GUGGENHEIM

Conservation Department

Identity Report

Computer-based Artwork

Last update: 8/16/2017

Accession No.	2016.40	
Artist	Sun Yuan and Peng Yu	
Title	*Can't Help Myself*	
©, Year	2016	
Medium Line	*As currently in TMS:*	KUKA industrial robot, stainless steel and rubber, cellulose ether in colored water, lighting grid with Cognex visual-recognition sensors, and polycarbonate wall with aluminum frame
	Suggested correction:	
Edition	Is the work editioned (Y/N)? N If yes, indicate work number and edition size + number of artist proofs: n/a Multiple editions of the work may be exhibited simultaneously (Y/N): n/a	
Document Authors	Name, Date:	Jillian Zhong, Contract Computer Science Specialist, and Alexandra Nichols, Samuel H. Kress Fellow in Time-based Media Conservation, 11/29/2016
Artwork Examined by	Name, Date:	Jillian Zhong and Alexandra Nichols, 10/19/2016 – 11/3/2016
Information Sources	*List the sources that were referenced to create this identity report. Sources may include artist statements, installation instructions, catalogue entries, transcripts from artist interviews, emails/corespondance, and other files.* • Onsite collaboration with KUKA engineer "Harry" Shi Tangheng, Cognex engineer Han, and KUKA Project Manager Junjie Yu conducted 10/20/2016 – 11/3/2016 during the install of the work • Artist-provided KUKA Operation Manual – Conclusion and Instruction of Kuka.docx • Interview with Engineers 11/3/2016 – Kuka_Engineers_Interview_2016_11_03.wav • Artist Interview with Sun Yuan and Peng Yu 11/4/2016 – Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav • Conservation examination conducted by Jillian Zhong and Alexandra Nichols 10/19/2016 – 11/3/2016 • Karen Kedmey, Artsy Review 11/8/2016 – 2016_11_08_Artsy_Review.pdf • Caroline Elbaor, Artnet News Review 11/4/2016 – 2016_11_04_Artnet_Review.pdf • Barbara Pollack, New York Times 10/27/2016 – 2016_10_27_NYT_Review.pdf • Azura Wannmann, Curator's Project Review 12/26/2016 – 2016_12_26_Creators_Project_Review.pdf • Jason Sayer, Architect's Newspaper Review 11/7/2016 – 2016_11_07_Architects_Newspaper_Review.pdf • Richard James Havis, South China Morning Post 12/31/2016 – 2016_12_31_South_China_Morning_Post_Review.pdf • Jason Farago, New York Times Review 12/01/2016 – 2016_12_01_NYTimes_Review.pdf	

1. ARTWORK OVERVIEW

1.1 ARTWORK DESCRIPTION AND INTENDED EXPERIENCE

Can't Help Myself consists of a programmable robotic arm (KUKA model KR180 R3100 K) which operates at a full 360 degree range. The robotic arm has been modified by the artists with the addition of a shovel attachment with rubber squeegee on the end of the arm (fig. 1), a black coating on its exterior (fig. 2), and polyurethane foam elements added to provide protection of the engine from exposure to liquid (figs. 3 and 4). The robot is installed on a raised 7m x 7m wooden platform with a white, waterproof coating (fig. 5), which is surrounded by a floor-to-ceiling protective barrier of clear polycarbonate panels mounted to aluminum beams (fig. 6). The raised platform is covered with approximately 48 gallons of a viscose, dark-red liquid (fig. 7). A ceiling-mounted grid (fig. 8) holds 18 LED lights and 4 GigE Cognex industrial cameras centered above the robot. Visual recognition system software utilizes the video feed from the cameras to detect the location of the red liquid. The robot is programmed using KUKA's proprietary programming language, KUKA Robot Language (KRL). The robotic arm is programmed to continually squeegee the liquid towards the center of the flooring and towards the robot's base while the liquid seeps towards the outer edges, as well as to perform a set of gestures.

Fig. 1 Rubber squeegee attachment

Fig. 2 Robotic arm body with black coating

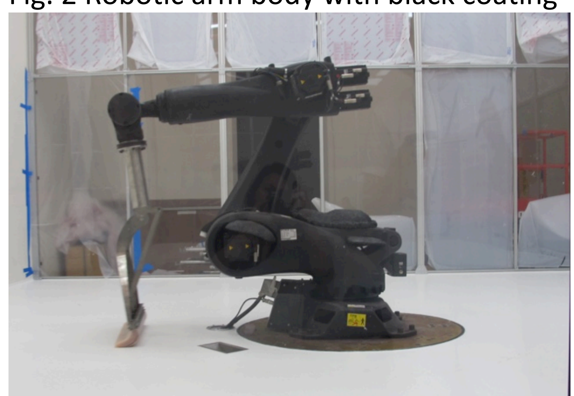


Fig. 3 Polyurethane foam attachments

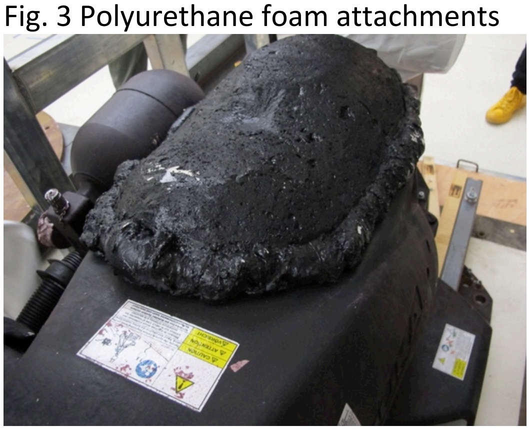


Fig. 4 Polyurethane foam attachments

Fig. 5 Raised wooden platform with white, waterproof coating

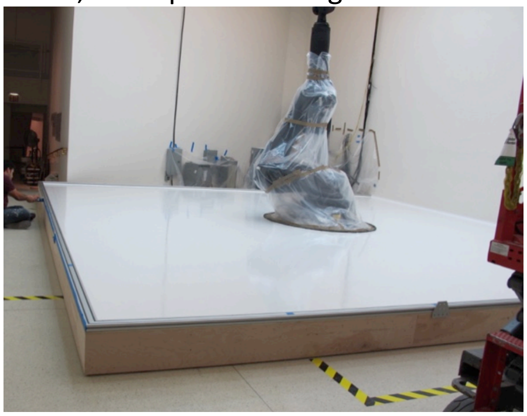
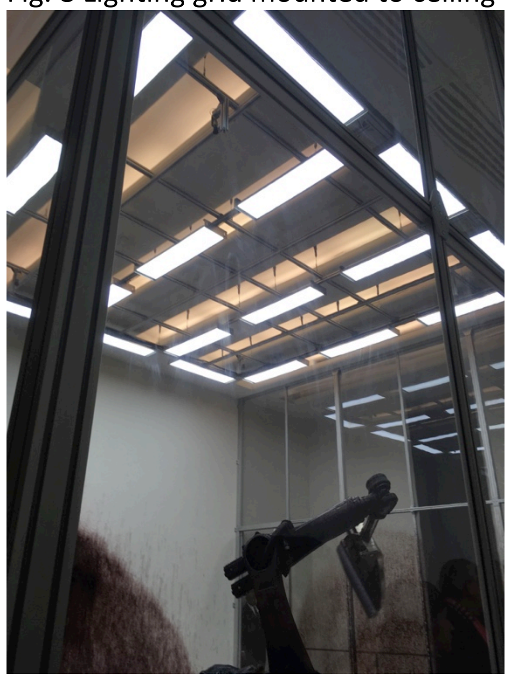


Fig. 6 Image of polycarbonate barrier, as being installed

Fig. 7 Red liquid

Fig. 8 Lighting grid mounted to ceiling



Adjacent to the work, there is a control room containing the KUKA control unit and the Cognex VC5 Vision Controller, an industrial 80 gallon mixer, an electrical pump to transfer liquid between the mixer and the exhibition space, and a power transformer, if necessary.

The robotic arm is powered by a high voltage power cable, which connects the plug on the base of the robot to the KUKA control unit. A second KUKA-proprietary connectivity cable connects the two units. For the majority of their length the cables are hidden underneath the raised decking surrounding the robot so that they will not interfere with the robot's movements. They are fed through a small hole in the platform in proximity to the robot so that they can be attached to the plugs on the base of the robot. The drainage system connecting a hole on floor of the raised platform to the mixer is also stored underneath the platform.

At the beginning of the day, the robot must be manually started to boot up the robot. The liquid needs to be pumped from the mixing reservoir on to the decking in the exhibition space. When the robotic arm is stopped, it must be moved to the home position using the controls on the handheld KUKA tablet. At the end of the day, the robot needs to be powered down, and the liquid removed from the exhibition space using a combination of the pump system and the use of squeegees being manually pushed by art handlers. The decking must then be cleaned daily using water and soft rags to remove any excess pigmented liquid.

