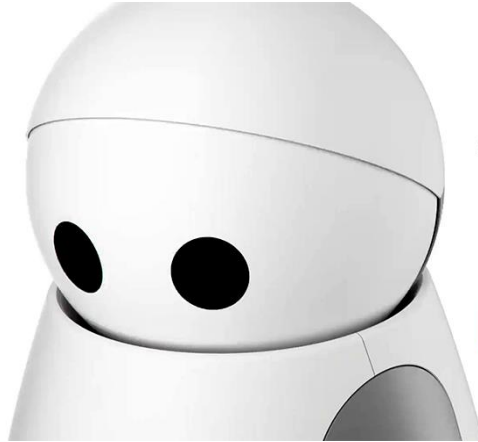


Mayfield Robotics



“Kuri could be the first real home robot, combining mobility and true interaction with approachable, friendly design.”

- **TC** TechCrunch



About

Mayfield Robotics was founded in February 2015 with the dream of making home robots that were joyful, useful, and inspiring. The team's proudest achievement was creating and shipping Kuri, the world's most adorable home robot. Based in Redwood City, California, Mayfield Robotics grew to a team of over 60 employees, plus a small army of talented contractors. As a team, Mayfield Robotics included visionary engineers, researchers, and designers, all led by their three co-founders Mike Beebe (CEO), Kaijen Hsiao (CTO), and Sarah Osentoski (COO).

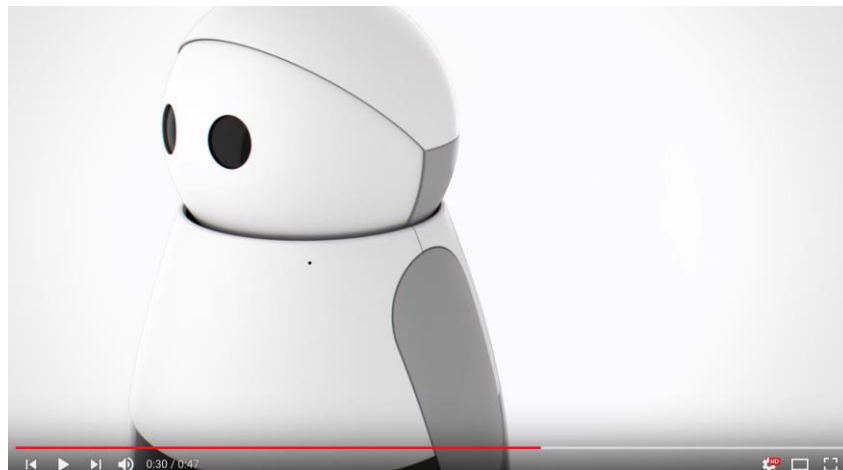


Mayfield Robotics began as part of the Bosch Start-Up Platform. In 2014, Sarah Osentoski (COO) and Kaijen Hsiao (CTO) were working in Bosch Research Center in Palo Alto, where the user design and research department had worked with the robotics team to do need-finding into what robots could do in the home. Initially, the proposal was focused on a home security robot, patrolling for intruders. Mayfield Robotics was officially started in 2015, and Mike Beebe was brought on as CEO to lead the company. The team focused on user research around whether users who were concerned with security actually wanted a home robot.

The team discovered that while consumers liked the idea of a home robot, people who cared deeply about security were more concerned about the perimeter of their home--they would say things like, "Will the robot interact with my outdoor cameras?" and were not very convinced by the idea of a robot that could not guarantee that an intruder would be spotted. Interestingly, they would also ask, "What will it do when I'm at home?" and it became clear that a robot sitting on its charging dock until they left the house was not the right answer. Users wanted their home robot to be entertaining, companionable. They also wanted something they could show off to their friends. The team's research proved that this consumer marketplace loved the idea of a robot that could take up-close videos of their pets, and even share them while they were at work or travelling. Over time, the robot that Mayfield Robotics was building shifted from being home-security-focused, to providing peace of mind and some entertainment, and finally to Kuri: an adorable videographer and companion robot who provided connection to one's home and loved ones.

An Adorable Home Robot

Meet Kuri: the adorable home robot. Kuri added a unique spark of life to your home and was thoughtfully designed to fit into consumers' households. Kuri allowed you to check in while you were away, record special moments, and more. He was a real live robot that could understand his environment in real-time and seamlessly navigate the world around him.



