In colaboration with:

TU Delft

WET CLEANING FUNCTION

FOR

ROBOT VACUUM CLEANERS

by: Fermin Espin Franco

APPENDICES

Master Thesis

Wet Cleaning Function
for Robot Vacuum Cleaners

APPENDICES

Disclaimer

This master thesis is written in context of the master Integrated Product Design at the faculty of Industrial Design Engineering at the Delft University of Technology in The Netherlands.

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PHILIPS

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Graduate student
Fermin Espin Franco

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1.1 Comments & Ratings

COMMENT	MODEL
the pads are quite expensive+A2:A109	Braava Jet240
Mopping pad replacements are expensive	Braava Jet240
Washable mopping pads are not included	Braava Jet240
Exchangeable parts: rotational brush or accessory to just vaccum long hairs	Ecovacs Deebot M81Pro
plenty of features fro the money you pay	Ecovacs Deebot M81Pro
it comes with a lot of accessories	Moneual ME685
it comes with some replacements which is quite convenient	Proscenic 790T WIFI
batteries for the remote control are not included	Proscenic 790T WIFI
It can handle a large area of laminate floor	Braava 390t
It is good for basic cleaning jobs	Braava 390t
It only does a small room before you need to recharge	Braava Jet240
good for small apartments	Braava Jet240
It works well as a complement of a roomba or a previous cleaning	Braava Jet240
each mopping pad last only for 20-25 square meters	Braava Jet240
small coverage area	Braava Jet240
The supplied virtual wall doesn't work very well	Haier T325 Pathfinder
We use it in between hoovering to keep on top of dog hair	Haier T325 Pathfinder
does not support virtual wall technology	Proscenic 790T WIFI
A good choice for small space cleaning	Roomba Scooba 450
Does a good job on small to medium sized rooms or room sections	Roomba Scooba 450
You need sometime before You know how to properly divide your house with the virtual walls to get good results	Roomba Scooba 450
When the battery runs fully empty (when trapped), the computer is locking down and makes the robot unusable. Neither re-charging nor on-off switching do cure these lock downs	Haier T325 Pathfinder
the battery is easy to take appart in case it has to be replace	Proscenic 790T WIFI
battery last for only 40 minutes	Roomba Scooba 450
battery keep on breaking	Roomba Scooba 450
built-in battery makes you have to change the whole unit if it breakes	Roomba Scooba 450
It compacts the dit in the dustbin very well so it can vacuum for longer before the full dustbin message pops out	Ecovacs Deebot M81Pro
Emptying the container is easy enough.	Ecovacs Deebot R95 MKII
has a large dustbin	Proscenic 790T WIFI
Low maintenance	Braava 390t
It's really simple to prep, use, and clean up after	Braava Jet240
easy to use	Braava Jet240
easy setup	Ecovacs Deebot M81Pro
easy to use	Ecovacs Deebot M81Pro

easy maintenance	Ecovacs Deebot M81Pro
The different cleaning modes are really useful	Ecovacs Deebot R95 MKII
It requires no assembly except you have to set wireless settings and download the app	Ecovacs Deebot R95 MKII
easy set up	Ecovacs Deebot R95 MKII
Very easy setup	Ecovacs Deebot R95 MKII
easy maintenance	Haier T325 Pathfinder
Easy to use	Haier T325 Pathfinder
At the end of a clean, the robot itself will be a bit dirty and should be cleaned up. I don't mean the dirt bin, I mean the brushes, sensors, vacuum inlet and particularly, the cleaning cloth	Haier T325 Pathfinder
It is really comfortable that it cleans and you only needs to get worry about emptying the bin after two days/uses	I Life V5s Pro
Easy to use	I Life V5s Pro
Easy to use and set up	I Life V5s Pro
easy maintenance	Moneual ME685
a lot of maintenance	Roomba Scooba 450
easy to use	Roomba Scooba 450
easy to refil & empty when it is done	Roomba Scooba 450
The edge detection is good	Braava 390t
It will mop round furniture but it can be time consuming and excruciating to watch, I clear the room basically apart from the table	Braava 390t
It missed 2/5th of a room on 3 occasions.	Braava 390t
It can leave small areas witout clean	Braava 390t
misses areas of the floor, particularly when it finds obstacles	Braava Jet240
it is a bit stupid dealing with obstacles	Ecovacs Deebot M81Pro
it does not detect small stairs	Ecovacs Deebot M81Pro
when it has to come back to the charging dock sometimes it gets a bit lost before it does or it runs out of battery	Ecovacs Deebot M81Pro
does not get gunked too easily	Ecovacs Deebot M81Pro
it leaves some areas without cleaning	Ecovacs Deebot M81Pro
It cleans by identifying the edges of the room and then goes up and down or across in an overlapping pattern to ensure the whole floor is covered fully	Ecovacs Deebot R95 MKII
The mapping bit is amazing	Ecovacs Deebot R95 MKII
for some reason it couldnt find the charging station but after a little reset it was back up and running	Ecovacs Deebot R95 MKII
laser maping	Ecovacs Deebot R95 MKII
It takes a while to cover a room since it doesn't learn a route	Haier T325 Pathfinder
where the sunlight shines directly on the floor the hoover thinks it is a wall	Haier T325 Pathfinder
gets stuck easily	Haier T325 Pathfinder
as the cleaning seems in random order, it can clean some areas more and leave other areas in the room	Haier T325 Pathfinder
It deals well with obstacles	I Life V5s Pro
It does not reach every spot in the house because it does not make a map of the house	I Life V5s Pro

It gets stuck on the furniture	I Life V5s Pro
Sometimes it gets stubborn with certain areas and you have to guide it with the remote control	I Life V5s Pro
It bumps against the furniture all the time	I Life V5s Pro
it gets stuck on the cables	I Life V5s Pro
the cleaning route is a bit random so it passes through the same areas several times and leaves other areas without cleaning	Moneual ME685
It gets a bit lost when it has to come back to the charging dock	Moneual ME685
It felt downstairs, it is dead now	Moneual ME685
Robot cannot be moved while working	Proscenic 790T WIFI
cannot change the room mid-cyclie	Roomba Scooba 450
It won't come back to the charging dock when it is finished	Braava 390t
it does not have a charging dock	Braava Jet240
it depends too much on the user to recharge	Braava Jet240
it comes back to the dock automatically	Ecovacs Deebot M81Pro
does not charge the battery automatically	Roomba Scooba 450
there is no charging dock	Roomba Scooba 450
it does not come with a charging dock	Roomba Scooba 450
Its silent	Braava 390t
it is really quite	Braava 390t
very quiet	Braava Jet240
it was quieter than I expected	Ecovacs Deebot M81Pro
low noise level	Ecovacs Deebot M81Pro
Really quite	Haier T325 Pathfinder
It is noisier than conventional vacuum robots	I Life V5s Pro
It is not really quite	I Life V5s Pro
Is quite (60dB) considering the strong suction power	Proscenic 790T WIFI
It does not reach corners	Braava 390t
it tackles corners and edges super efficiently	Braava Jet240
does not clean the edges very well	Ecovacs Deebot M81Pro
it leaves corners witout cleaning	Ecovacs Deebot M81Pro
I cannot reach corners	Roomba Scooba 450
It misses the edges	Roomba Scooba 450
no automated schedule	Braava 390t
You can adjust the amount of water it sprays using the associated bluetooth control via the iPhone app	Braava Jet240
You can reduce the water spray volume if preferred, say on laminate or wood	Braava Jet240
if you want to reduce the water output for instance, no option but to use the mobile app	Braava Jet240