1.2 DEVELOPMENT OF ARTWORK
1.2.1 CONTRIBUTORS

- Sun Yuan, Artist – Came up with general movements for Harry to program into the KUKA robot
- Peng Yu, Artist – Came up with general movements for Harry to program into the KUKA robot
- Yu, KUKA Project Manager
- Harry, KUKA Engineer/Programmer
- Han, Cognex Engineer/Programmer

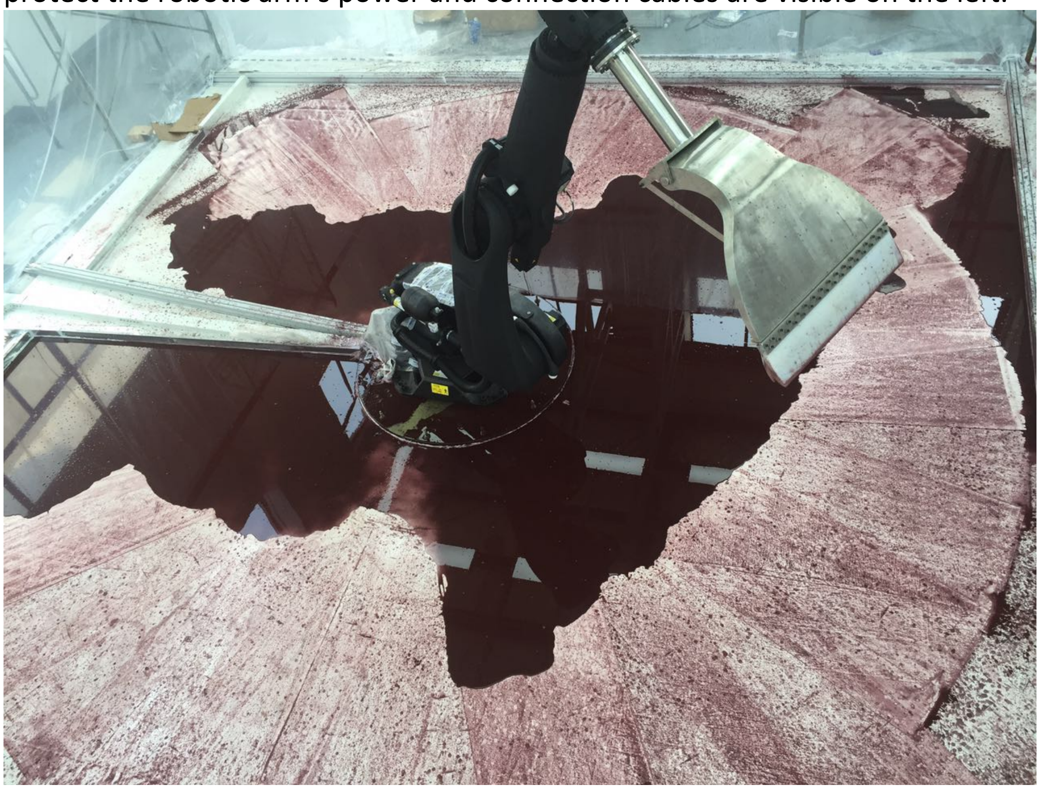
1.2.2 DEVELOPMENT ENVIRONMENT
The work was largely developed by the artists, Han (KUKA Engineer/Programmer), and Han (Cognex Engineer/Programmer) in a warehouse in Shanghai and finalized on-site at the Guggenheim.

The code for the KUKA robotic arm was developed by the engineer (Harry) on his laptop, likely using KUKA Officelite or KUKA WorkVisual 4.0 software.
The code for the visual recognition system was developed in Cognex Designer v2.0 on a Cognex VC5 controller unit.

1.2.3 DEVELOPMENT NOTES
The installation environment at the Guggenheim was modified from the original testing environment in China. In the testing environment in China, the robotic arm was directly mounted to the floor, and there was no raised decking or drainage system installed. Since there was no decking to hide the robot's power

and connectivity cables extending from the robotic arm to the KUKA control unit, these cables were laid directly on the floor. To prevent the spreading liquid from damaging the cables, small barriers were placed around the cables (fig. 9). During testing in Shanghai, the robot was not programmed to operate in the regions where the power cords were located, so the test environment at Shanghai did not include a full 360 degree movement of the arm. Once the robotic arm was installed at the Guggenheim, Harry, the KUKA engineer, wrote additional code to program the robot's interactions in the regions previously obscured by the cables.

Fig. 9 Image of *Can't Help Myself* during testing in Shanghai. Barriers installed to protect the robotic arm's power and connection cables are visible on the left.



Although the testing environment in Shanghai also measured approximately 7m x 7m, the angles for the boundaries were not measured, and space was not a perfectly square space. In addition, the testing environment's flooring was not level. As a result, the KUKA engineers needed to calibrate the robot's movements to fit the physical space of the installation at the Guggenheim and operate safely within this space. The adjustments included calibrations for how low the robotic arm should move to come in contact with the raised decking surface and the extent of the reach of the arm as it extends towards the raised safety barriers.

2.3 ART HISTORICAL CONTEXT OF THE ARTWORK

“If you're like me, the viscous red liquid will remind you of blood—but Sun Yuan and Peng Yu emphasize that the work is not based on symbolism, and is open to interpretation. Regardless, the image confronts us with issues surrounding what the artists call the "pleasure and panic" of anticipating the future. "Only in the accidents of a computer glitch, a power failure or losing a cellphone can we realize that we are kidnapped by today's knowledge structure," the artists tell The Creators Project. "The stronger such sense of dependence feels, the stronger the feelings of panic and pleasure it brings. The most frightening part is that no matter how we reflect on it, it cannot be stopped… At the same time fears are exciting, for the knowledge beyond our experience is coming." –Source: Azura Wannmann, Curator’s Project Review 12/26/2016 (2016_12_26_Creators_Project_Review.pdf)

“The artists who tested the limits of the Guggenheim as an institution are the team of Sun Yuan, 42, and Ms. Peng, 44 (the other female artist), who in the past have made installations using human body fat, live animals and corpses. At the Guggenheim, they will present a shovel-wielding machine scooping up a bloodlike liquid as it seeps across the floor.” –Source: Barbara Pollack, New York Times 10/27/2016 (2016_10_27_NYT_Review.pdf)

“A controversial young art duo included in the show breaks new ground with *Can’t Help Myself* (2016), a gigantic robot equipped with a single arm upon whose end a shovel-like object is attached. It is the brainchild of Beijing-based artists Sun Yuan and Peng Yu. Described by the press release as “guard” of sorts, the robot’s duty is to contain a pool of dark liquid resembling blood as it starts to seep away. The more the substance oozes, the more frantic the robot grows, shoveling the liquid in a move that leaves behind smears and traces of red.” –Source: Caroline Elbaor, Artnet News Review 11/4/2016 (2016_11_04_Artnet_Review.pdf)

“In a gallery one floor above Zhou Tao’s meditative piece, a crazy sight rears up in front of viewers. A frenetic robotic arm buzzes, whines, dips, and stretches inside a clear box whose walls are splattered with a bloodlike liquid. A pool of this liquid surrounds the base of the arm, which works ceaselessly, at times even seeming to pant with exhaustion. This is *Can’t Help Myself* (2016), a project by Beijing-based duo Sun Yuan & Peng Yu. Their overburdened arm is taken from an automotive assembly line. A precise, versatile machine, here the arm responds to the artists’ programmed commands to contain the liquid forever spreading away from it. The scene suggests an aftermath. Is this what will come of the ongoing arms race—now ratcheted up by AI technology—between China, Russia, and the United States: a machine left to clean up humankind's mess?" –Source: Karen Kedmey, Artsy Review 11/8/2016 (2016_11_08_Artsy_Review.pdf)

"The lingua franca of "Tales of Our Time" is video, but there's one giant sculpture: a crazed industrial robot equipped with a squeegee, installed in a room-size see-through chamber. Programmed by the Beijing artists Sun Yuan and Peng Yu, a husband-and-wife duo with a reputation as Chinese *enfants terribles*, the robot mops up liquid, with the viscosity of molasses and the color of blood, according to a set of rules: When a sensor detects that the liquid has flowed past a certain boundary, the robotic arm swoops down and cleans it up off the floor, and splashes the white gallery walls with the red fluid, like in a slasher film. It's a legible, if forced, metaphor for the societal hazards of algorithms and automation. It's also a rather expensive piece of Snapchat bait." –Source: Jason Farago, New York Times Review 12/01/2016 (2016_12_01_NYTimes_Review.pdf)

2.4 ARTIST STATEMENTS

In their original project layout for this new commission, the artists proposed:

"We will install three mechanical arms around the gallery's three corners. There will be a large puddle of sticky liquid (unknown and fluid liquid) in the center of the gallery. Because of the fluidity of the liquid, it will slowly spread around. The three mechanical arms will scan the movements through its sensory system, controlling the mechanical arms to continuously move its shovel from different angles, sending the liquid back to the center. By doing so, the area of the liquid always stays in control, without exceeding the arms' controllable range.
This will create such effects:
As long as the liquid is moving from somewhere, the mechanical arm will shovel it back to the center. The liquid continues to move, the arm will immediately shift angles and motions to send the liquid back, creating a set of busy motions."
–Source: Artist's proposal (Proposal text English and Chinese.docx)

During the artist interview conducted 11/4/2016, the artists indicated that it would be acceptable to replace the KUKA robotic arm and squeegee attachment if they become damaged or unable to operate properly in the future. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

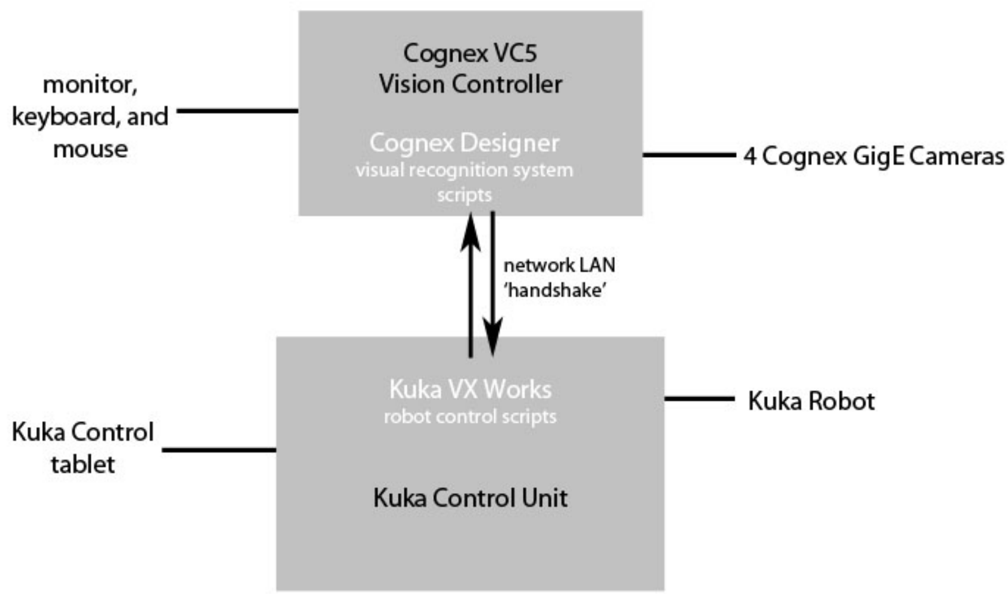
2.5 TECHNICAL DESCRIPTION

There are two systems that communicate with each other through a network LAN and after establishing a 'handshake signal' connection: the Cognex visual recognition system and the KUKA robot system. The Cognex visual recognition system script identifies the sectors of the floor that need to be scraped. Depending on the readings of the Cognex visual recognition script, the KUKA controller unit runs custom scripts in which the robot performs gestures and swiping movements to interact with the liquid in the exhibition space.

