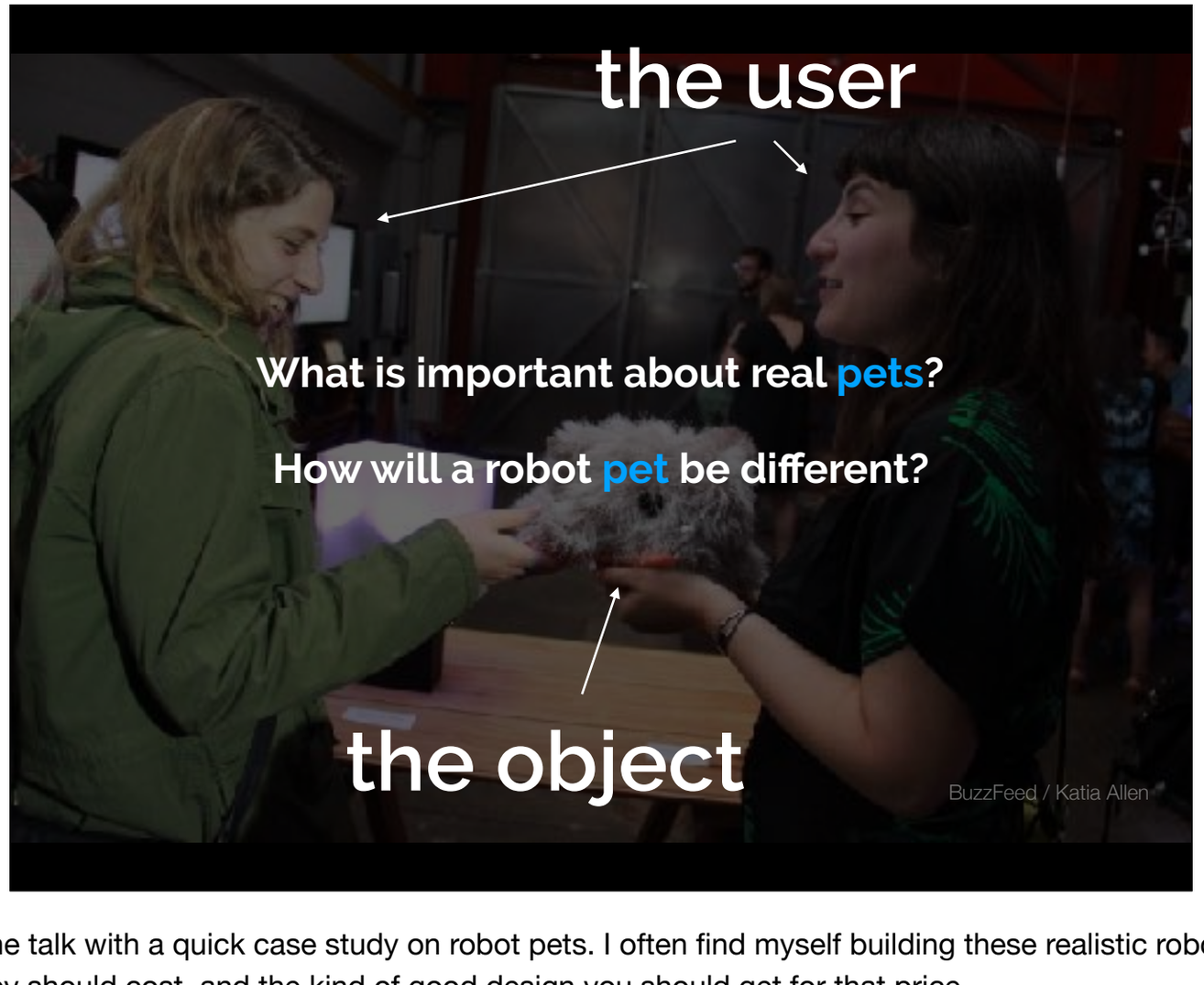


When you’re designing a robot that imitates a known form of life, you should always ask yourself:

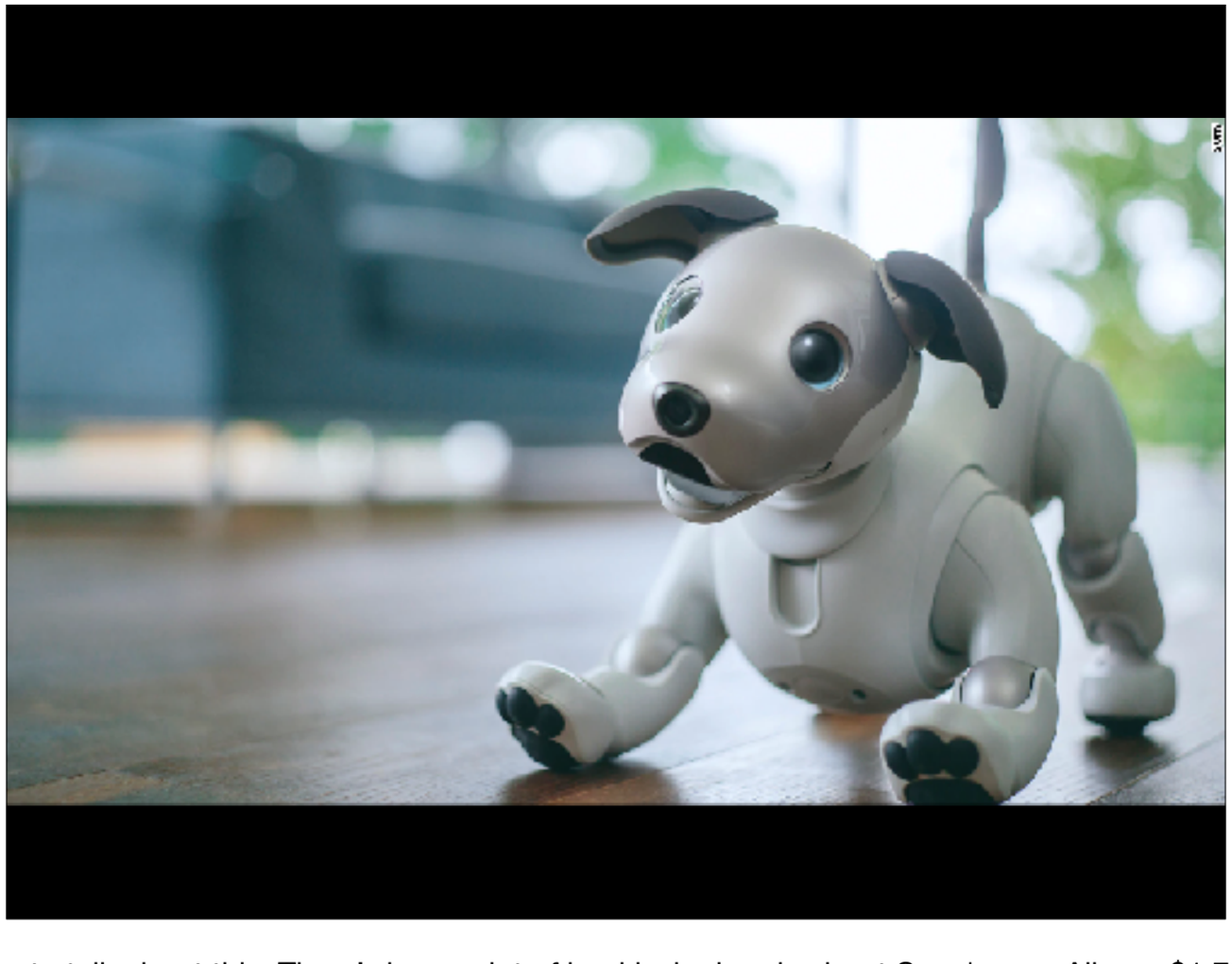
What is important about the real, alive version? And how will a robot version different?

It’s important to ask these questions as you work with biomimicking objects. Consider that the Amazon Echo, while it has some biomimicking elements, is as different from your actual executive assistant as a bicycle is from a horse. The unalive version is completely different in the way we perceive, relate to, and use it. Not accounting for that in the design, documentation, and usability would result in poor products and confused users.

But if you accept that the robot is a robot, you can avoid the uncanny valley and open up avenues for usability that become massively popular and useful to humans. Alexa doesn’t try to do everything your EA would do, because Alexa’s not an EA and shouldn’t try to be.