it offers a mapping system only available in high end products in a mid end product	Ecovacs Deebot M81Pro
very pratical wifi connection to program or drive it through your phone	Ecovacs Deebot M81Pro
The settings programmed through the remote control are not visible on the app and viceversa	Ecovacs Deebot M81Pro
the app is really handy to program the areas you want to clean or schedule the cleaning	Ecovacs Deebot R95 MKII
the app is pretty cool for checking its progress/setting it a specific task	Ecovacs Deebot R95 MKII
WIFI connection	Ecovacs Deebot R95 MKII
Difficulties connecting the App	Ecovacs Deebot R95 MKII
it has a count down timer not a clock, so scheduling things at first can be confusing.. the instruction manual is not very clear on this	Haier T325 Pathfinder
It cannot be scheduled by days	I Life V5s Pro
commands from the app reach the robot with delay	Proscenic 790T WIFI
connects to wifi	Proscenic 790T WIFI
the app is really handy to program the days you want to clean	Proscenic 790T WIFI
some problems connecting to the App	Proscenic 790T WIFI
It is not possible to see the current location of the robot or the mapping of the areas which have been cleaned already	Proscenic 790T WIFI
there is no automated schedule	Roomba Scooba 450
You cannot programm it when you are out	Roomba Scooba 450
I was very surprised by the amount of dust and dirt it had collected for the short time it had been running	Ecovacs Deebot M81Pro
Good performance on hard floors	Ecovacs Deebot M81Pro
Good vacuuming performance	Ecovacs Deebot R95 MKII
It vacuum s really well	Ecovacs Deebot R95 MKII
It works well on short haired rug carpets	Ecovacs Deebot R95 MKII
Vacuum performance is just normal	Ecovacs Deebot R95 MKII
It doesn't work in carpets	Haier T325 Pathfinder
It picks up only dust and not much else	Haier T325 Pathfinder
The little brushes come off easily when caught on something	Haier T325 Pathfinder
It vacuum pretty well	I Life V5s Pro
It vacuums really well	I Life V5s Pro
good vacuuming perofrmance	Moneual ME685
Is very efficient handling pet hair	Proscenic 790T WIFI
has a strong suction mechanism	Proscenic 790T WIFI
actually works on carpets	Proscenic 790T WIFI
it handles pet hair without problem	Proscenic 790T WIFI
that the cloth seems to get dry after 30mins of use as the wick in the dispenser does not let sufficient water out	Braava 390t
took 40 minutes to do what I can do in 5	Braava 390t
the wet mop does a fantastic job	Braava 390t

it will wipe but lacks the intensity of roller/scrubbing action or indeed a mop and bucket	Braava 390t
Tile undulations and seams are not ideal as its simply a non scrubbing, flat wiping motion	Braava 390t
I already own a Roomba vacuum cleaning robot, but this is a perfect compliment	Braava 390t
I use a robot vac for collecting dirt and dust so very rarely use the dry mop, but when I have it does collect it well, but just takes dust round with it.	Braava 390t
It works well as a complement of a roomba or a previous cleaning	Braava 390t
The wheels leave marks	Braava 390t
Not able to clean grout	Braava 390t
Battery life isn't a problem on large areas but it can run out of water	Braava Jet240
I would still say medium size rooms work perfectly	Braava Jet240
it runs out of water before the battery runs out	Braava Jet240
It does a surprisingly good job of cleaning up stains.	Braava Jet240
it is not quick about cleaning	Braava Jet240
I do have a Roomba which I use first for picking up dust before setting this	Braava Jet240
additional pads can get expensive	Braava Jet240
Tought stains require manual intervention	Braava Jet240
mop is not effective	Ecovacs Deebot M81Pro
It cannot vacuum and mop at the same time	Ecovacs Deebot M81Pro
5 levels of cleaning in one pass	Ecovacs Deebot M81Pro
It gives you clean moped floors without having to lift a finger	Ecovacs Deebot R95 MKII
Unique feature is that this robot not just vaccuming-it also wet cleaning floor!	Ecovacs Deebot R95 MKII
we take advantage of the added mop feature every now and then	Ecovacs Deebot R95 MKII
it can't charge with the mop on, so you have to remember to add the mop before the cycle	Ecovacs Deebot R95 MKII
It can vacuum and mop at the same time	Ecovacs Deebot R95 MKII
The mopping mode is convenient	Ecovacs Deebot R95 MKII
when used with water tank container full, has great difficulty in moving around	Haier T325 Pathfinder
don't use it as a wet mob on schedule on wooden floors, once its done moping it returns to the base and the floor underneath is soaking wet	Haier T325 Pathfinder
The mop falls off quite often when I pick the vacuum cleaner up	Haier T325 Pathfinder
It does not leave the floor excesively wet after mopping	I Life V5s Pro
the wet cleaning mode does not really clean, it passes a wet mop but is not comparable to the Scooba	I Life V5s Pro
The wet mode mode does not convince me	I Life V5s Pro
The wet cleaning mode does not clean heavy stains and you need to mop in some areas afterwards	I Life V5s Pro
the wet cleaning does not work really well	I Life V5s Pro
The wet mode works well but does not rmove heavy stains	I Life V5s Pro
The wet mopping mode does not get the mop wet enough by itself, you have to wet the mop beforehand	Moneual ME685
the mopping mode does not replace the manual cleaning	Moneual ME685

also mops the floor	Proscenic 790T WIFI
mopping results could be better	Proscenic 790T WIFI
you have to remove the main brush to use the mop. The suction mechanism will work at the same time but the robot is left with only sidebrushes	Proscenic 790T WIFI
the wep mopping mode does get the mop wet enough by itself	Proscenic 790T WIFI
It leaves a lot of water behind	Roomba Scooba 450
three pass cleaning does not work on dry climates	Roomba Scooba 450