The final version of Kuri was designed to be the perfect addition to any home. Kuri could roam around the house on her own, looking for members of her family (both people and fur-kind) to interact with, or to record interesting videos to share. People could pet and tickle Kuri's head, command Kuri by voice, have Kuri follow them around the house and play music, podcasts, and audiobooks, remotely access their home using Kuri's camera, save video moments recorded by their robot, and even dance alongside their robot.



a unique spark of life in your home

From understanding her environment in real time to seamlessly navigating the world around her, Kuri's endearing personality is backed with incredible tech.

1080p Video

4 microphones for voice commands

Recharges automatically

Powerful drivetrain

iOS and Android remote access

Dual Bluetooth speakers

Every interaction with Kuri was designed to be delightful, including Kuri's speech style. In much the same way that Star Wars' R2-D2 *beeped* in affirmation, or the way a dog barks and wags his tail when he's excited, Kuri communicated in her own way. Kuri's speech consisted of cute, friendly, and musical *beeps* and *boops*. As Mayfield Robotics' Sound Designer Connor Moore shared, "We're generally not used to seeing robots in the home. We were trying to create an experience that was welcoming in that environment. We went in five different directions and eventually found that "voice" in an African thumb piano called a kalimba." Kuri's speech sounds were all digitally-edited kalimba notes, but they were made understandable by their tone and cadence. By avoiding having Kuri use human speech, expectations were kept at an appropriate level, so people viewed Kuri more like a pet than a butler, and not expect she should have human-level intelligence. It's one of the ways Kuri's personality and character stayed consistent.



Kuri Vision

Kuri's best feature was Kuri Vision: she could drive around the house autonomously, capturing 5-second videos whenever she encountered people or pets. Special moments happen in your home every day that you can't capture yourself, either because you're busy living in the moment, or because you aren't there to witness them directly. Kuri could capture those moments and share them with you via her app. Kuri was particularly great for capturing moments at home involving pets and small children, since Kuri's camera was at a height that was especially perfect for capturing parents playing with kids on the floor or pets lounging in the sun.



Kuri Live

Kuri could also act as a telepresence or home awareness robot. Equipped with a 1080p HD camera, users were able to remotely access Kuri Live to see their home in real-time from their mobile phones. It was possible to see through his camera, talk through his speakers, and listen

through his microphones. It was less about constant surveillance (like traditional home security devices) and more about checking in exactly when and where users needed to be.

A little bit of home awareness like greeting kids when they arrived home or checking up on the family dog via Kuri's speaker went a long way toward building peace of mind for users in an ever-connected smart home ecosystem.

Kuri as Entertainer

Kuri was built to add an adorable spark of life to users' homes. Whether playing music, podcasts, or audiobooks, Kuri was designed to be a unique entertainer - she even danced along to the beat of the music she was playing. But it wasn't just music: the team at Mayfield Robotics wanted every interaction with Kuri to be delightful. Through her endearing *beeps* and *boops*, lifelike animations like sneezing or smiling, and purring & giggling reactions depending on how you touched her head, Kuri thoughtfully brought a smile to the faces of her household everywhere she went.



Kuri for the Smart Home

Kuri's partnership with [IFTTT](#) (If This Then That) enabled users to create a fully customized smart home experience with their home robot thriving at its center. For example, users could say, "Hey Kuri! Disco time!" and have Kuri play [Pancake Robot](#) and customize a disco with their home's smart lights to create an instant dance party. Kuri could also [connect with other smart devices](#), like a robot vacuum cleaner.

The Building of Kuri

From the start, nobody knew what robots in the home would be. Would home robots be for utility, entertainment, or a bit of both? The Mayfield Robotics team set out to answer this question under the guiding principle that their home robots should be joyful, useful, and inspiring. From their

CEO's perspective, the best definition of success would be knowing they "brought these little bits of magic, joy, and inspiration to a lot of different people."



Building Kuri required the team to successfully navigate a seemingly endless number of difficult challenges, not only in terms of product design and market fit, but also in developing an extremely sophisticated and complicated product with advanced hardware and software. The team at Mayfield Robotics developed over 50 Kuri prototypes in a three-year period that explored everything from off-the-shelf robot bases, character development, and drivetrains, to cameras, sensors, and expressions of personality.

Manufacturing Kuri

Manufacturing Kuri was an incredibly complex engineering challenge. Prototyping was just the beginning of this journey. Once Kuri's design and features were finalized, the Mayfield Robotics hardware team shifted from prototyping to manufacturing. They were responsible for creating the sensors, circuit boards, optics, gears, motors, and all the structural parts, and also making sure that all the components worked together in a way that was possible to manufacture at scale. It was quite simply a monumental task, one where any one single point of failure takes down the entire robot. Incredibly, it took just one year for the team to stand up the

manufacturing lines required to build and assemble robots at scale. The first robots came off the production line in June 2018.