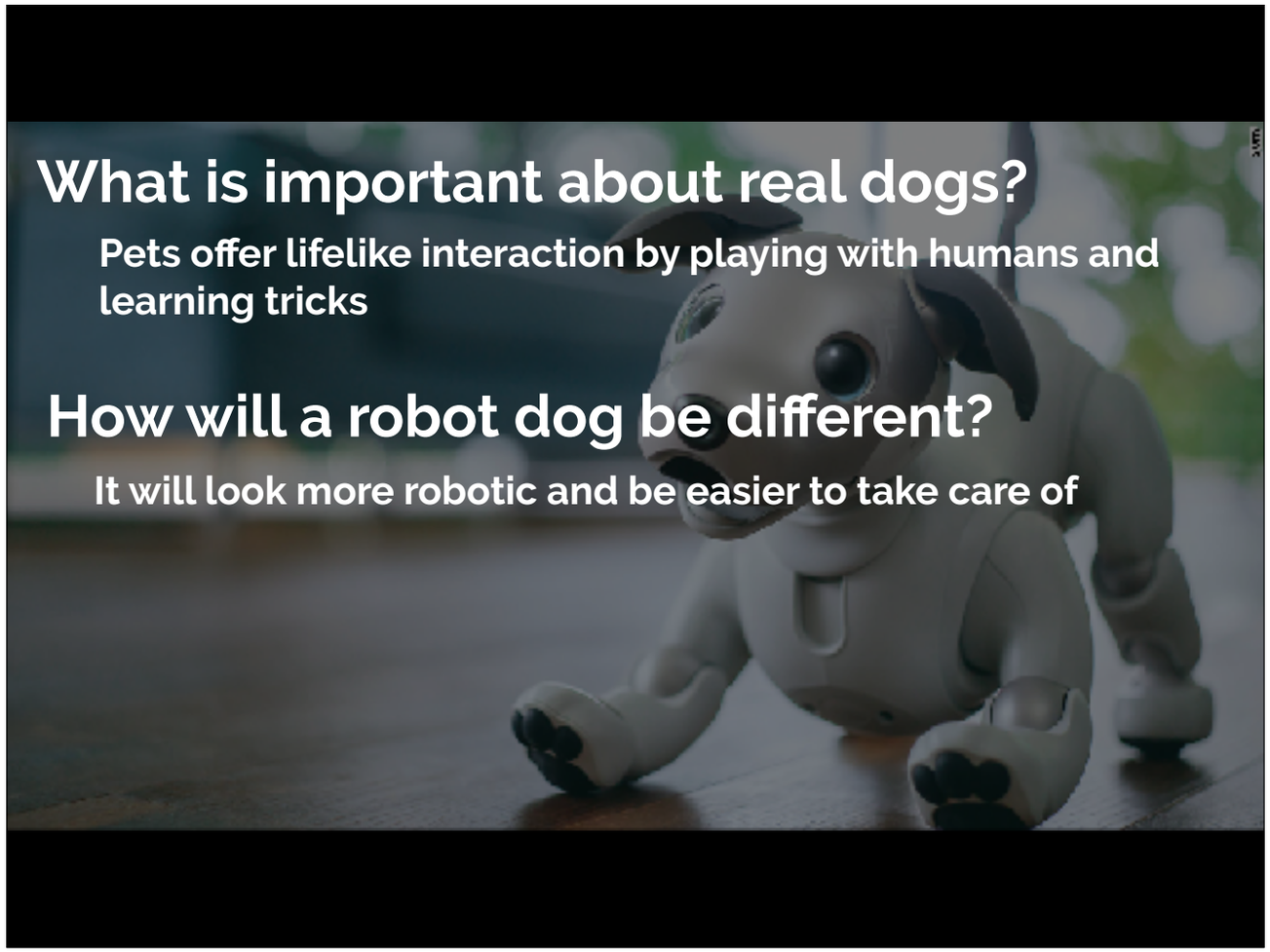


To illustrate this point, I'd like to close the talk with a quick case study on robot pets. I often find myself building these realistic robot critters, so I have some thoughts and opinions on this topic, on how much they should cost, and the kind of good design you should get for that price.