APPENDIX

1.2 Pugh Matrix

PARTICIPANTS

NAME	SCORES													
NUMBER OF PARTICIPANTS	6													
PARTICIPANT 1	Topic	Weight of Criteria	Orion	Orion Detach	Power Orion Detach	Delorean	Delorean Roll	Delorean Opp Roll	Delorean Roll WR	Aqua trio	Komodo	Sonicare + Delorean	Spray Sonicare + Delorean	Spray Multi. Sonicare + Delorean
	water management	6	0	0	0	3	1	1	1	2	2	1	2	2
	water consumption	3	0	0	0	-1	-1	-2	-2	-3	-3	-1	-2	-2
	energy consumption	4	0	0	1	0	-1	-1	-1	-3	-1	-1	-1	-1
	heavy stains	8	0	0	1	0	0	1	1	3	3	2	3	3
	crevices	2	0	0	1	0	0	1	1	1	1	1	1	1
	uneven surfaces	7	0	0	0	0	0	0	0	3	3	1	1	3
	simplicity	5	0	-1	-2	-2	-2	-3	-3	-3	-3	-2	-2	-3
	eff working time	1	0	0	0	0	0	0	0	0	0	0	0	0
			0	-5	4	5	-11	-9	-9	23	31	14	25	34
PARTICIPANT 2		Weight of Criteria	Orion	Orion Detach	Power Orion Detach	Delorean	Delorean Roll	Delorean Opp Roll	Delorean Roll WR	Aqua trio	Komodo	Sonicare + Delorean	Spray Sonicare + Delorean	Spray Multi. Sonicare + Delorean
	water management	7	0	1	1	3	3	3	3	3	3	3	3	3
	water consumption	8	0	0	0	0	0	0	0	1	1	1	0	0
	energy consumption	5	0	0	-1	0	-1	-2	-1	-3	3	-1	-1	-2
	heavy stains	1	0	0	0	0	-1	1	-1	3	3	2	2	2
	crevices	3	0	0	0	0	0	0	0	3	2	0	0	0
	uneven surfaces	6	0	0	0	0	0	1	0	3	2	0	0	0
	simplicity	2	0	-1	-2	-1	-3	-3	-3	-3	-2	-2	-3	-3
	eff working time	4	0	0	-1	0	-1	-2	3	-3	2	1	1	1
			0	5	-2	19	9	12	9	38	61	22	12	7
PARTICIPANT 3		Weight of Criteria	Orion	Orion Detach	Power Orion Detach	Delorean	Delorean Roll	Delorean Opp Roll	Delorean Roll WR	Aqua trio	Komodo	Sonicare + Delorean	Spray Sonicare + Delorean	Spray Multi. Sonicare + Delorean
	water management	7	0	0	1	3	2	2	2	3	3	2	-1	-2
	water consumption	6	0	0	0	-1	-1	-1	-1	-2	-2	-1	-3	-3
	energy consumption	8	0	2	-1	-1	-3	-3	-3	-3	-2	-2	-2	-2
	heavy stains	1	0	0	1	1	1	2	1	3	2	2	3	3
	crevices	2	0	0	0	0	0	0	0	3	2	2	3	3
	uneven surfaces	3	0	0	0	0	1	1	1	3	3	3	3	3
	simplicity	5	0	-1	-2	-2	-3	-3	-3	-3	-2	-2	-3	-3
	eff working time	4	0	0	1	2	2	2	2	3	3	2	2	1
			0	11	-10	-2	-27	-26	-27	-12	-2	-3	-38	-45
PARTICIPANT 4		Weight of Criteria	Orion	Orion Detach	Power Orion Detach	Delorean	Delorean Roll	Delorean Opp Roll	Delorean Roll WR	Aqua trio	Komodo	Sonicare + Delorean	Spray Sonicare + Delorean	Spray Multi. Sonicare + Delorean
	water management	3	0	0	0	2	2	2	1	1	1	2	2	2
	water consumption	7	0	0	0	1	-2	-2	-2	-2	-2	1	-2	-2
	energy consumption	2	0	0	-3	-2	-2	-2	-2	-3	-3	-2	-2	-2
	heavy stains	6	0	0	1	0	0	1	0	0	0	1	1	1
	crevices	1	0	0	0	0	0	0	0	1	1	1	1	1
	uneven surfaces	5	0	0	0	0	0	0	0	1	1	1	1	1
	simplicity	8	0	-3	-2	-3	-3	-3	-3	-3	-3	-3	-3	-3
	eff working time	4	0	0	0	0	1	1	1	1	1	0	0	0
			0	-8	-16	-15	-36	-32	-45	-28	-28	-3	-24	-24
PARTICIPANT 5	Topic	Weight of Criteria	Orion	Orion Detach	Power Orion Detach	Delorean	Delorean Roll	Delorean Opp Roll	Delorean Roll WR	Aqua trio	Komodo	Sonicare + Delorean	Spray Sonicare + Delorean	Spray Multi. Sonicare + Delorean
	water management	8	0	3	3	3	2	2	3	3	3	1	1	1
	water consumption	7	0	2	2	1	1	1	1	2	2	1	0	0
	energy consumption	3	0	0	-1	2	2	2	2	-3	-3	-2	-2	-2
	heavy stains	6	0	-1	1	1	1	2	2	3	3	1	1	1
	crevices	5	0	0	0	0	0	0	0	3	3	0	0	0
	uneven surfaces	4	0	0	0	0	0	0	0	0	0	0	0	0
	simplicity	2	0	3	1	0	0	-2	-3	-2	-1	-2	-3	-3
	eff working time	1	0	-1	2	2	2	2	3	3	3	-2	-2	-2
			0	38	43	43	35	37	43	58	60	11	2	2
PARTICIPANT 6		Weight of Criteria	Orion	Orion Detach	Power Orion Detach	Delorean	Delorean Roll	Delorean Opp Roll	Delorean Roll WR	Aqua trio	Komodo	Sonicare + Delorean	Spray Sonicare + Delorean	Spray Multi. Sonicare + Delorean
	water management	8	0	0	0	2	2	2	2	2	2	1	2	2
	water consumption	5	0	0	0	0	0	0	0	1	1	1	1	1
	energy consumption	2	0	0	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
	heavy stains	5	0	0	2	0	2	2	2	-2	-2	2	2	2
	crevices	2	0	0	0	0	0	0	0	1	1	1	1	1
	uneven surfaces	4	0	0	0	0	0	0	0	0	0	1	1	1
	simplicity	6	0	0	2	-2	-2	-2	-3	-2	-2	-2	-2	-3
	eff working time	3	0	0	0	-1	-1	-1	2	-1	-1	-1	-1	-1
			0	0	20	2	12	12	6	2	4	19	27	27

TOTAL

NAME	SCORES														
NUMBER OF PARTICIPANTS	6														
TOTAL	Topic	Average Weight of Criteria	Orion	Orion Detach	Power Orion Detach	Delorean	Delorean Roll	Delorean Opp Roll	Delorean Roll WR	Aqua trio	Komodo	Sonicare + Delorean	Spray Sonicare + Delorean	Spray Multi. Sonicare + Delorean	Weight Criteria Order
	water management	6.5	0	0.7	0.8	2.7	2.0	2.0	1.7	2.3	2.3	1.7	1.5	1.3	8
	water consumption	6.0	0	0.3	0.0	0.0	-0.5	-0.7	-0.7	-0.3	-0.3	0.3	-1.0	-1.0	7
	energy consumption	4.0	0	0.3	0.0	-0.3	-1.0	-1.3	-1.0	-2.8	-1.2	-1.7	-1.7	-1.8	3
	heavy stains	4.5	0	-0.2	0.2	0.3	0.5	1.5	0.8	1.8	1.7	1.7	2.0	2.0	4
	crevices	2.5	0	0.0	0.2	0.0	0.0	0.2	0.2	2.0	1.7	0.8	1.0	1.0	1
	uneven surfaces	4.8	0	0.0	0.0	0.0	0.2	0.3	0.2	1.7	1.5	1.0	1.0	1.3	6
	simplicity	4.7	0	-0.2	-1.7	-1.7	-2.2	-2.7	-3.0	-2.7	-2.2	-2.0	-2.5	-2.7	5
	eff working time	2.8	0	-0.2	-0.2	0.5	0.5	0.3	1.8	0.5	1.3	0.0	0.0	-0.2	2
			0	6.8	3.8	14.3	2.7	2.8	-1.2	14.8	22.0	14.2	2.5	1.5	

APPENDIX

I.3 Proving Sonicare

For the Sonicare technology, because it would be a new application in floorcare, there is not information about its behavior. Several questions will have to be answer to optimize this system:

Does the principle work?

Get one actuator, mount it in a robot and test if it cleans.

What motion works better on heavy stains/crevices/uneven surfaces? What parameters make it perform better (amplitude, frequency, pressure, etc)?

To answer this question, a possible test is to use a piece of transparent plastic and film the behavior of the system with a slow-motion camera to see which motion is more effective dissolving the stains. Thanks to this test, other parameters such as amplitude and frequency could be partially determined.

What is the best material for the brush?