3. ARTWORK ANATOMY

3.1 TECHNICAL CONSTITUENTS AND THEIR RELATIONSHIPS

3.1.1 Graphic Illustration (e.g. schematic diagram, flowchart, UML diagram)



3.1.2 Narrative Description

The KUKA system consists of the robotic arm (fig. 10) and KUKA controller unit (fig. 11), which are connected by custom data and power cables. See **Section 3.2 LIST OF ARTIST-PROVIDED ARTWORK COMPONENTS** for a full inventory of artist-provided components for this artwork. The control unit consists of 2 CPUs: the foundation of the robot is running KUKA VxWorks OS, the control platform is running Windows. The control platform is interfaced with the KUKA Control tablet; any control of the robot arm (start and stop scripts) is made through the KUKA Control tablet. The robotic arm's custom scripts are written in KUKA Robot Language (KRL), a proprietary programming language similar to Pascal.

Fig. 10 KUKA Robotic Arm KR180 R3100 K, with custom paint (2016.40.2)

Fig. 11 KUKA KRC4 Control Unit (2016.40.19)

The visual recognition system consists of 4 GigE Cognex industrial cameras (fig. 12) mounted to the lighting grid. These cameras are connected to a Cognex VC5 Vision Controller (fig. 13) with yellow CAT6 cables. The Cognex Vision Controller is running a Windows OS and is operated with the use of a monitor, keyboard, and mouse. The scripts that read and interpret the data from the cameras are written in C# using the Cognex Designer engine. The Cognex VC5 Vision Controller is connected to the KUKA Control Unit with a 15m Ethernet cable.

Fig. 12 GigE Cognex industrial cameras (2016.40.43-.46)

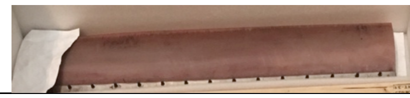
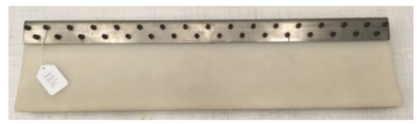
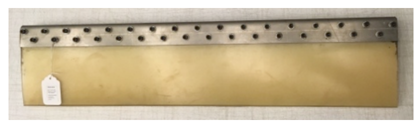
Fig. 13 Cognex VC5 Vision Controller (2016.40.35)

3.2 LIST OF ARTIST-PROVIDED ARTWORK COMPONENTS

3.2.1 Artist-provided Physical Components

Table 1 Inventory of Artist-provided Components

Component #:	TMS Component Name:	Additional Notes	Image
2016.40.1	Certificate of Authenticity		
2016.40.2	KUKA Robotic Arm KR180 R3100 K, w/custom paint		
2016.40.3	Custom Shovel Attachment, 45 3/8"H x 31 ½" W x 12 ½" D, 1 of 2	Used in 2016 SRGM exhibition	
2016.40.4	Custom Shovel Attachment, 44"L x 31 5/8"W x 10"D, 2 of 2		 

2016.40.5	Silicone Squeegee for Shovel Attachment (.3), 7 ½"H x 31 ½"W x 1 ¾"D, 1 of 4	Used in 2016 SRGM exhibition	
2016.40.6	Silicone Squeegee for Shovel Attachment (.4), 7"H x 31 5/8"W x 2"D, 2 of 4		
2016.40.7	Silicone Squeegee for Shovel Attachment (.3), 7 7/8"H x 31 ½"W x 2"D, 3 of 4	White squeegee, measures 2 ¾"D with metal attachment	
2016.40.8	Silicone Squeegee for Shovel Attachment, 7 ¼"H x 32 ¼"W x 1"D, 4 of 4	Yellow squeegee, measures 2 ¾"D with attachment	
2016.40.9	Bolts and washers for attaching shovel attachment to robot (.2)		
2016.40.10	Artist-produced Painted Foam Protective Attachment - Top Center		At opening:  At Deinstall: 

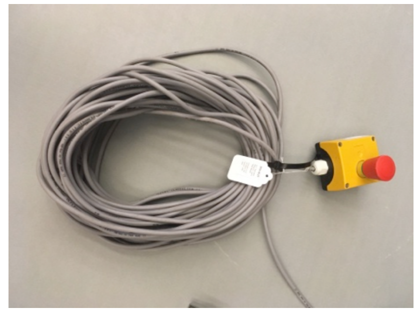
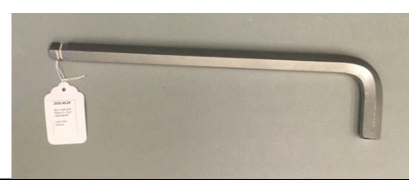
2016.40.11	Artist-produced Painted Foam Protective Attachment - Proper Left Large		At opening:  At deinstall: 
2016.40.12	Artist-produced Painted Foam Protective Attachment - Proper Left Small		At opening:  At deinstall: 

2016.40.13	SRGM-produced cord cover		 
2016.40.14	Steel Plate Mount, with bolts		
2016.40.15	Bolts attaching robot (.2) to steel plate mount (.14)		
2016.40.16	Power Cable With Connector, for Robotic Arm (2016.40.2)	Identifying marks: "00-182-465 / 7M" and "600V FT1 LL46064 359.1097.32 14/15". The end which connects to the robot is labeled "X30",	

		while the end which connects to the KRC4 is labeled "X31"	
2016.40.17	Spare Power Connector, for Robotic Arm (2016.40.2)	Can be used for the robot's power cable or for connecting the "kill switch" and two-part door safety switch to the KRC4. Manufacturer: Harting	
2016.40.18	Data Cable With Connector, for Robotic Arm (2016.40.2)	Identifying marks: "00-174-774" and "KUKA Type 20/08 359.1100.06 26/15". The male connector, labeled "X21", connects to the KRC4, while the female connector, labeled "X31", connects to the robot.	
2016.40.19	KUKA KRC4 Control Unit		

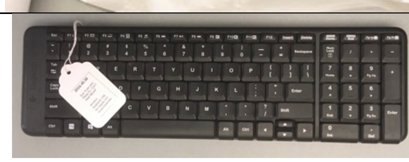
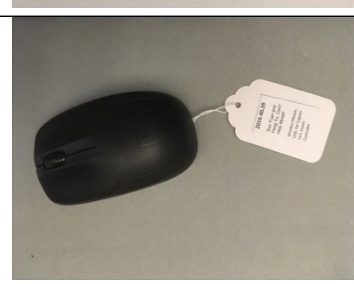
2016.40.20	Key for KUKA KRC4 Control Unit (2016.40.19)	This key opens the KUKA KRC4 Control Unit (2016.40.19), Case for Cognex VC5 Visual Control Unit (2016.40.41), and the Electrical Distribution Box for Visual Recognition System (2016.40.36)	
2016.40.21	Power Cable with Connector, for KUKA Control Unit (2016.40.19)	One end is hard-wired into the power source	
2016.40.22	Grounding cable, connects KUKA Control Unit (2016.40.19) to Robot mount	Ends of cables have orange paper taped around cable	
2016.40.23	Grounding cable, connects KUKA Control Unit (2016.40.19) to power source	Ends of cables have orange paper taped around cable	Similar to above but without clamp on one end

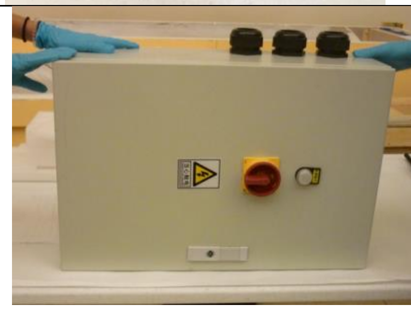
2016.40.24	KUKA Tablet Handheld Control Unit, with cable	Connects to KUKA Control Unit (2016.40.19). Identifying marks on cable: "00-181-563" and "AwM 20963 80°C 30V ERNST & ENGBRING 352.C014.08 15/15". Has 2 USB ports (for loading scripts).	 
2016.40.25	Set of 2 keys on keyring, for KUKA Tablet (2016.40.24)		
2016.40.26	Mount for KUKA Tablet (2016.40.25)		

2016.40.27	Emergency Cut-off Switch "Kill-Switch"	SIEMENS 35B3 801-0DG3 “kill switch” with grey cable (identifying marks: “Ölflex Classic 110 561 WDE-Reg.Nr.7030 RoHS CE”), connects to the KRC4 via a Harting connector (.17)	 
2016.40.28	Safety Door Lock, In Two Pieces, With Cord	Euchner Riegel NZ-A Safety Bolt, with grey cable (identifying marks: Lappkabel Stuttgart Ölflex Classic 115CV 12 6 1,0 RoHS), connects to the KRC4 via a Harting connector (.17)	 
2016.40.29	Allen Wrench, 14 ¼”L x 4”W x 7/8”D	Used to tighten the bolts connecting the robot to the circular mount (.15)	