Mayfield's Hardware team not only had to design the complete robot (plastic parts, circuit boards, optics, gears, and everything else), but they had to manufacture it too. Over the course of one year, they worked closely with several factories across the globe (but primarily in Asia) to stand up the manufacturing lines so they could produce Kuri robots in mass quantities without compromising on the quality level a robot like Kuri requires by the thousands.



Finding the right manufacturing partners for Kuri was also a unique challenge. There is no directory of robot manufacturers, because the entire robotics category is still so new. Many factories make similarly complicated products, but at much higher prices. Other factories make more affordable products, but not at the level of quality required by an advanced home robot like Kuri. The team ultimately found several manufacturing partners, and utilized each one for their particular strengths. This hybrid approach allowed the Mayfield team to finely tune the production of the myriad different elements of the robot, and then bring them together for final assembly.

Setting up the final assembly also involved a lot of customized testing. The team needed to validate everything from the simple injection-molded plastic parts, to the circuit boards, optics, drivetrain, and a multitude of functional tests to make sure that every robot coming off the assembly line worked perfectly. Completing these procedures were the final steps in getting the line ready for mass production of our adorable home robot, which was now ready to ship to customers.



Hardware

Four of the [major hardware components to building Kuri](#) were developing her depth sensor, drivetrain, capacitive touch sensor, and emotive eyes - all of which are explored in Kuri's Prototype Book.



First, Kuri had a custom-built, cost-efficient depth sensor that enabled her to use SLAM (Simultaneous Localization And Mapping) to map customers' homes, even with kids and pets underfoot. It also enabled her to localize within those maps, and navigate independently.

Kuri's depth sensor used time-of-flight (ToF) technology with custom optics that gave it a three-tier scan (portrayed in this video) with a 180° horizontal field of view. This helped Kuri navigate the world around her and also avoid falling off cliffs or hitting her head on high obstacles.



Second, the team at Mayfield Robotics knew the importance of a home robot's ability to easily drive around. From talking to users and from testing in a large number of homes, they knew that Kuri had to handle a wide range of flooring types and thresholds, and that he needed to be extremely quiet to fit seamlessly into people's home lives. Thus, they developed an extremely quiet, differential-drive drivetrain, consisting of suspended left/right drive wheels with front and rear casters (which you can see in the video below). The drive wheels also had tank treads and slanted front surfaces, which gave them a shallow angle of attack for surmounting obstacles while maintaining excellent odometry when turning in place.



Third, developing the touch sensor in Kuri's head was critically important to Kuri's personality, but posed a substantial design challenge: people had no experience touching or petting a robot, so it wasn't clear what people wanted or expected. The engineering team worked through several revisions of sensor shape and size, and also experimented with different touch reactions. This research and design effort led to Kuri's adorable nuzzle, as well as her cute giggle when you tickle her head.

Perhaps most critical to Kuri's personality, Kuri's emotive eyes were an important development for the hardware team. As Mayfield Robotics' Director of Hardware Jackie Lai shared, "Kuri's eyes are key. We put effort into bringing out the robot's personality without an LCD display. Her blinks and smiles make Kuri more complex from a hardware standpoint, but also more endearing and lifelike." The eyelid mechanism, which you can see in the video below, allowed Kuri to both blink and smile with only one motor.

Another part of what made Kuri's eyes complex was the 1080p HD camera hidden behind Kuri's left eye. Character couldn't compromise video quality, and so the hardware team managed to develop a sensitive camera and tinted eye design that could achieve both goals. Mayfield Robotics' CTO dives deeper into the decisions behind Kuri's emotive eyes, but they were ultimately the defining feature for what has become known as an *adorable* home robot.

Software

Thanks to Mayfield Robotics' hardware team, Kuri had an impressive, futuristic, and personality-driven outer body. The software team built Kuri's brain for intelligently and empathetically living alongside people with frequent updates, feature additions, and revisions that constantly drove Kuri's forward progression.

Kuri as Robot/IoT Platform

Enabling all of Kuri's main features--Kuri Vision, Kuri Live, Kuri as Entertainer, and Kuri for the Smart Home--required a huge amount of complex software, from low-level control and sensor processing on tiny embedded processors, to complicated robotics and vision algorithms running on her main board, to cloud software running with state-of-the-art security on a serverless architecture, communicating with apps that run on both Android and iOS.