For this test, an idea is to take a piece of hard floor (wooden floor) and let the prototype work on the surface four a period of X hours and see if it damages the surface.

What amount of water is required by the system to deal with dirt?

To answer this question, first is necessary to find out which is the real impact of water in the process of removing stains from the floor together with the vibrating brush. Second, it is necessary to know how the different parameters affect the way water behaves.

How much weight can an actuator move? (mass of the brush plus the friction against the surface)

How many brushes and which size?

How many actuators do we need?

What is the optimal speed movement for the robot in order to be able to clean heavy stains in one pass?

It will be required to get a balanced solution to optimize the system and get a proper cleaning using an acceptable amount of water and energy. At the end of the process the solution should be able to deal with the stains defined on "Stains Removing" in ideally one pass.

To know if a principle works, it is necessary to test it. To do so, a fast prototype has been built using the minimum elements required to reduce the building time. Afterwards a fast test has been performed to see if the prototype is able to handle stains.

A set of stains will be created to see if the working principle has any impact on them. Any specific measurements apart from visual observations will be made at this point.

START

1 STROKE

APPENDIX

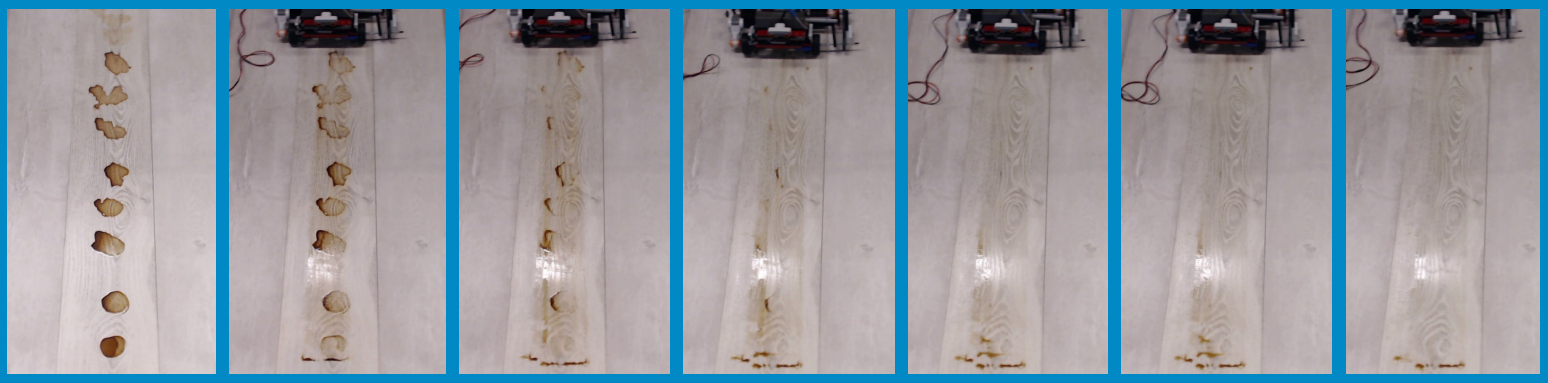
1.4 Pick Up Mop Vs Pick Up Mop + Sonicare

TESTING THE IDEAS – IMPACT OF THE DIFFERENT ELEMENTS

The stains used on the following tests were made out of coffee with one sugar and dried for at least 12 hours. The procedure followed was obtained from "*Stain Removing*".

PICK UP MOP

The first goal is to determine the impact of each of the elements (PICK UP MOP and brush) on the system. In order to achieve it, PICK UP MOP will be tested alone to test the whole system afterwards and observe the difference in Performance.



start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes | 6 strokes

PICK UP MOP + BRUSH LOW FREQ

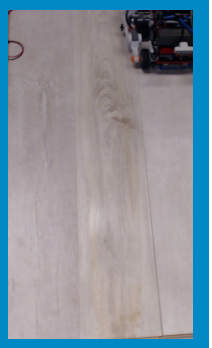

start


1 stroke

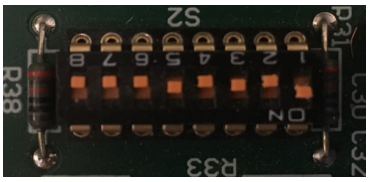

2 strokes


3 strokes

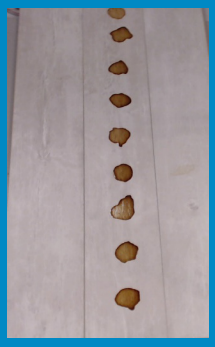

4 strokes


5 strokes

LOW FREQUENCY SETTINGS:
Not measured



PICK UP MOP + BRUSH MID FREQ


start

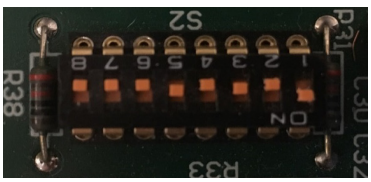

1 stroke


2 strokes


3 strokes


4 strokes

MID FREQUENCY SETTINGS:
100Hz



PICK UP MOP + BRUSH HIGH FREQ


start

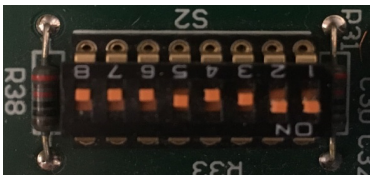

1 stroke


2 strokes


3 strokes


4 strokes

HIGH FREQUENCY SETTINGS:
200Hz

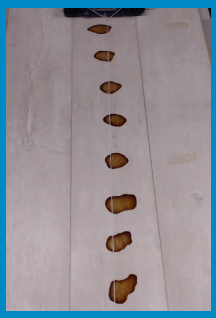


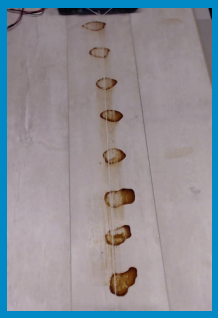
TESTING THE IDEAS – IMPACT OF THE DIFFERENT ELEMENTS

The performance of medium and high frequencies is better than low frequencies. Therefore, the medium frequency setting has been tested using different speeds.

PICK UP MOP + BRUSH MID FREQ 30% & 50% SPEED

50% SPEED (LEGO NXT SETTINGS)


start


1 stroke


2 strokes


3 strokes


4 strokes


5 strokes

30% SPEED (LEGO NXT SETTINGS)


start


1 stroke


2 strokes

The speed has a big impact on the performance of the working principle. From now on, the speed used for the tests will be 30% and the frequency will vary between mid and high freq to determine the impact of the variable.

APPENDIX

1.5 Test On Different Stains

TESTING THE IDEAS – COFFEE

The stains used on the following tests were made out of coffee with one sugar and one creamer. Afterwards, they dried for at least 12 hours. The procedure followed was obtained from "*Stain Removing*".