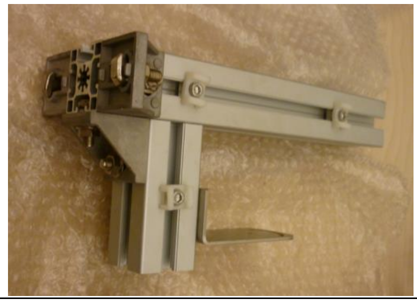
2016.40.30	DVD with Assembly Instructions for KUKA products		
2016.40.31	DVD with “KRC4 Docs & Parts”		
2016.40.32	DVD with KUKA WorkVisual 4.0 (compiler), contains .33		
2016.40.33	Content from DVD with KUKA WorkVisual 4.0 (compiler)		To upload to server
2016.40.34	Custom Computer Code for KUKA Robot		On USB flash drive on 7th floor, upload to server

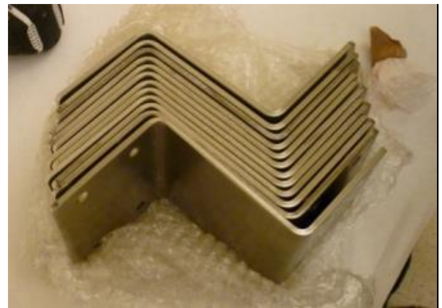
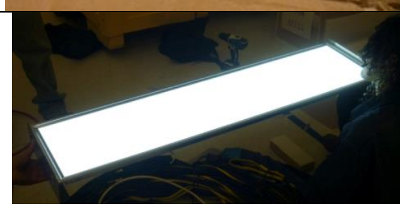
2016.40.35	Cognex VC5 Vision Controller, computer	Is installed in tan metal case (2016.40.36). Runs on Windows OS with Cognex Designer v2.1 software	 
2016.40.36	Case for Cognex VC5 Vision Controller (2016.40.35)	Case includes Mean Well DR-120-24 power supply and fan, both hard-wired to the case and the VC5 Vision Controller (.35). Can be locked/opened with key from KUKA control unit (2016.40.20)	 

			
2016.40.37	Dell LCD Monitor for Cognex VC5 Vision Controller, with VGA cable and power cable	For Cognex VC5 Vision Controller (2016.40.35)	 
2016.40.38	Wireless Computer Keyboard, USB, for Cognex VC5 Vision Controller	For Cognex VC5 Vision Controller (2016.40.35)	
2016.40.39	Wireless Computer Mouse, USB for Cognex VC5 Vision Controller	For Cognex VC5 Vision Controller (2016.40.35)	

2016.40.40	USB receiver for keyboard (2016.40.38) and mouse (2016.40.39), for Cognex VC5 Vision Controller (2016.40.35)	Inserted into USB port on Cognex VC5 Vision Controller (2016.40.35)	
2016.40.41	Electrical Distribution Box, for Cognex Vision Recognition System	Can be opened with key for KUKA control unit (2016.40.20). Runs on 220V, cannot be run using a step-up transformer.	 
2016.40.42	Custom Computer Code for Cognex Visual Recognition System		To be uploaded to server
2016.40.43	GigE Cognex Industrial Camera with CAT6 UTP Data Cable, 1 of 4	Screws for cameras take a 2.5mm allen key	

			 
2016.40.44	GigE Cognex Industrial Camera with CAT6 UTP Data Cable, 2 of 4	Screws for cameras take a 2.5mm allen key	See 2016.40.43
2016.40.45	GigE Cognex Industrial Camera with CAT6 UTP Data Cable, 3 of 4	Screws for cameras take a 2.5mm allen key	See 2016.40.43
2016.40.46	GigE Cognex Industrial Camera with CAT6 UTP Data Cable, 4 of 4	Screws for cameras take a 2.5mm allen key	See 2016.40.43
2016.40.47	Mount and bolts for attaching Camera to Lighting Grid, 1 of 4	Label: Camera 1	

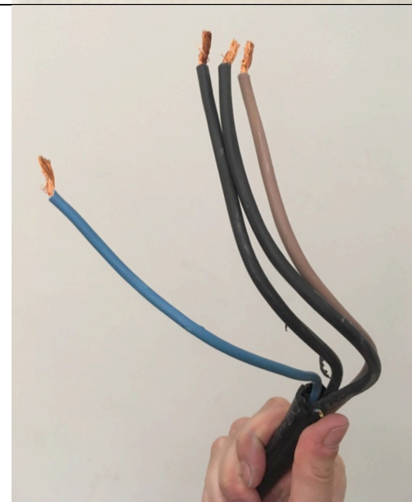
			
2016.40.48	Mount and bolts for attaching Camera to Lighting Grid, 2 of 4		See 2016.40.47
2016.40.49	Mount and bolts for attaching Camera to Lighting Grid, 3 of 4	Label: Camera 3	See 2016.40.47
2016.40.50	Mount and bolts for attaching Camera to Lighting Grid, 4 of 4	Label: Camera 4	See 2016.40.47
2016.40.51	Lighting Grid, includes beams, brackets, and bolts	Used for mounting cameras (2016.40.43-.46), camera mounts (2016.40.47-50), and lights (2016.40.52-.71) above robot	 

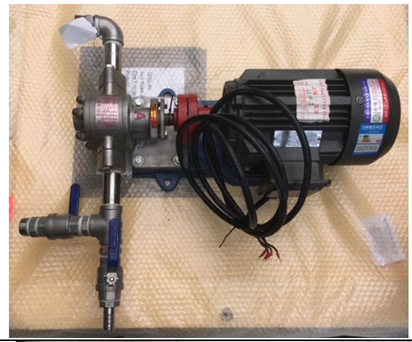
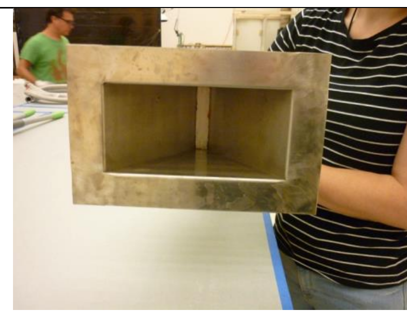
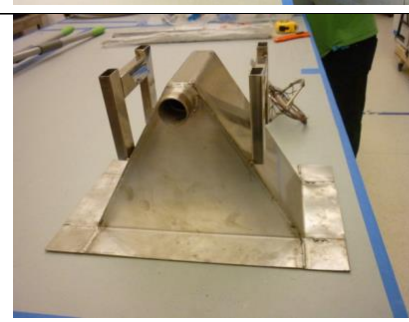
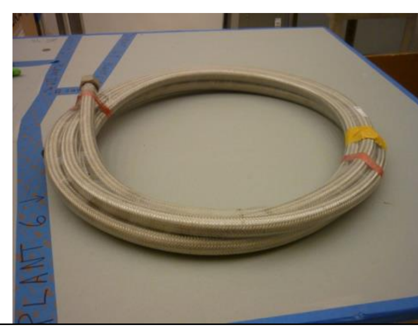
			 
2016.40.52	LED Light Panel, 120V - 240V, 1 of 20		  

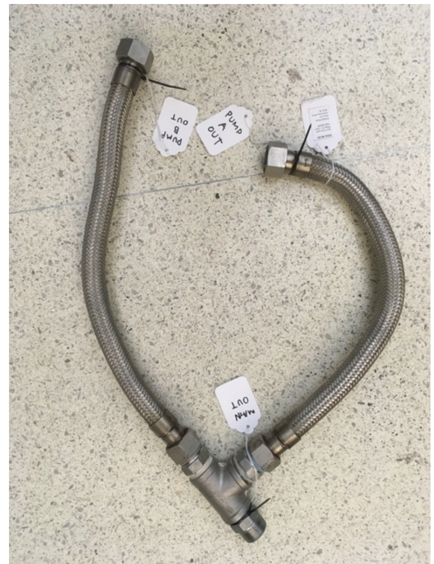
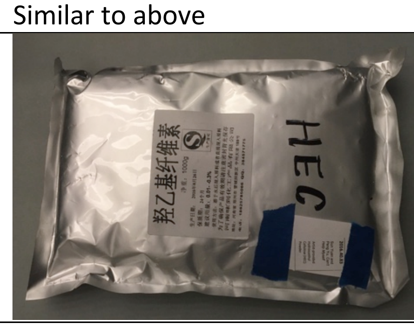
			
2016.40.53	LED Light Panel, 120V - 240V, 2 of 20		See 2016.40.52
2016.40.54	LED Light Panel, 120V - 240V, 3 of 20		See 2016.40.52
2016.40.55	LED Light Panel, 120V - 240V, 4 of 20		See 2016.40.52
2016.40.56	LED Light Panel, 120V - 240V, 5 of 20		See 2016.40.52
2016.40.57	LED Light Panel, 120V - 240V, 6 of 20		See 2016.40.52
2016.40.58	LED Light Panel, 120V - 240V, 7 of 20		See 2016.40.52
2016.40.59	LED Light Panel, 120V - 240V, 8 of 20		See 2016.40.52
2016.40.60	LED Light Panel, 120V - 240V, 9 of 20		See 2016.40.52
2016.40.61	LED Light Panel, 120V - 240V, 10 of 20		See 2016.40.52
2016.40.62	LED Light Panel, 120V - 240V, 11 of 20		See 2016.40.52
2016.40.63	LED Light Panel,		See 2016.40.52