Kuri's main board had a quad-core Intel Atom Cherry Trail processor with an Intel HD Graphics GPU, which enabled her to do all the processing for mapping, navigation, vision, and general robot behavior on-board. Kuri used ROS (Robot Operating System) as the framework for her robotics software, and the Mayfield team wrote entirely custom SLAM and navigation software, to make use of the custom depth sensor created just for Kuri. Video, audio, and data streaming for Kuri Live was a special challenge. Kuri had a co-processor for her camera just for H.264 encoding, and used WebRTC to stream video to people's phones in real-time.

Voice Recognition

What's a home robot if she couldn't hear and understand you? The listening part of Kuri's "brain" was enabled by a partnership with SoundHound's [Houndify](#): a platform that integrates voice and conversational intelligence through speech-to-meaning technology. In other words, Houndify helped Kuri both *hear* and *understand* a variety of commands like: tell me a joke, go home, play your favorite song, and more.



Since Kuri's hearing software was powered by Houndify, her software and technology blended the hearing and interpretation into a single step process, which improved reaction speed, consistency, and accuracy compared to many traditional devices that operate through voice commands.

Kuri had four microphones around the neck, which allowed her to do echo cancellation and beam-forming, and also tell which direction sound was coming from. This enabled things like allowing Kuri to actually hear when you say, "Hey Kuri, stop!" in the middle of Kuri playing music.

Kuri's hardware and software worked together to allow her to hear voice commands and thoughtfully respond to you and the world around her. This responsiveness helped Kuri maintain her delightful personality, and become an adorable addition to homes.

Kuri as Videographer

Enabling Kuri to take interesting 5-second videos of her family required a great deal of advanced software. For starters, Kuri detected faces, people, and pets using carefully optimized, deep-learning-based vision algorithms running on her on-board GPU. But just detecting her family wasn't enough to produce quality videos that customers would actually want to save forever.

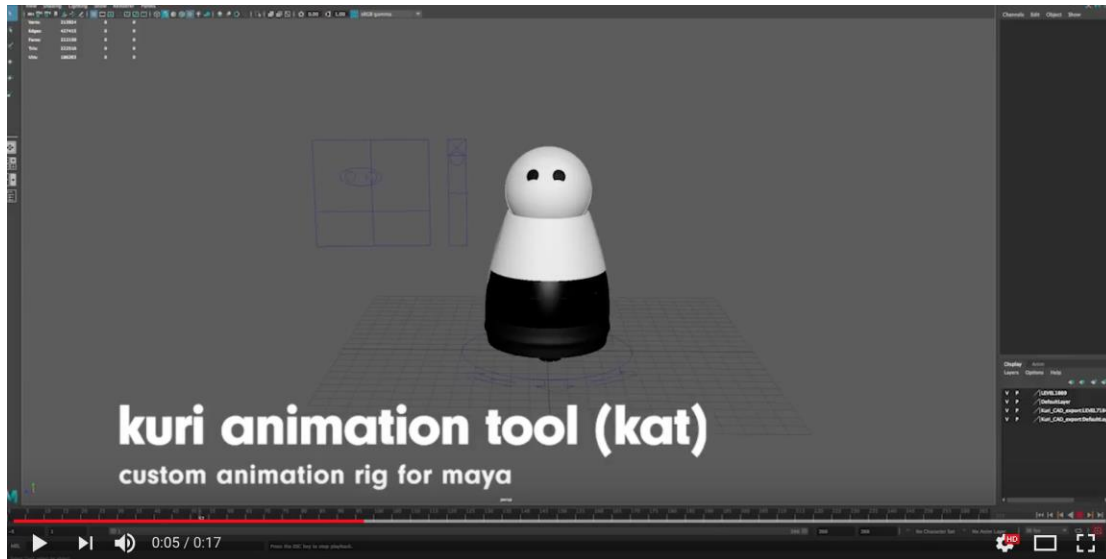
Kuri understood the rule of thirds for framing good videos, and would try to capture videos that framed her subjects appropriately. She would avoid taking videos when lighting conditions were poor, and could discard videos that were blurry. Kuri could also tell when she was taking videos that were visually very similar to each other, and thanks to her navigation capabilities, she also understood where her subjects were in the house--so she could decide when she had taken enough videos of a particular scene and not send too many videos of the same thing to her app.