PICK UP MOP + BRUSH 30% SPEED

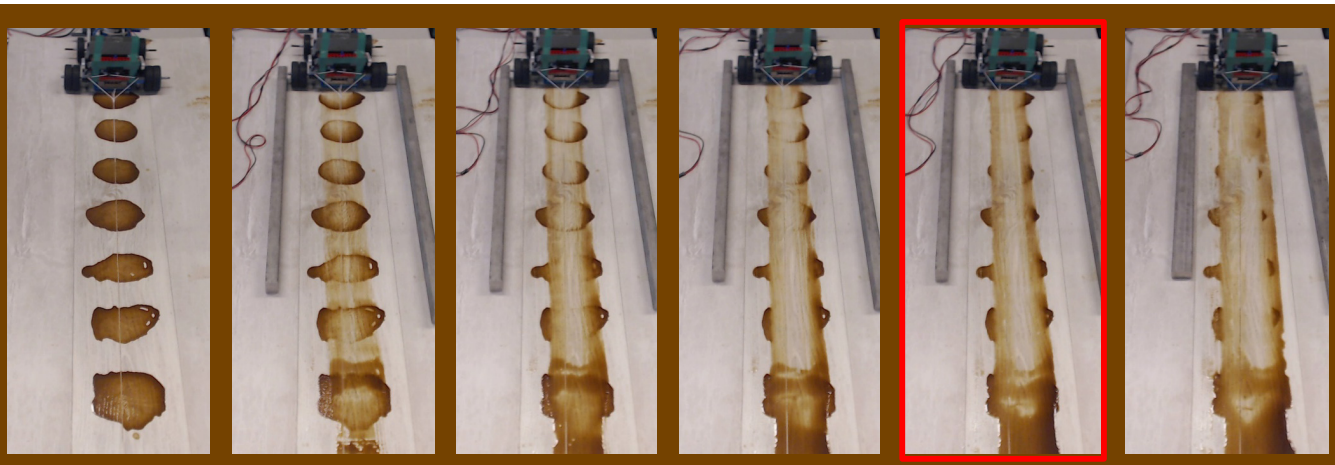
MID FREQ

start | 1 stroke | 2 strokes | 3 strokes | 4 strokes

HIGH FREQ

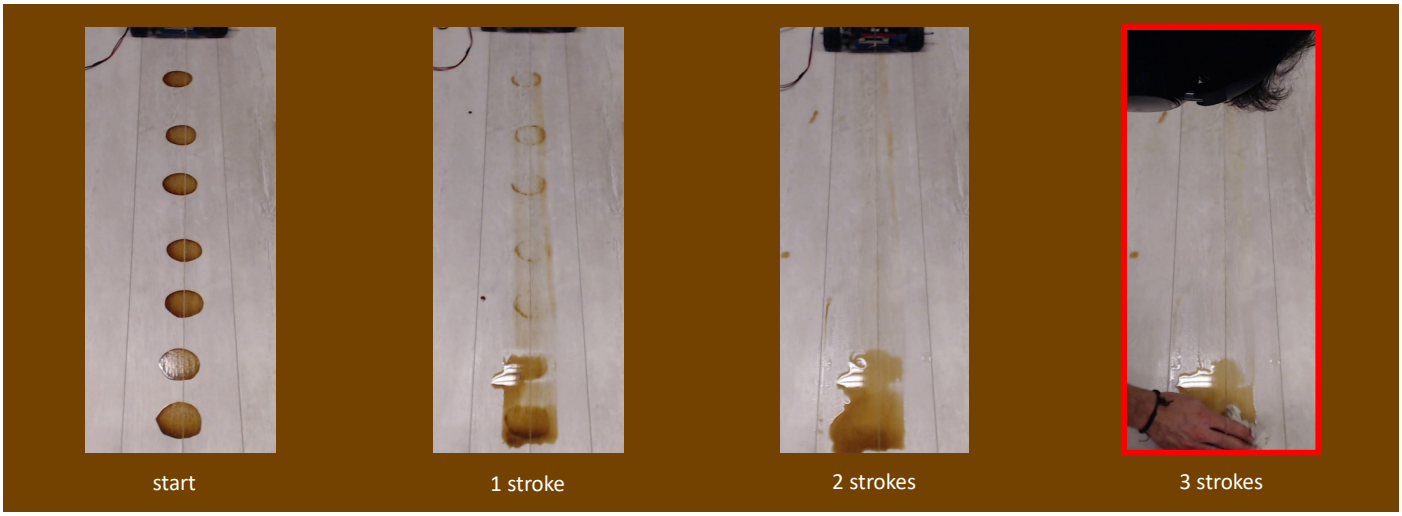
start | 1 stroke | 2 strokes | 3 strokes | 4 strokes

PICK UP MOP + BRUSH MID FREQ 30% SPEED ON HEAVY STAINS



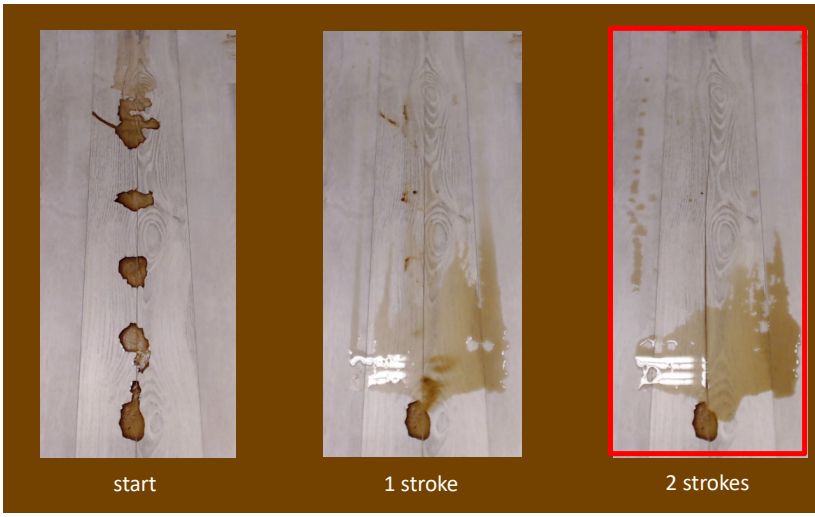
start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes

PICK UP MOP + BRUSH HIGH FREQ 30% SPEED ON HEAVY STAINS



start | 1 stroke | 2 strokes | 3 strokes

AQUA TRIO USING ITS OWN WATER SUPPLY 50% SPEED



start | 1 stroke | 2 strokes

AQUA TRIO 30% & 50% SPEED WITH SPRAY WATER SUPPLY

50% SPEED

30% SPEED

WATER TANK+MOP 30% & 50% SPEED WITH SPRAY WATER SUPPLY

30% SPEED

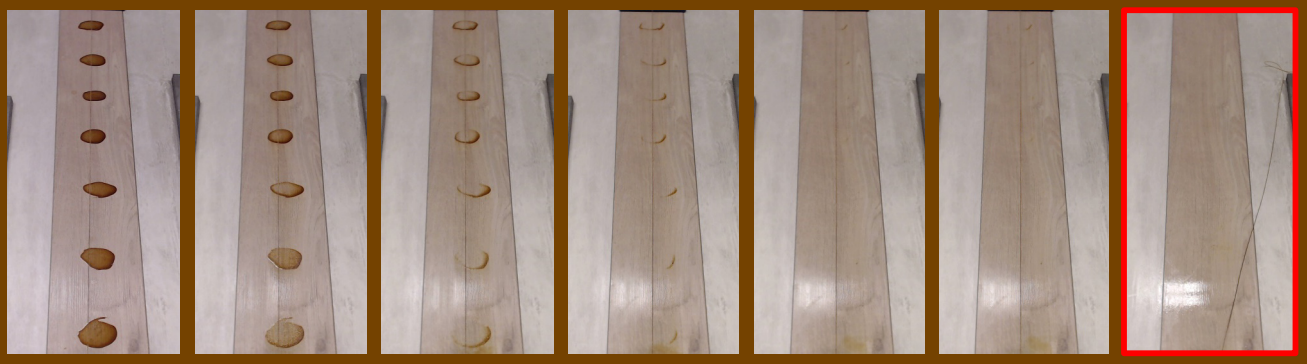
50% SPEED

AQUA TRIO WITH 30% SPEED ON HEAVY STAINS

AQUA TRIO WITH 50% SPEED ON HEAVY STAINS

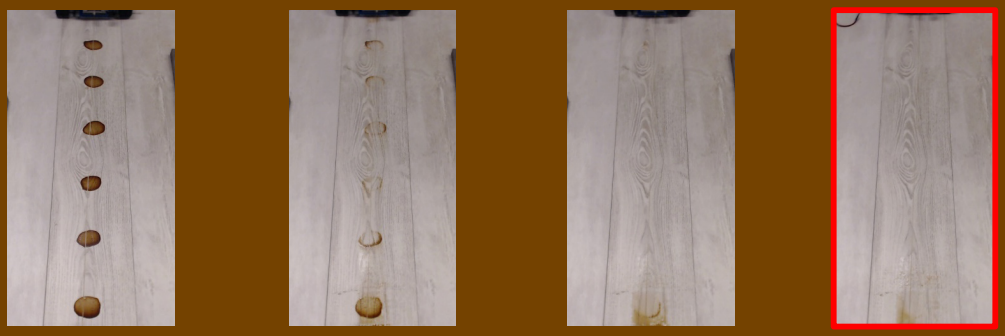
WATER TANK+MOP 30% SPEED ON HEAVY STAINS

WATER TANK+MOP 50% SPEED ON HEAVY STAINS



WATER TANK+MOP+BRUSH MID & HIGH FREQ WITH SPRAY WATER SUPPLY

MID FREQ



HIGH FREQ

WATER TANK+MOP +BRUSH MID & HIGH FREQ ON HEAVY STAINS

MID FREQ

start

1 stroke

2 strokes

3 strokes

HIGH FREQ

start

1 stroke

2 strokes

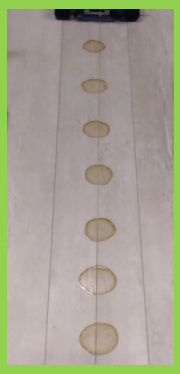
3 strokes

TESTING THE IDEAS - TEA

The stains used on the following tests were made out of tea from the machine in the corridor with one sugar and dried for at least 12 hours. The procedure followed to create the stain was obtained from "*Stain Removing*".

PICK UP MOP+BRUSH MID & HIGH FREQ 30% SPEED

MID FREQ



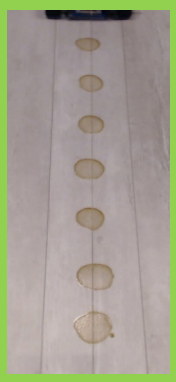
start

1 stroke

2 strokes

3 strokes

HIGH FREQ



start

1 stroke

2 strokes

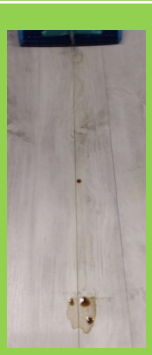
3 strokes

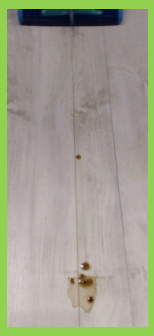
4 strokes

AQUA TRIO 30% & 50% SPEED WITH SPRAY WATER SUPPLY

30% SPEED


start


1 stroke


2 strokes


3 strokes


4 strokes

50% SPEED


start


1 stroke


2 strokes


3 strokes

WATER TANK+MOP 30% & 50% SPEED WITH SPRAY WATER SUPPLY

30% SPEED


start


1 stroke


2 strokes


3 strokes


4 strokes


5 strokes

50% SPEED


start


1 stroke


2 strokes


3 strokes


4 strokes

WATER TANK+MOP+BRUSH MID & HIGH FREQ WITH SPRAY WATER SUPPLY

MID FREQ

start

1 stroke

2 strokes

3 strokes

4 strokes

HIGH FREQ

start

1 stroke

2 strokes

TESTING THE IDEAS – SPREAD SOY

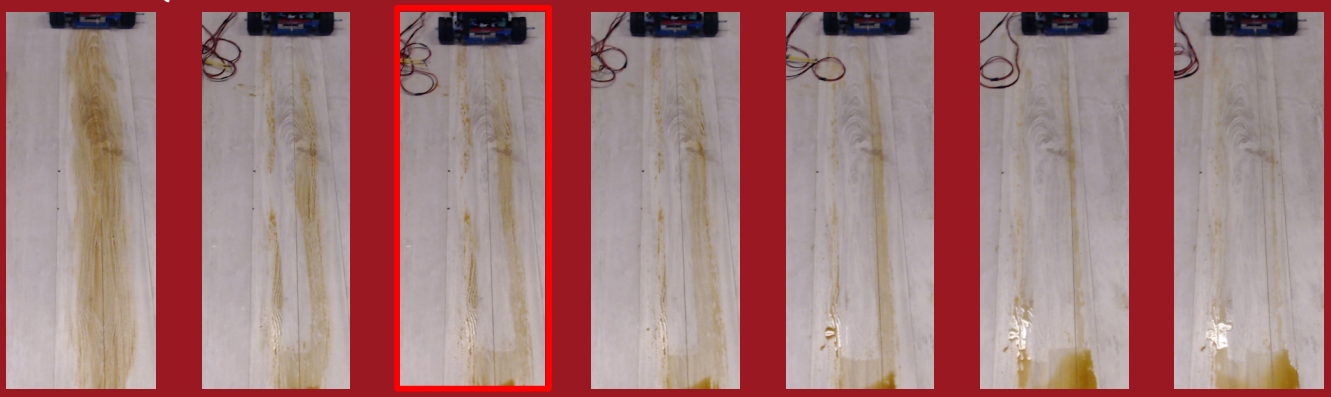
Stains of soy sauce were generated by applying 20-25 drops with a syringe to a piece of laminate and spreading them with the fingers along the laminate. The stains dried for at least 12 hours.