	120V - 240V, 12 of 20		
2016.40.64	LED Light Panel, 120V - 240V, 13 of 20		See 2016.40.52
2016.40.65	LED Light Panel, 120V - 240V, 14 of 20		See 2016.40.52
2016.40.66	LED Light Panel, 120V - 240V, 15 of 20		See 2016.40.52
2016.40.67	LED Light Panel, 120V - 240V, 16 of 20		See 2016.40.52
2016.40.68	LED Light Panel, 120V - 240V, 17 of 20		See 2016.40.52
2016.40.69	LED Light Panel, 120V - 240V, 18 of 20		See 2016.40.52
2016.40.70	LED Light Panel 120V - 240V (replacement), 19 of 20	Does not have attached armature	See 2016.40.52
2016.40.71	LED Light Panel, 120V - 240V (replacement), 20 of 20	Does not have attached armature	See 2016.40.52
2016.40.72	18 Cables with Transformers for Light Panels (2016.40.53-.71)	Identifying marks: "60227 IEC53 (RVV) 300/500V 2 x $0.75mm^2$"	
2016.40.73	Spare Transformer for cables for Light Panels (2016.40.72), 1 of 2		

2016.40.74	Spare Transformer for cables for Light Panels (2016.40.72), 2 of 2		
2016.40.75	Mixer	Capacity: approximately 80 gallons	
2016.40.76	Pump Control Unit	13 7/8"L x 10"W x 33"H	

2016.40.77	Power Cable for Pump Control Unit (2016.40.76)	Hard-wired into pump control unit and power source. Identifying marks: “YZ 300/500V CCCA005749”	
2016.40.78	Power Cable for Mixer (2016.40.75)	Hard-wired into mixer and power source. Identifying marks: “300/500V 3x4mm^2 + 2x2.5mm^2 16/01/04 13#”	
2016.40.79	Valves for Mixer (2016.40.75)		
2016.40.80	Pump Compressor, Labeled “A”, 1 of 2	23” L x 10” W x 9”H	

			
2016.40.81	Pump Compressor, Labeled "B", 2 of 2	23" L x 10" W x 9"H	
2016.40.82	Metal Drain, 14"L x 9"W x 8"H, 1 of 2	Used in the 2016 SRGM iteration	
2016.40.83	Metal Drain (spare), 14"L x 9"W x 8"H, 2 of 2		
2016.40.84	Braided Metal Hose with Attachment, for attaching to Drain		

2016.40.85	Braided Metal Hose, for connecting .84 to .80 & .81		
2016.40.86	Braided Metal Hose, for connecting mixer (.75) to .80		
2016.40.87	Braided Metal Hose, for connecting mixer (.75) to .81		Similar to above
2016.40.88	Artist-provided Hydroxyethyl Cellulose (HEC) Powder, reference		
2016.40.89	Artist-provided thickening agent, Hydroxypropyl Methyl Cellulose (HPMC) Powder,		

	reference		
2016.40.90	Miscellaneous additional hardware and equipment	Two Heng Ye wrenches for attaching/detaching hoses, some spare screws and T-bolts, A set of four oversized bolts (possibly for attaching the mount to another mount), a silver and black cord connector associated with the KRC4, and a small metal plate.	

3.2.2 Artist-provided Artwork Files

<u>Custom Computer Code for KUKA robot (2016.40.34)</u>

.src and .dat files make up each script. .src files contain executable code while .dat files store variables.

Significant folders:

- /KRC/R1/Program/Main Program

art - main executable that references other scripts

- /KRC/R1/Program/Logic

firstRun – intro sequence that runs at startup of piece

path_planing – logic for choosing gestures

- /KRC/R1/Program/Gestures

scripts for all 32 gesture animations

Custom Computer Code for Cognex Visual Recognition System (2016.40.42)

The code for the visual recognition system is contained within a single .cdp file, which is viewable using Cognex Designer software but can not be exported.

KUKA WorkVisual 4.0 Compiler (2016.40.33)

Compiler provided on KUKA-provided DVD (2016.40.32)

3.3 ASSOCIATED ELEMENTS OUTSIDE OF THE COLLECTION

n/a

3.4 ADDITIONAL COMPONENTS REQUIRED TO RUN THE PIECE

3.4.1 Liquid

For the 2016 SRGM iteration, the artists developed a recipe for the thickened, pigmented liquid to be used in the artwork in collaboration with Objects Conservator Esther Chao. Although the overall color and thickness of the liquid should be maintained for future exhibitions, the brand of watercolors/colorants utilized may vary. In the 2016 SRGM iteration, Sargent Art watercolors were chosen because they did not stain the waterproof coating applied to the raised decking. It is possible that in future iterations, different brands of watercolors may be more appropriate due to availability and reaction with the decking applied for that iteration. The viscosity of the liquid may be measured using a viscosity cup (fig. 14). Once filled, the viscosity cup should fully empty at a rate of approximately 2 minutes.

Fig. 14 Viscosity cup

Can't Help Myself requires at least 50 gallons to operate properly; ideally, between 50 and 54 gallons should be present in the mixer. Approximately 48 gallons of liquid are pumped onto the raised decking in the exhibition space, and the remaining gallons remain in the bottom of the mixer (measuring a depth of 4.5 inches) and do not get pumped into the exhibition space. It is important that the proper levels of liquid are maintained throughout the exhibition. If there is too much or too little liquid, the visual recognition system will not properly execute the full range of movements as intended by the artists. In the 2016 SRGM iteration, the artwork was replenished weekly on Thursdays with 20-40 gallons of liquid, depending on how much liquid was lost throughout the week.

The following is the recipe for creating one 5-gallon bucket of pigmented Hydroxyethyl Cellulose (HEC) liquid:

- 5 gallons warm water
- 400mL powdered HEC powder, a plant-based thickener
- 1 4oz bottle of Sargent Art red watercolor
- 1 4oz bottle of Sargent Art yellow watercolor
- 8mL of black Chinese calligraphy ink
- 50mL of sodium benzoate (may not be necessary for every batch; should be assessed by conservation)

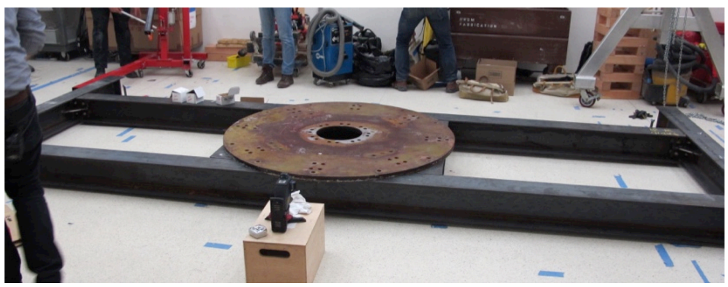
Instructions:
1) Fill a 5 gallon bucket with warm water.
2) Add 400mL of HEC to the water.
3) Mix with a power drill mixer attachment. Use your hands to break up large clumps of powder and leave to sit for 1-2 days.
4) After 1-2 days, mix again. The liquid should be thoroughly and uniformly blended. At this point, add the sodium benzoate (if necessary).
5) Add 4oz red watercolor, 4 oz yellow watercolor, and 8mL black calligraphy ink. Mix well using a spatula, scraping the sides of the buckets during stirring, to incorporate the colorants.

To determine the amount of liquid that will need to be replenished, insert a dipstick to measure the depth of the liquid present in the mixer once all of the liquid has been extracted from the raised decking in the exhibition space. The artwork requires a depth of 20.5 inches of liquid in order to operate properly. If the liquid depth is measured as less than 10 inches, 5 5-gallon buckets of pigmented HEC liquid and 3-4 5-gallon buckets of water will need to be added. If the liquid depth is more than 12 inches, only 3-4 5-gallon buckets of pigmented HEC liquid and 2-3 5-gallon buckets of water will need to be added.

3.4.2 Steel Mount

A large steel mount is required to stabilize the robotic arm and secure it to the exhibition space's floor. The For safety reasons, the mount must provide sufficient stability to prevent the robot from flexing during operation. In the 2016 SRGM iteration, the robotic arm and artist-provided circular steel mount was bolted to a large "H"-shaped mount (fig. 15).

Fig. 15 "H"-shaped mount used in the 2016 SRGM iteration

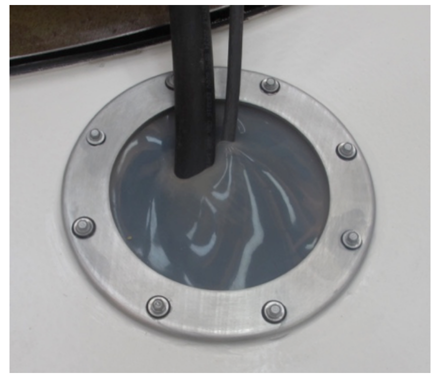


3.4.3 Raised Decking

Raised decking fabricated around the robot's mount acts as a surface for the liquid to spread and for the robot to scrape. The use of a raised decking is essential to conceal and protect the power and communication cables and the drainage system. The decking is coated with a white, waterproof coating that resists staining. It is essential that the decking coating does not react with the pigmented liquid, as the Visual Recognition System depends on the contrast between the white decking coating and the dark red liquid to operate. Gasketing should be installed at the joint between the raised decking and the robot's mount to prevent seepage of liquid underneath the raised decking (fig. 16). A hole must be cut in the raised decking to feed the robot's power and data cables from underneath the decking and a diaphragm will need to be installed to allow for flexible movement of the cords but to protect the cables from exposure to liquid (fig. 17). An additional hole will need to be cut to install the drain. The interface between the decking and the drain must be sealed prior to operation of the work.

Fig. 16 Gasketing installed around the robot's circular mount to prevent seepage of liquid under the decking

Fig. 17 Diaphragm installed to pass power and data cables between the robot and the KUKA controller unit



3.4.4 Protective Dam

A dam measuring approximately 8" high or greater and outfitted with a top covering must be installed surrounding the base of the robot to protect the gasketing around the mount and the robot's mechanical components from prolonged contact with the liquid (fig. 18).