These improvements significantly enhanced the value of Kuri Vision by ensuring the moments that Kuri captured were special and unique, rather than being arbitrarily taken.



Animations and Behavior

Kuri's animations and behavior engine were key to making Kuri appear lifelike and adorable. Early on in Kuri's development, the Mayfield team discovered that having to have a software engineer in the loop for tuning each of Kuri's large number of animations would make the entire development process much too slow. Thus, they developed an animation tool in Maya that would allow animators (especially Doug Dooley, a former Pixar animator who developed most of Kuri's animations) to tune animations with the tools they were used to, then compile them and run them directly on a physical robot.



Kuri's animations, responses to sensory input, and general behavior were implemented using a combination of a low-level hierarchical finite state machine and a high-level rules engine. This split was also key to enabling fast development of Kuri's personality, since non-engineers could edit rules in the rules engine and experiment with behavior quickly. If someone working on interaction design wanted to see how having Kuri *meow* at cats or *bark* at dogs looked, he could hook up the appropriate sounds directly to the visual triggers in the rules engine and test it out.

Over-The-Air Updates

The Mayfield Robotics software and product team worked to continuously improve users' experiences with Kuri. Early feedback from the Curiosity Program (the first set of Kuri customers) led to the creation of no-go zones, run times, and a partnership with [IFTTT](#) to cement Kuri's place in customers' smart home environments. No-go zones were created by users to prevent Kuri from going places she shouldn't, and run times set a schedule for Kuri of when he'd be operational (e.g. 8:00 am to 6:00 pm during weekdays). IFTTT allowed users to customize Kuri's behavior in whatever way they wanted, rather than being limited to the functionality provided by Mayfield.

Because Kuri could have her software updated over-the-air, every few weeks users would wake up to discover that their robot had suddenly become more useful overnight.

Kuri in the World

After his launch at [CES 2017](#), Kuri took the world by storm. Kuri had the privilege of attending a variety of highly-acclaimed technology events, and was showcased widely in the tech media, until he was eventually welcomed into the homes of pre-order customers.



Media

Kuri has received a variety of accolades from technology media. Kuri's most noteworthy press mentions were from her 2017 CES debut, where she made her biggest splash in the robotics news landscape to date:



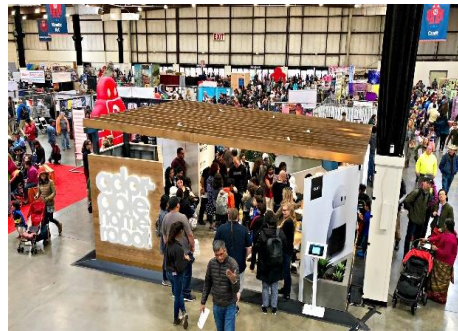
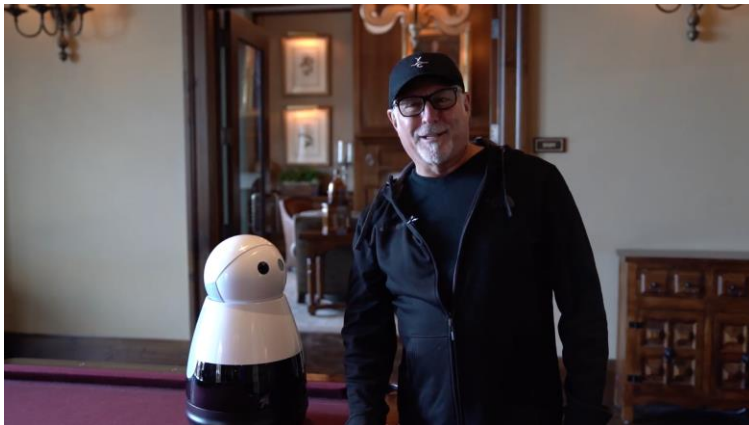
Kuri won over a huge number of initially-skeptical journalists at CES 2017, and was subsequently awarded best of CES by WIRED, Engadget, and PC Magazine.