PICK UP MOP+BRUSH MID & HIGH FREQ 30% SPEED

MID FREQ

start | 1 stroke | 2 strokes | 3 strokes | 4 strokes

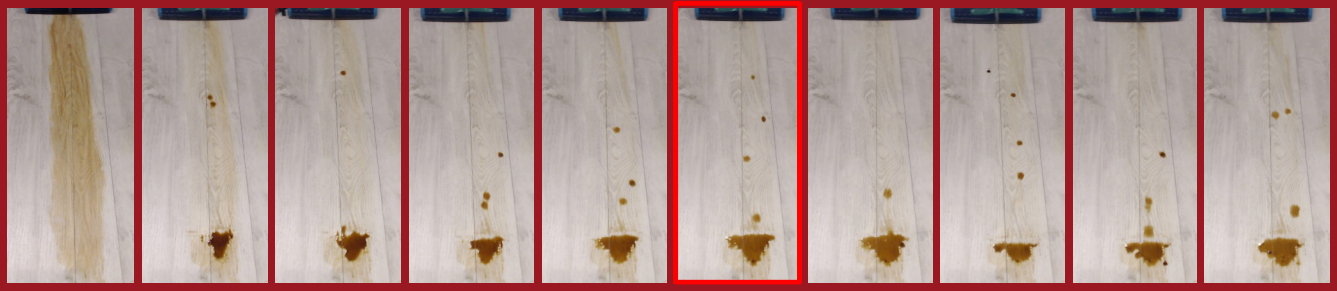
HIGH FREQ



start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 6 strokes | 7 strokes

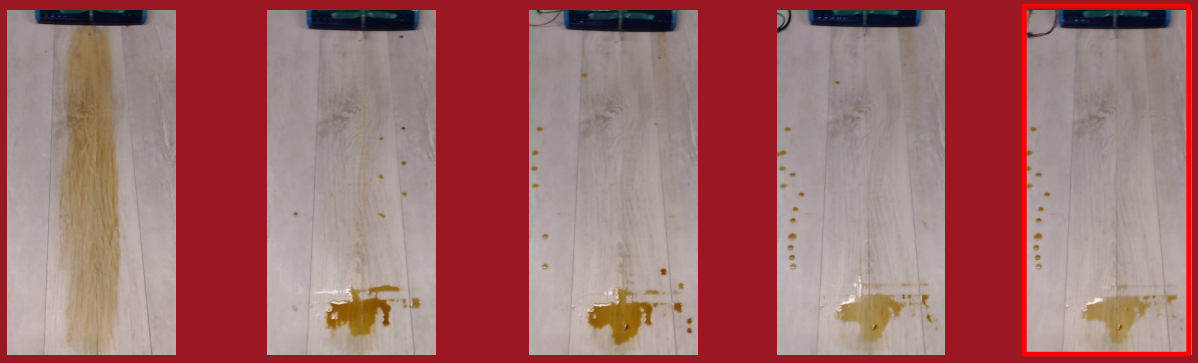
AQUA TRIO 30% & 50% SPEED

30% SPEED



start | 1 stroke | 2 strokes | 3 stroke | 4 strokes | 5 strokes | 6 stroke | 7 strokes | 8 stroke | 9 strokes

50% SPEED



start | 1 stroke | 2 strokes | 3 strokes | 4 strokes

WATER TANK+MOP 30% & 50% SPEED

30% SPEED

start | 1 stroke | 2 strokes | 3 strokes | 4 strokes

50% SPEED

start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes

WATER TANK+MOP+BRUSH MID & HIGH FREQ

MID FREQ

start

1 stroke

HIGH FREQ

start

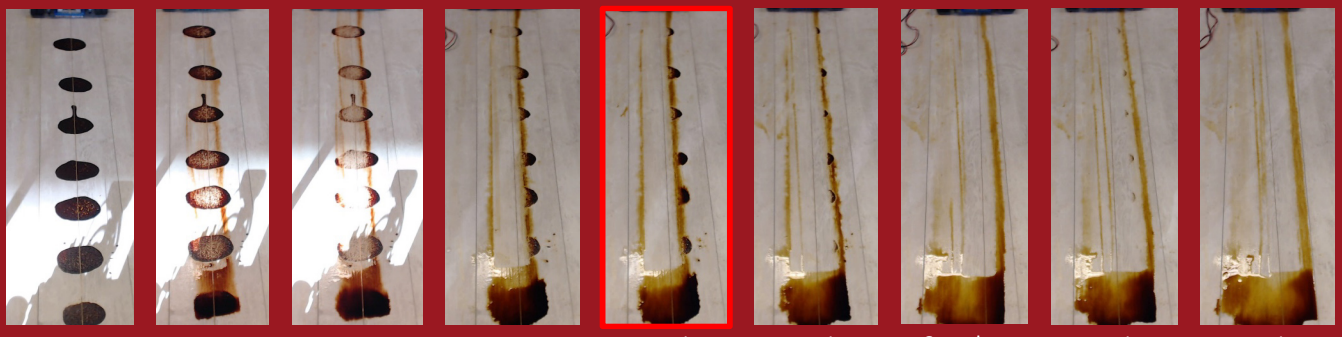
1 stroke

TESTING THE IDEAS –HEAVY SOY STAINS

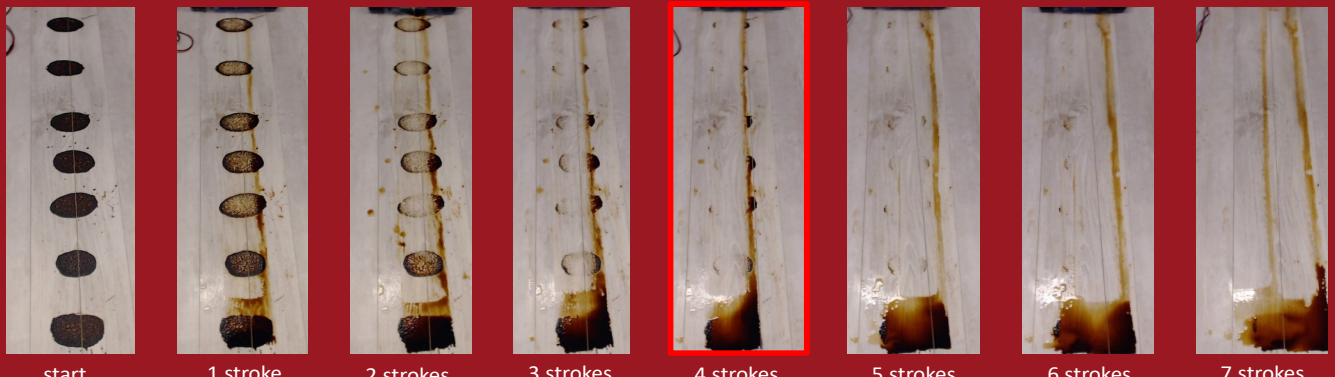
Heavy stains of soy sauce were generated by applying 2.4 ml of soy per stain with a syringe to a piece of laminate. The stains dried for at least 12 hours.