Fig. 18 Dam installed for the 2016 SRGM iteration

3.4.5 Safety Barriers

Clear protective barriers must be installed on all sides of the robot to which visitors have access (fig. 19). The barriers protect the visitors from injury in the case of a failure and also protect visitors from splashing liquid. In the 2016 SRGM iteration, these barriers were fabricated from polycarbonate sheets with aluminum mullions.

Fig. 19 Installation of barriers around the robot enclosure

3.4.6 Transformer

Depending on the voltage of the available at the exhibiting institution, a transformer and high-voltage power supply (fig. 20) may be required to ensure an uninterrupted power supply to the robot, the KUKA controller system, and the visual recognition system. Ideally, a second transformer will be used for the pump and mixer so that they could be run at the same time as the robot to prevent power failure from using too much power. The robot, mixer, and pump all require 380V of power.

Fig. 20 Transformer and high-voltage power source installed for the 2016 SRGM iteration

3.5 REPLACEABILITY OF COMPONENTS

3.5.1 KUKA Components

All hardware components of the KUKA robot arm, KUKA Control Unit, and KUKA Control tablet can be serviced and replaced by KUKA USA or China. Standard KUKA software components can also be serviced by KUKA. –Source: Interview with KUKA Engineers (Kuka_Engineers_Interview_2016_11_03.wav)

Custom software written for the KUKA robotic arm (2016.40.34) and KUKA's WorkVisual 4.0 compiler (2016.40.33) is backed up on the Guggenheim's protected Conservation Video server.

3.5.2 Cognex Visual Recognition System Components

All hardware components of the Cognex Visual recognition software can be serviced and replaced by Cognex (USA or China). The Cognex Designer 2.1 software is standard; however, a license is required for its installation on other units. –Source: Interview with KUKA Engineers (Kuka_Engineers_Interview_2016_11_03.wav)

The file containing custom scripts for the visual recognition system (2016.40.42) is backed up on the Guggenheim's protected Conservation Video server.

3.5.3 Lights

The artists would like for the same model rectangular 120V – 240V LED light panels (2016.40.52-.71) to be used and replaced as long as is possible. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

The make/model of the LED light panels are not indicated on any identifying labels on the light panels. The Guggenheim has two replacement panels which may be swapped out in the case of a failure of one of the light panels during exhibition.

3.5.4 Attachments

Upon acquisition, the artists provided the Guggenheim with two custom shovel attachments, accessioned as 2016.40.3 and 2016.40.4 (figs. 21 and 22). The dimensions for 2016.40.3 are 45 3/8"H x 31 ½" W x 12 ½" D, while the second shovel attachment, 2016.40.4, measures 44"L x 31 5/8"W x 10"D. As the two shovel attachments have different dimensions, if the shovel attachment is swapped during an exhibition, the robot will need to be recalibrated.

Fig. 21 Custom shovel attachment, 1 of 2 (2016.40.3)

Fig. 22 Custom shovel attachment, 2 of 2 (2016.40.4)

The artists also provided four silicone squeegee attachments upon acquisition, 2016.40.5-.8. The artists have indicated that it would be acceptable to replace the squeegee attachment in the case that its performance is no longer acceptable. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

The artists are open to the idea of replacing the polyurethane foam inserts which protect areas of the robot's internal mechanisms from splashing liquid 2016.40.10-.12; in the artist interview, they were more concerned with functionality of the inserts than the materials or appearance. They suggested that the current inserts could be either cast into another material, or the inserts could be completely refabricated from molded plastic or resin. It is likely that if the inserts were refabricated, that they would require gasketing to seal the interior mechanisms from splashing liquid. However, the interior mechanisms must still be accessible in case there is a problem. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

4. CONTENT EXAMINATION: BEHAVIORS & FUNCTIONS

4.1 ENVIRONMENT OF EXAMINATION (DETAILED SPECIFICATION)

4.1.1 Software and Hardware Environment

The examination was carried out on the same hardware and software that was utilized for exhibition. Examination was conducted during installation of the work in the exhibition environment.

4.1.2 Examination Method

Date: 10/20

Examiner: Jillian Zhong, Alex Nichols

Method: Spoke to Cognex sensor engineer Han, who explained and demonstrated display on monitor of Cognex visual sensor control system. Showed code samples within Cognex designer.

Date: 10/21
Examiner: Jillian Zhong
Method: Viewed test of robot, which was conducted by Kuka engineer Harry. After testing, Harry explained script behavior of the robot arm on a high level as well as its interactions with the Cognex visual sensor control system. Harry also showed the interior of the Kuka control box as well as the basic operations of the buttons on the Kuka control tablet while the machine was powered off.

Date: 10/28
Examiner: Jillian Zhong
Method: Viewed test of robot after the new flooring was installed. Testing was conducted by Harry alongside the artists. Viewed adjustment of gesture locations as they were calibrated for the new environment's height and sector boundaries.

Date: 10/30
Examiner: Jillian Zhong
Method: Viewed test of robot's gestures at 30% speed at every possible location by Harry. Spoke to Harry and Han about when each gesture is done and how it is determined. Viewed test of robot arm with some isolated liquid on the floor.

Date: 11/2
Examiner: Jillian Zhong
Method: Viewed instruction of Piotr by Harry and Han on start up and shut down of installation. Piotr was also instructed on how to reset and restart the machine on auto if it is paused at different stages. Filmed every gesture of the robot while Harry and Han narrated the number of sectors crossed and the Chinese name given by the artists.

Date: 11/3
Examiner: Jillian Zhong, Alex Nichols, Joanna Phillips
Method: Interview with Harry, Han, and Mr. Yu, the three engineers along with translator Lawrence.

Date: 11/4
Examiner: Jillian Zhong, Alex Nichols, Joanna Phillips, Esther Chao

Method: Interview with the artists Sun Yuan and Peng Yu, along with translator Lawrence.

4.1.3 Environment-specific behaviors

The work has evolved significantly during the installation process either due to technical specification issues or the requirements of the artists. No further adjustments will be made in this exhibition environment, and the robot will run consistently as long as the quantity and viscosity of the liquid remains constant.

4.2 ENVIRONMENT OF SOURCE CODE ANALYSIS

A backup of the Kuka controller's custom scripts has been obtained (554484.zip). A backup of the Cognex visual system file has also been obtained (KUKA_NEW.cdp). The Kuka files are viewable in a standard text editor. The Cognex file must be viewed within the Cognex Designer development environment.

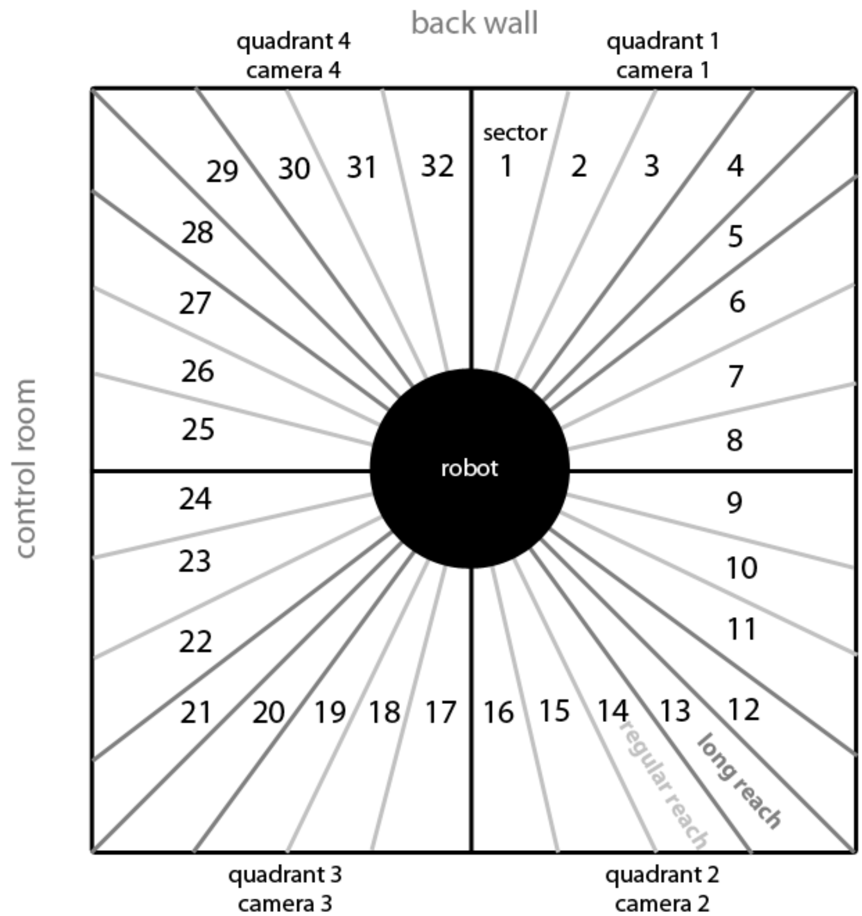
4.3 ARTWORK BEHAVIORS & FUNCTIONS

4.3.1 Visual Recognition System

The 4 cameras divide up the floor area into 4 quadrants. Each quadrant contains 8 sectors, making a total of 32 sectors (fig. 23).

The cameras are black and white. In the visual recognition software, the red liquid on the floor is represented by black pixels and the white floor by white pixels. The specific sector the robot will target for scraping is determined by the percentage of black pixels out of total pixels in each sector. For each camera, the script will read in the image sent from the camera and compute a decimal number for each region based on percentage of black pixels compared to the total pixels in region. The numbers of each region for the quadrant will be compared to each other to find the maximum number (the region with the highest percentage of black pixels). If that region's percentage is over a set threshold (70%), it is considered 'dark' and the location of that region will then be sent to the KUKA control unit's script.