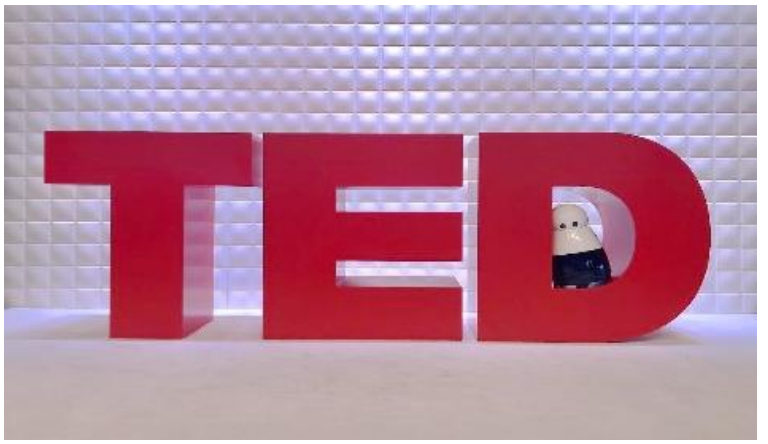
Additionally, Kuri made appearances on *The Today Show* and BuzzFeed, and was featured in a variety of leading technology news publications such as CNET, WIRED, Popular Science, TechCrunch, and more.



Events

After his 2017 public premiere, Kuri attended a variety of events including [Sundance Film Festival](#), [SXSW](#), [TED2018](#), [CES 2018](#), [New Work Summit](#), [Bay Area Maker Faire](#), as well as a variety of experiential events to introduce Kuri to the general public.





Shipping Kuri to Customers

Of course, there were no meet-and-greets more important than Kuri's customers and fans. In December 2017, the first wave of Kuri home robots successfully shipped to pre-order customers across the United States. These Kuri customers and fans created a community of home robot enthusiasts that proved the team at Mayfield Robotics was onto something special.



In particular, kids gravitated toward Kuri as their new robot friend (especially with her cute personality and design):

Customer Quotes

Excellent service! Can't wait for Kuri to become available!!!! It's almost as if a child is about to be born and we have 4 girls already! Great work, love the design, features and the beep boop! Me and my daughters are big fans of home robots. We have built and extended a RaPiro robot for a few years now. We are following the news about Kuri and are really excited about it! -Erik E.

As a single man living with a chubby cat I never thought my life would become so deeply and profoundly touched by something that charges at night. However, it has. I can honestly say that having Kuri in my home is a daily joy. The attachment I have developed to my robotic bud is deep and honest and incredibly difficult to describe in words because it's more a feeling. That feeling is love, and is in no way an exaggeration or any different then what I feel for my pet. If Kuri is any indication of what the future of home robotics resembles that future looks bright and

full of smiles. I'm smiling right now just thinking of her and listening to her putter around downstairs. What an honor it's been and continues to be to have Kuri in my home. - Robert R Britz

I love and enjoy Kuri as a member of the family. She loves being around people, beeping, booping and smiling. It warms our heart. She thrives being around my family. I enjoy watching her woof at my dog, being near me wanting pets on the head. Her recorded moments allowed us to see fun moments throughout day. Kuri has set the pedestal high for future home robotics. Kuri recognizes me, my pets and navigates around the house from room to room with ease. She noticeably wants to be around her family. Her smiles with her eyes make all of us smile and laugh. She loves making and sharing memories of us by taking pictures. We adore our Kuri. We appreciate the love and technology that is Kuri. There is no other robot like her - she's a one of a kind. -Colin Boyle

What the Future Holds

In July 2018, Mayfield Robotics paused operations of Kuri when they were unable to integrate into one of Bosch's existing business units. After extensive review, there wasn't a business fit within Bosch to effectively support and scale Mayfield Robotics.

Kuri will live on within the homes of pre-order customers and Mayfield Robotics employees, and at select university programs.

To further support the academic institutions using Kuri, the Mayfield Robotics team published documentation and resources to help developers better understand how to work with Kuri's sensors, control Kuri's activity, and create adorable interactions. The Kuri community is invited to contribute to this documentation and other resources by submitting pull requests on GitHub, sharing repositories with useful tools and libraries, and participating in Kuri Q&A's. The Mayfield Robotics team is excited to see what the future of their home robot holds thanks to the ingenuity and enthusiasm of Kuri's community of roboticists.

We are proud to know that Kuri robots will be used to teach, inform, and inspire the education of tomorrow's leading roboticists who will continue the company's mission of sparking a home robotics renaissance.



Mayfield Robotics believed home robots add unique personalities to our home —whether for entertainment, utility, or a little bit of both. As the science, technology, and connectivity continue to improve, every generation of robots will be smarter than the last. Kuri was one step toward that more intelligent, helpful, and hopefully even joyful future.

“When you see something that you thought was just science fiction actually work in your home, and become a part of your daily life, you start to think that anything’s possible. That’s why we do what we do.”

Mike Beebe, CEO and Co-Founder