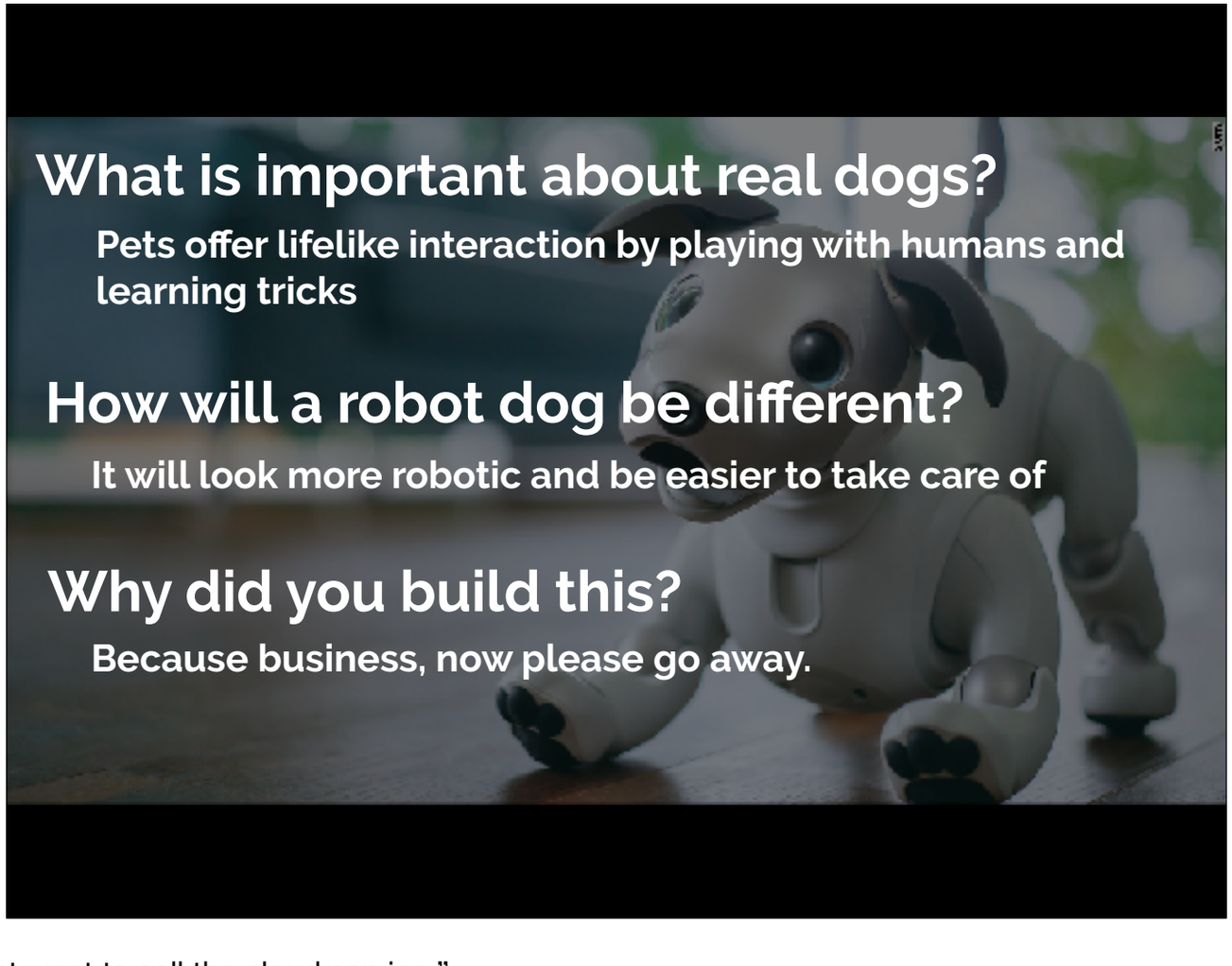


Some of you have guessed that I’m going to talk about this. There’s been a lot of backlash already about Sony's new Aibo, a $1,700 robotic revival of the old toys of the early 2000s. The new Aibo is said to learn with a cloud-based brain. By uploading your floorplan and more to Sony's services, it can learn to navigate your house and develop a unique personality... This will run you about $25/month.

The American tech audience seems understandably disinterested. Automatic uploads of your house and more to the cloud sounds a little dangerous, being subject to surveillance or unsafe data storage. And for most, the price tag is simply too high for what you’re getting.