Fig. 23 Arial View of Area Division at SRGM Exhibition Environment



4.3.2 Communication Between the Cognex Visual Recognition System and the KUKA Control Unit

When both systems are started, the initial data connection has to be made for communication between the KUKA control unit and the Cognex Visual Recognition System to occur. This connection will remain intact until either system is powered down. A request for a data connection must be initiated from the KUKA tablet within the KUKA control unit script named “art”. The KUKA control unit sends a request to the Cognex system and gives a 3-second window for a response. If a connection signal is sent from the Cognex Visual Sensor system within that time frame, a handshake connection is made. To complete the data connection, a technician must send a response from the visual recognition system Cognex software within the 3-second window. This establishes the handshake between the KUKA control unit system and the Cognex Visual Sensor Controller system. After the handshake has been established, the KUKA control unit script requests the cameras to shoot and send back data. Based on the data received back, the script will direct the arm to do different gestures.

4.3.3 Scrapes, Gestures, and Special Gestures

The movement of the robot consists of scrapes, gestures, and special gestures.

A *scrape* is the brushing motion in which the robotic arm extends and the squeegee makes contact with the floor, followed by a pull towards the base of the robot. This motion is used for moving the liquid on the floor towards the center of the room. There are two standard reaches for scrapes. The long reach, measuring 128”, is used for the two sectors in each corner of the square floor (sectors 4, 5, 12, 13, 20, 21, 28, and 29). The regular (shorter) reach, measuring 96”, is used for all other sectors. The file name for the script is **pos1**.

Gestures are the artistic motions of the robot arm that are performed before scrapes of sectors. While performing a unique motion, the gestures move the arm from a starting sector to a destination sector. Table 2 describes 25 possible gestures:

Table 2 Gestures performed by the KUKA robotic arm

Difference Between Starting Sector # And Destination Sector #	**English Name of Gesture**	**Chinese Character for Gesture/ Pinyin Romanization**	**File Name of Gesture Script**	**Description of Gesture**
6	Twist	扭腰 Niǔ yāo	pos6twist	
7	Torch	火炬 Huǒjù	pos7torch	
8	Draw the Bow	拉弓 Lā gōng	pos8draw	
9	Scratch an Itch	挠痒痒 Náo yǎngyang	Pos9itch	

10	Turn Over Twice	反转两次 Fǎn zhuǎn liǎng cì	pos10turnover2	
11	Downward Kick	向下踢 Xiàng xià tī	pos11kickbottomfeet	
12	Goose	鹅 É	pos12goose	
13	Salute	敬礼 Jìnglǐ	pos13salute	
14	Bow and Shake	弯腰颤动 Wān yāo chàndòng	pos14bowshake	
15	Burn Sky	烧天 Shāo tiān	pos15burnsky	
16	Wave	波浪 Bōlàng	pos16wave	
17	Sewing Machine	缝纫机 Féngrènjī	pos17sewing	
18	Yong Chun	咏春 Yǒng chūn	pos18yongchun	
19	Stop 3 Seconds	听令等三秒 Tīng lìng děng sān miǎo	pos19Stop03	
20	Huang Feihong	黄飞鸿 Huáng fēihóng	pos20huangfeihong	
21	Kick	踢 Tī	pos21kick	
22	Cheerful	庆祝 Qìngzhù	pos22cheerful	
23	Nine Wires	九段线 Jiǔduàn xiàn	pos23ninewires	
24	Semi-circle	半圆 Bànyuán	pos24semicircle	

25	Chop	劈刀 Pī dāo	pos25chop1	
26	Submarine	潜水艇 Qiánshuǐ tǐng	pos26submarine	
27	Ass Shake	扭屁股 Niǔ pìgu	pos27ass	
28	Self-rotate	自转 Zìzhuǎn	pos28selfrotate	
29	Jian Zhao	见招 Jiàn zhāo	pos29jianzhao	
30	Raise Hand	举手 Jǔ shǒu	pos30RaiseHand	
31	Return Home	回"home" Huí "home"	unknown	
Special Gesture #1	unknown	unknown	unknown	
Special Gesture #2	unknown	unknown	unknown	
Special Gesture #3	unknown	unknown	unknown	
Special Gesture #4	unknown	unknown	unknown	First occurs after 30 gestures, repeats every 60 gestures thereafter
Special Gesture #5	unknown	unknown	unknown	First occurs every 60 gestures, repeates every 60 gestures thereafter

Special gestures are movements that are triggered by special instances outside of the behavior described above. The nicknames and file names for the special gestures are not known at this time. These gestures can be a combination of scrapes or other gestures. There are five total special gestures performed in two different situations. Three are performed when none of the sectors are identified as "dark". The two remaining gestures are performed every 30 gestures.

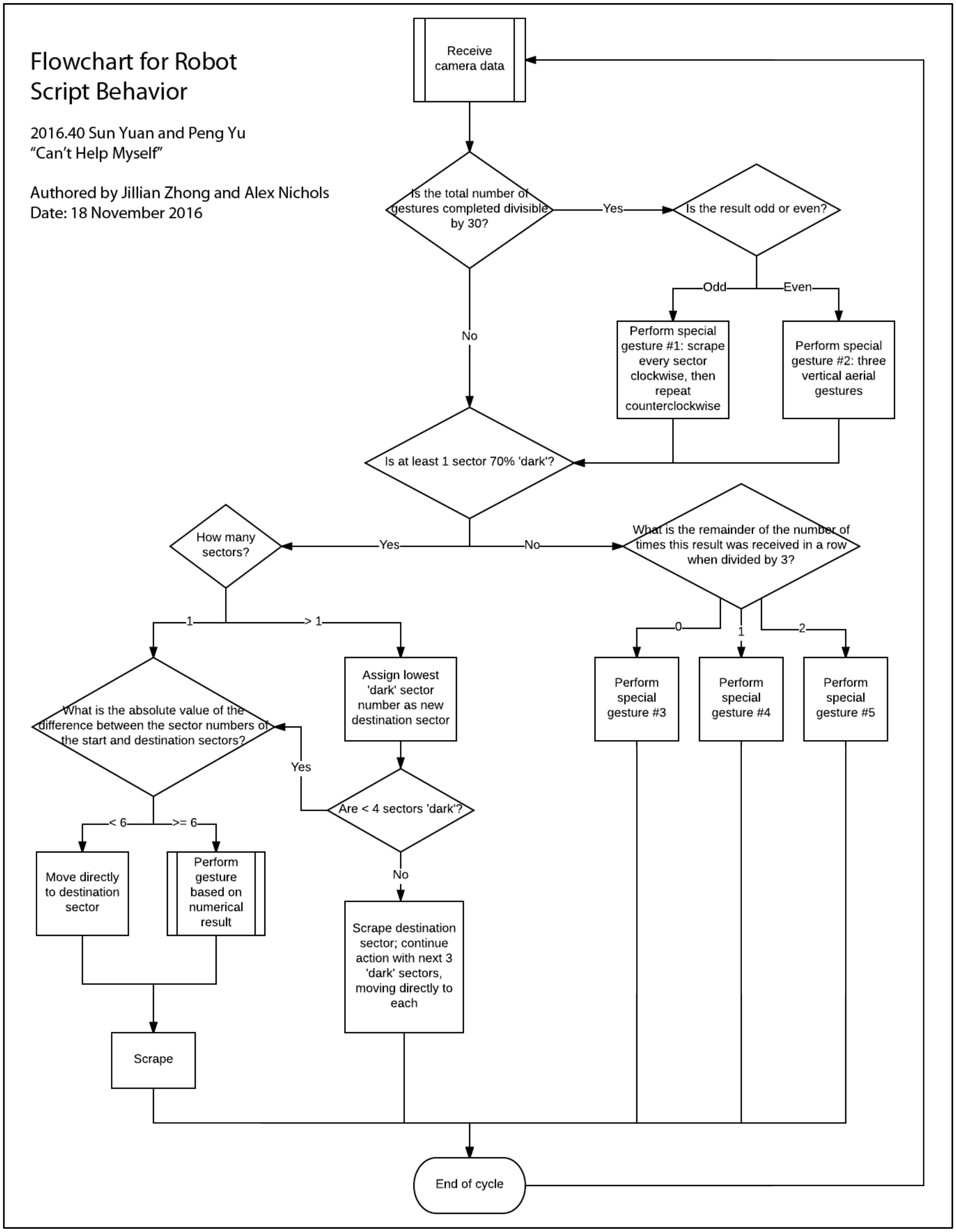
4.3.4 Gesture Selection

Depending on what data is received from the cameras, the custom scripts running within the KUKA control unit determine the behavior of the robotic arm. See figure 24 for a flowchart of the robot's behavior.

There are 3 main situations:

1. If it is a normal instance (default), the robot will complete a gesture while moving to a sector which is "dark" and then scrape that sector. If there is more than one sector which have been labeled "dark", the robot will go to the sector which has the lowest number (eg. preference will go to sector 4 vs sector 7).
2. If any four sectors are 'dark' simultaneously, the robot will complete four scraping motions in a row (one in each sector). The robot will move directly from one sector to another without completing a gesture between each scrape, regardless of number of sectors crossed. The robot will start with the sector with the lowest sector number.
3. If no sectors are 'dark' (no sectors received from visual recognition system), the robot will complete a special gesture (one out of a three possible gestures - either special gesture #3, #4, or #5). Start with special gesture #3 and cycle through the three gestures, doing one each time the camera sends no sectors.

Fig. 24 Flowchart for Robot Script Behavior



Besides these 3 situations, there is a special situation that depends on the number of gestures done by the robot in total so far:
After every 30 gestures, the robot will complete one of two special gestures (either special gesture #1 or #2). The first, special gesture #1, is single scrapes of every sector all the way around clockwise and then around again counter-clockwise. The second, special gesture #2, is made up of 3 vertical, aerial movements. The robot will choose the first special gesture and will alternate with the second special gesture every 30 gestures.