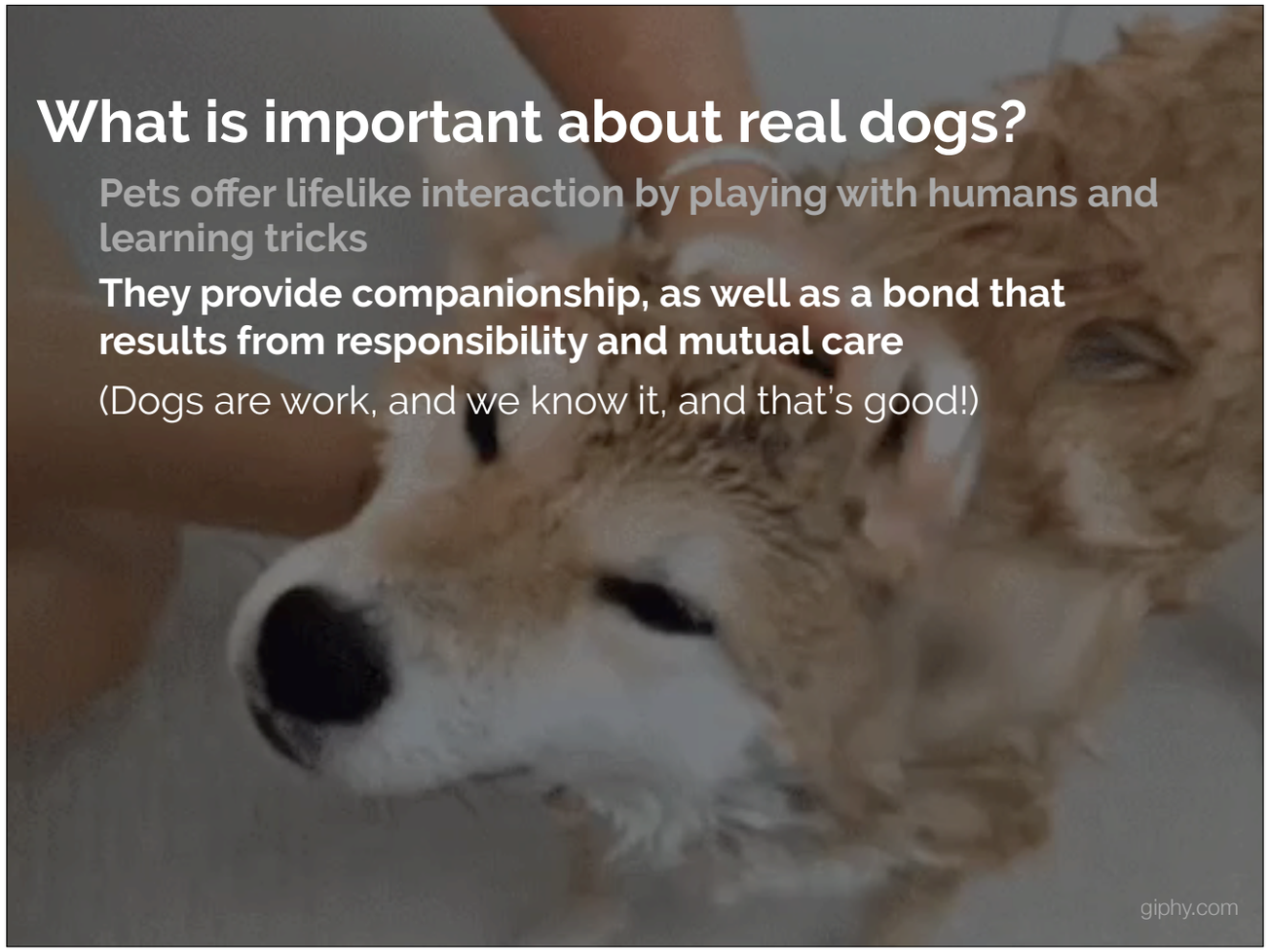


I think if I asked the designers of the modern Aibo these questions, I'd could expect something like these answers: that the important parts of having a dog involve the interaction, playing, movements that indicate affection. A robot dog is distinguished from a regular dog by its greater ease of use. I'd also expect a third answer that goes something like,



“Stop asking me these questions, we just want to sell the cloud service.”

In any case, these answers aren’t necessarily incorrect but they’re rather incomplete. I think as weekend hackers and fast thinkers, we can do better.



So let's redesign the modern robot pet, around the true reasons for having a real pet. With pets, bonding often comes as a result of care and work. The joy you feel when your dog finally learns to sit and stay is amplified because of all the work you put into helping him learn that trick. In the process of training your dog, you spent a lot of time bonding with him. Buying the "sit/stay trick" from the app store doesn't have the same effect.

Even outside of the emotional bonding, a lot of folks keep dogs **because** they require work to maintain. Parents get family dogs to teach children responsibility, young couples sometimes get dogs as a practice run before having a kid.

A dog you don't have to work for not only loses the emotional impact of a regular dog, but it also defeats much of the purpose for getting a dog in the first place.

So I think we can say that while there are people who would pay $1700 for a dog, the new Aibo isn't a dog.

How will a robot dog be different?

~~It will look more robotic and be easier to take care of~~

So let’s strike this earlier goal and, with an understanding of the importance of work in owning pets, make a better one.

Because robot pets can be so much more than just pets. Since people will definitely perceive it as a robot, let’s stop trying to pretend it’s only a dog. Lean into the robot part! It’s awesome!

How will a robot dog be different?

~~It will look more robotic and be easier to take care of~~

A robot dog is a totally new category of creature that provides therapeutic, lifelike references to real dogs

Our robot dog should at a minimum provide the sense of therapeutic bonding that people get from mutual companionship. It can do that, through a lot of the biomimicry we talked about already.

How will a robot dog be different?

~~It will look more robotic and be easier to take care of~~

A robot dog is a totally new category of creature that provides therapeutic, lifelike references to real dogs while giving the human a feel-good bond through work (hw/sw upgrades, maintenance).

But a robot is also an object of work. If you or I were to buy a robot dog, chances are we'd do it because we were going to hack on it on the weekends. The popularity of Aibo among researchers in the past was no surprise— it was some of the best open hardware you could get at that time.

Modern robot pets could give us some of the feedback of an organic pet, but at the same time be one that we can upgrade, work on, and personalize. Just like training a dog. That sounds better than a robot that restricts its all of its potential to pretend to be a low-tech meat dog. A pet you work to upgrade is both the pet of the past and the pet of the future.

How will a robot dog be different?