There are 25 different possible gestures that are done with scrapes. The gesture that is done depends on the sector numbers of the starting sector and the ending sector (which sector the arm is moving from and which sector the robot arm is moving to). This is calculated by subtracting the destination sector number from the starting sector number and then taking the absolute value. If this resulting number is less than 6, there is a direct movement to the destination sector followed by a scrape. For situations in which the resulting number is 6 or greater, there is a specific gesture linked to each of those resulting numbers. The robot arm will perform the specific gesture for that resulting number while moving to the destination sector and then a scrape.

4.3.4 Speed

Although the movements and speeds of the movements relative to each other were designed and set by the artists and the engineers, the overall speed of the robot script can be scaled to run at different speeds. The original intent of the artists was to run the piece at 100%; however, due to the instability of the mount at the Guggenheim installation, the robot experienced an unacceptable amount of shake while certain gestures were performed. There is no shake observed when the robot is run at 50% speed. The artists approved for the piece to run at 70% for this exhibition as a compromise between reaching the intended affect of the piece and safety of the piece and visitors.

5. INSTALLATION PARAMETERS

5.1 Installation Environment Requirements and Positioning of Equipment

5.1.1 Minimum and Maximum Room Dimensions

The minimum size for the installation space (the area with which the robotic arm interacts, aka the raised decking) is 7m x 7m square. Ideally, this work would be installed in a larger space. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

5.1.2 Ceiling Height Requirements
The ceiling height should be close to that used at the 2016 SRGM installation (16’11” / 5.16m). The ceiling height should not be any lower, as the robotic arm may hit the lighting grid. If the ceiling is significantly higher, the camera field may become too large and will negatively affect the ability of the visual recognition system from operating as intended. –Source: Interview with Kuka Engineers (Kuka_Engineers_Interview_2016_11_03.wav)

5.1.3 Position of Work in Space
The artists have indicated ideally, they would prefer that visitors can approach the work from all 360 degrees. They would prefer that the control room be fully detached from the robot’s exhibition space. However, they recognize that this may not be realistic, and find it acceptable if access to one side of the exhibition space is closed off to act as the control room, leaving only three sides available for visitors. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

The KUKA robotic arm, its associated mounts, and raised decking must be positioned in an area that is structurally sound and can withstand rapid shifts in weight during operation of the robot. See **Section 3.4.2** for further details.

5.1.4 Lighting Grid
The lighting grid, used to mount and position the lights and cameras associated with this work, will be installed centered above the robot. The minimum distance between the bottom of the light grid and the top of the raised decking (see below) is 15’8” (4.77m) –Source: SRGM Installation Diagram (2016_10_06_ Installation_Diagram3.tiff)

5.1.5 Raised Decking
The raised decking is fabricated around the robot to obscure the mount and cabling, and is coated with a non-staining, waterproof, white coating(s). Clear protective barriers will be installed around any sides of the deck in which there is no wall, so as visitors are protected from the robot in case of failure and are protected from splashing liquid.

The artists stated that ideally, the robot would be installed on a deck which was large enough so that the robot could fully extend its arm. However, the robot is currently configured for a deck measuring 7m x

7m, so the artists have indicated the exhibition space should stay as is for now. A circular deck would also be possible, but it would also require considerable reprogramming of the robot, as the gestures would have to be altered to fit the circular space, and the robot's reach during swiping movements would have to be modified. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

The raised decking fabricated around the robotic arm must be coated with a non-staining, waterproof, white coating(s). The coated decking should be level to encourage even flow of the liquid throughout the space during the work's operation. The coating may be either a matte or glossy finish; either surfaces work with the Cognex visual recognition system. –Source: Interview with Kuka Engineers (Kuka_Engineers_Interview_2016_11_03.wav)

See **Section 3.4.3 Raised Decking** for further details.

5.1.6 Position and Contents of Control Room

The control units for the KUKA robot and visual recognition controller unit must be placed nearby the robot (the distance is limited by the length of the robot's cords) in a control room. The control room will contain the KUKA control unit, the KUKA tablet handheld controller, the Cognex visual recognition system, the transformer, the liquid pump, the mixing reservoir, and the drainage system used to transfer the liquid from the exhibition space to the mixing reservoir. Although it is not necessary for the equipment to be directly adjacent to the robot, the KUKA robot must be visible from the equipment room during the operation of the robot.

As mentioned previously, ideally, the artists would have the control room completely separate from the robot's exhibition space, but recognize that this may not be feasible. The artists do not have a preference for the room to be visible or hidden, but believe it may be practically easier for the engineers to conduct testing on the robotic arm if they have a line of sight. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

5.1.7 Safety Barriers

Additional space will be necessary for the installation of the clear protective barriers. The barriers must be >3m high to prevent liquid from splashing onto guests. The artists do not believe that a ceiling barrier is necessary in a space with higher ceilings, as it is not likely that the liquid will splash above the lighting grid. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

See **Section 3.4.5 Safety Barriers** for further details.

5.1.8 Safety Switches

The "kill switch" and door switch must be installed in an area in which it is readily available to museum staff.

5.2 Visitor interaction and behavior

Visitors must not be allowed to enter the barriers or otherwise gain access to the robot's operational area. The robot can lift up to 180 kg and could potentially injure or kill anyone who gets in the way of the movement.

In the 2016 SRGM iteration, metal safety stanchions were installed in areas in which the robotic arm's maximum reach extended past the polycarbonate safety barriers. These were installed as a safety measure in case of mechanical failure of the robotic arm.

5.4 Lighting

18 LED lights illuminating the robotic arm and the decking are mounted above the robot, attached to the lighting grid. The LED lights for the lighting grid should not be changed. Ambient gallery light is also permissible. The artists prefer a natural sunlight color (4500K -5000K) –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

5.5 Sound

The artists would like the museum visitors to be able to hear the sound generated by the robot's movements.

5.6 Additional requirements

6. EXHIBITION AND ITERATION HISTORY

Dates	Exhibition	Image/Notes	See Iteration Sheet
2016-2017	*Tales of Our Time*, SRGM (November 4, 2016 – March 10, 2017)	Site-specific installation 	x

		Source: Tales of Our Time-exh_ph068.jpg  Source: Tales_Opening017.jpg	

7. HISTORY OF TECHNICAL CHANGE/MODIFICATION

The work does not currently have a history of technical changes or modifications since there has only been one iteration.

8. CONDITION ASSESSMENT

8.1 FUNCTIONALITY

The work is fully functioning at the time of its first iteration at the Guggenheim in 2016. The only compromise in the functionality of the work is the reduced running speed, resulting from the type of floor mount required by the historically-protected building.

8.2 ERRORS AND/OR UNINTENDED BEHAVIORS

n/a

8.3 SUGGESTED MODIFICATIONS

n/a

9. RISK ASSESMENT

9.1 HARDWARE

The robot arm may undergo damage overtime due to the shaking mount, liquid, and continued general use. KUKA engineers advised that with typical industry use, KUKA robotic arms do not need repairs until after 1-2 years after installation. The risk of the robotic arm needing repairs is low during the first 3-month exhibition. However, KUKA engineers must conduct a comprehensive check on the robot if it is taken out of storage for another exhibition in the future. Prolonged storage without activity increases the risk of the robot needing repairs. –Source: Interview with KUKA Engineers (Kuka_Engineers_Interview_ 2016_11_03.wav)

The large "H"-shaped floor mount made in compliance with the Guggenheim's protected status as a historic landmark experienced shaking during testing, resulting in increased risk of mechanical damage to the robot. The mount was monitored during exhibition, and no increase in the shaking was observed. It is possible that in future exhibitions, different mounting may result in a reduction of shaking, lowering the risk of damage.

9.2 SOFTWARE

The scripts must run within the specific environments they were created in. The scripts can be viewed in other machines but must be opened in the proprietary software they were created in. This software can be installed on any machine; however, it requires the purchase of a license.

10. MAINTENANCE AND SETUP REQUIREMENTS

10.1 SKILLS AND EXPERTISE NEEDED

Source code analysis would need to be conducted by someone who is already experienced with KUKA code. It is unlikely that someone who has only peripheral knowledge of the way KUKA robots are programmed would be able to fully understand the code in a way that is useful for comprehensive documentation or if interventive treatment is necessary.

10.2 WORK HOURS NEEDED

The artists do not require that they be present for the entirety of installation; they prefer that they are present for the last two days of the future installation so that they can give approval to the iteration. If they are not able to be present for any part of the installation, they would find it acceptable to provide approval after viewing video of the installation. –Source: Artist Interview 11/4/2016 (Sun_Yuan_and_Peng_Yu_Interview_2016_11_04.wav)

A KUKA engineer will need approximately 7 days to calibrate the robot for a new exhibition environment. Harry (the KUKA engineer who installed the robot for the SRGM 2016 exhibition) has indicated that he would need to train another engineer in person to understand how the robot operates. This training would take 1-2 weeks. –Source: Interview with KUKA Engineers (Kuka_Engineers_Interview_2016_11_03.wav)

11. SHORT- AND LONG-TERM PROGNOSIS & RECOMMENDATIONS

11.1 SHORT-TERM RECOMMENDATIONS

- Obtain Harry/Han/Mr. Yu's contact information for future communication and reference.
- Do a thorough condition check of the physical components associated with the work once off display.
- Establish a relationship with KUKA USA for future servicing issues.

11.2 LONG-TERM RECOMMENDATIONS

- With KUKA USA, discuss protocol for initiating the process for a future installation or conducting inspection of the KUKA environment.
- Obtain licensed versions of KUKA and Cognex Designer v2.0 IDEs.
- Research possible need for migration of code onto replacement control hardware in case of damage or wear.