~~It will look more robotic and be easier to take care of~~

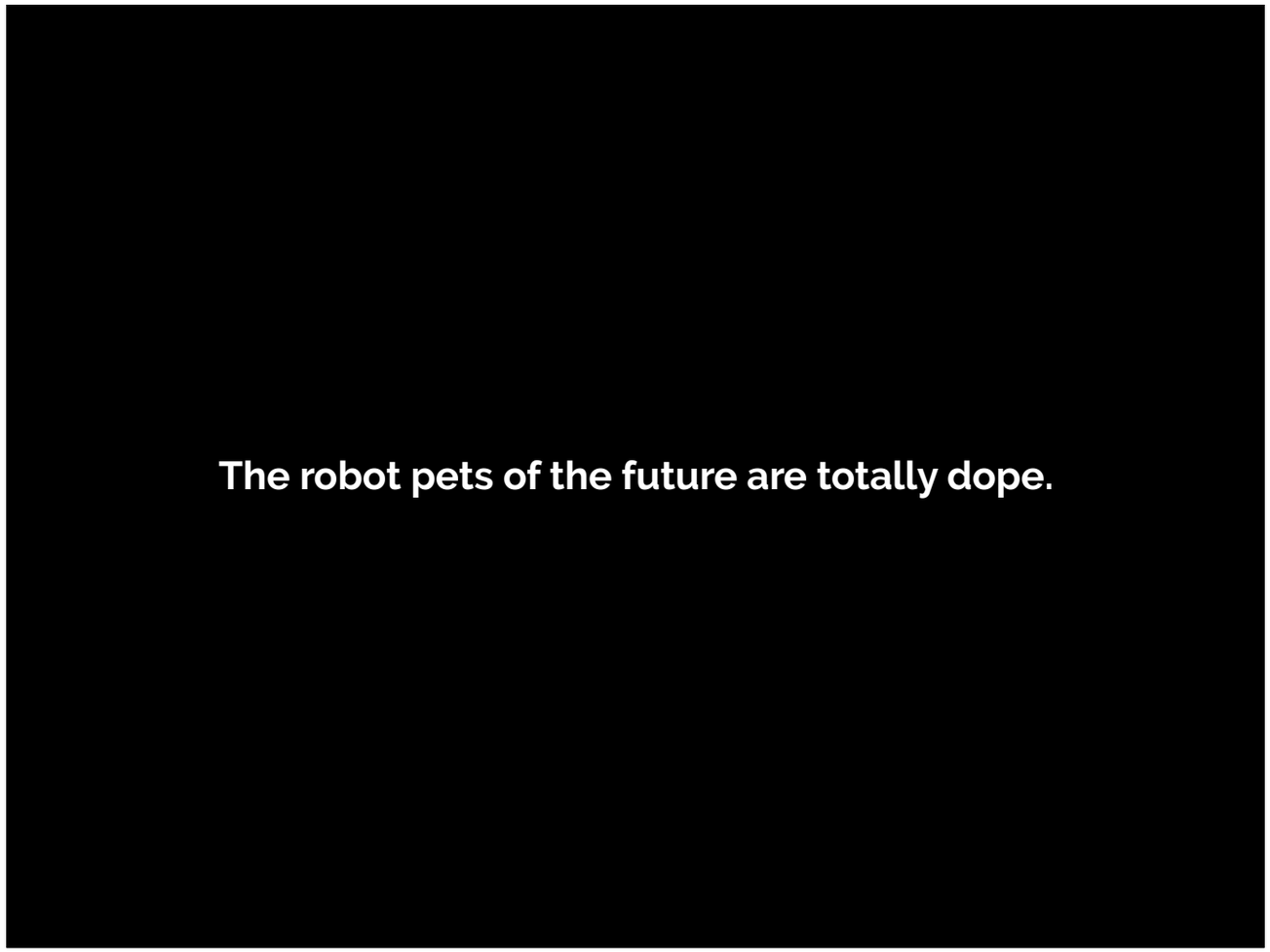
A robot dog is a totally new category of creature that provides therapeutic, lifelike references to real dogs while giving the human a feel-good bond through work (hw/sw upgrades, maintenance).

This relationship is a mesh between the relationship we have with external entities (dogs, cats, friends) and hobby objects and objects of use (gardens, cars, weekend projects)

And if you're skeptical that people will bond with an object by working on it, consider how you feel about your weekend projects— your hacks, your cars, your gardens. Consider how your kid feels about legos, sketchbooks, and blocks.

Working on objects can give us a profound sense of accomplishment and a bond to the object.

So working on our robot pets could give us a deep bond to a creature that already exhibits pretty good therapeutic biomimicry.



So I haven’t yet seen the robot pet of the future. But I think we can all agree that when it comes, it’s going to be totally dope.

We’re in an era where Makers are everywhere STEM has become an essential and highly necessary part of education. Well-designed robopets, which are open and have the potential for total customization, could play a great role in synthesizing technology with play, curation, creation, and self-care.

Dogs used to perform essential functions for humans in herding and hunting. Robot pets, by the same measure, should perform easy tasks or contain helpful technology, like reading lights or hotspots, temperature sensors or weather displays. And ideally, you, the user, could work on these functions yourself, as a part of the responsibility of taking care of and upgrading your pet. That way, each robot pet becomes a unique and one-of-a-kind critter, the same way each puppy is unique and one-of-a-kind, increasingly, as it ages into adulthood.

IxD for Robot Pets

A modern robopet should be simple in function, useful, easy to upgrade, and self-contained.

A modern robopet should create a bond with the user that is based on function and maintenance and reflects the users' relationships with themselves, much like a car or a garden.

A modern robopet should use good design to imply and establish a picture of life that promotes bonding, rather than relying on inadequate technology to imitate the intelligence of a living creature.

I could literally talk about this all day, but I won't. If you really want to know about robot pet design and the hypothetical advantages of a bespoke robot familiar, or anything about the biomimicry principles we talked about today, come see me afterward, I'd love to talk to you.

You can also reach me here— This is my email, this is me on twitter. Thank you very much, everyone!