PICK UP MOP+BRUSH MID & HIGH FREQ 30% SPEED

MID FREQ

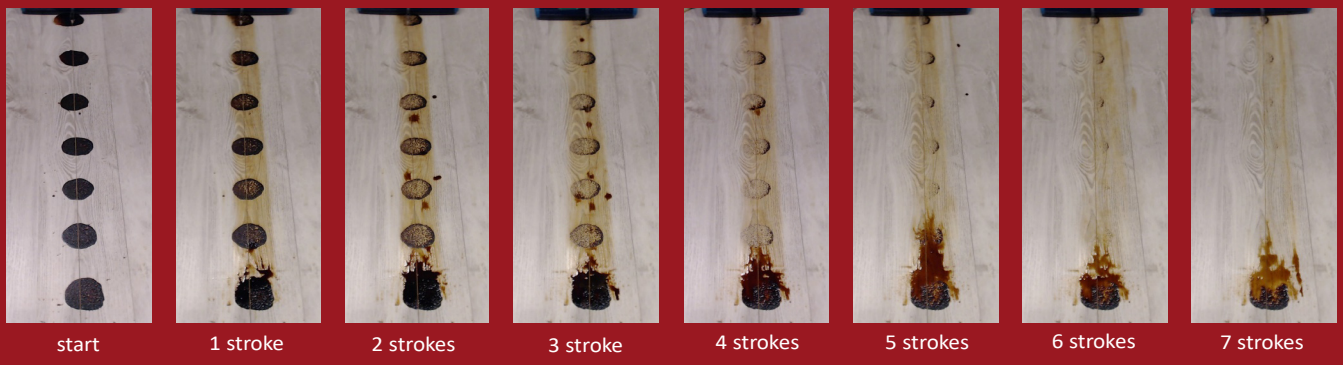


HIGH FREQ



AQUA TRIO 30% & 50% SPEED

30% SPEED

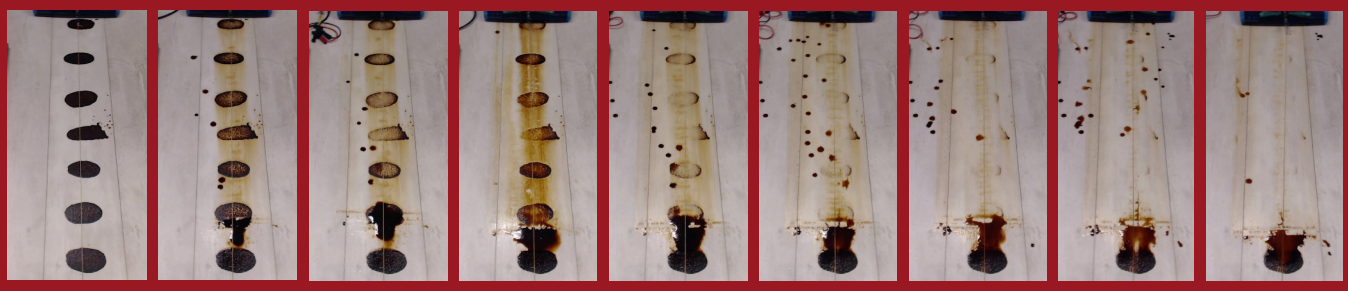


start | 1 stroke | 2 strokes | 3 stroke | 4 strokes | 5 strokes | 6 strokes | 7 strokes

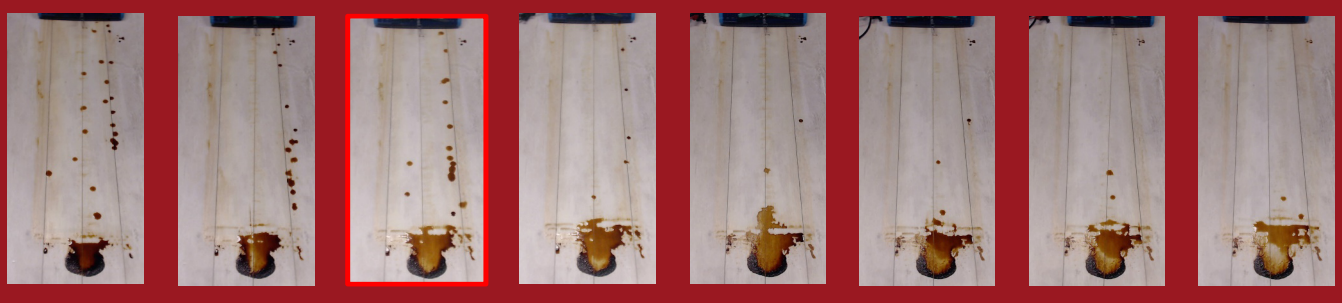
8 strokes | 9 stroke | 10 strokes | 11 strokes | 12 strokes | 13 strokes | 14 strokes

AQUA TRIO 30% & 50% SPEED

50% SPEED



start | 1 stroke | 2 strokes | 3 stroke | 4 strokes | 5 strokes | 6 strokes | 7 strokes | 8 strokes

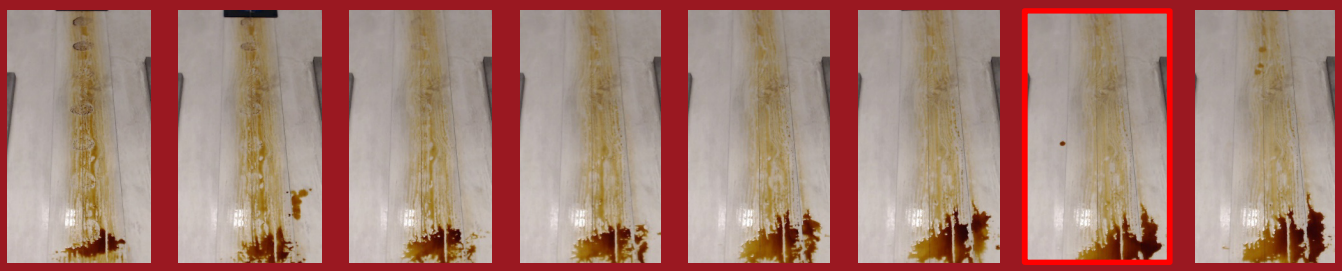


9 strokes | 10 stroke | 11 strokes | 12 strokes | 13 strokes | 14 strokes | 15 strokes | 16 strokes

WATER TANK+MOP 30% & 50% SPEED WITH SPRAY WATER SUPPLY

30% SPEED

start | 1 stroke | 2 strokes | 3 stroke | 4 strokes | 5 strokes | 6 strokes | 7 strokes

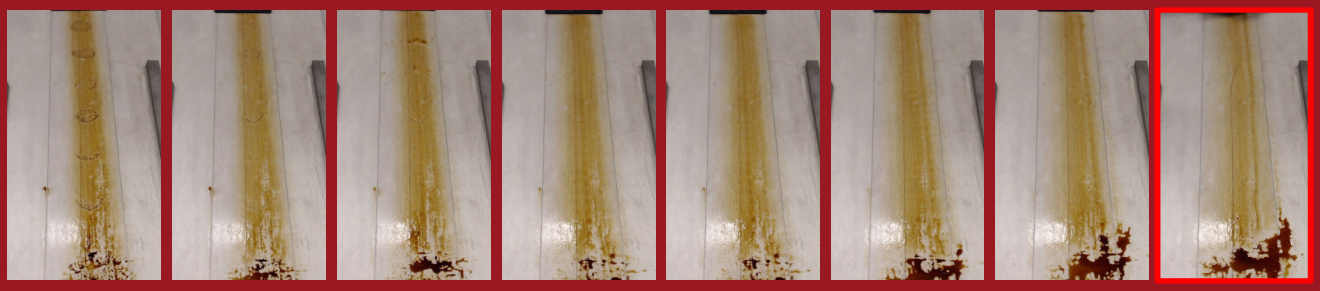


8 strokes | 9 stroke | 10 strokes | 11 strokes | 12 strokes | 13 strokes | 14 strokes | 15 strokes

WATER TANK+MOP 30% & 50% SPEED

50% SPEED

start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes | 6 strokes | 7 strokes | 8 strokes



9 strokes | 10 stroke | 11 strokes | 12 strokes | 13 strokes | 14 strokes | 15 strokes | 16 strokes

WATER TANK+MOP+BRUSH MID & HIGH FREQ 30% SPEED

MID FREQ

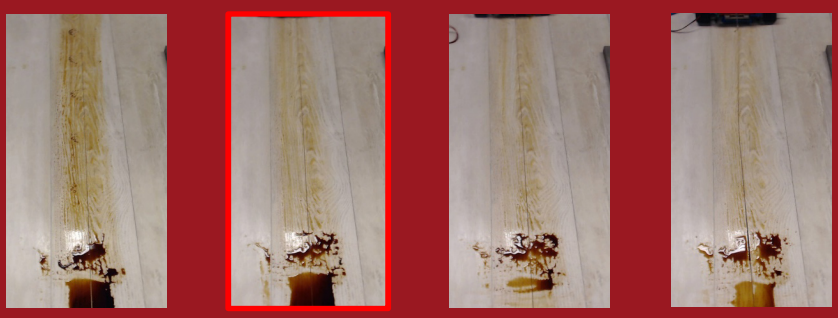
start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes | 6 strokes

7 strokes | 8 strokes | 9 strokes | 10 strokes | 11 strokes | 12 strokes

WATER TANK+MOP+BRUSH MID & HIGH FREQ 30% SPEED

HIGH FREQ

start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes



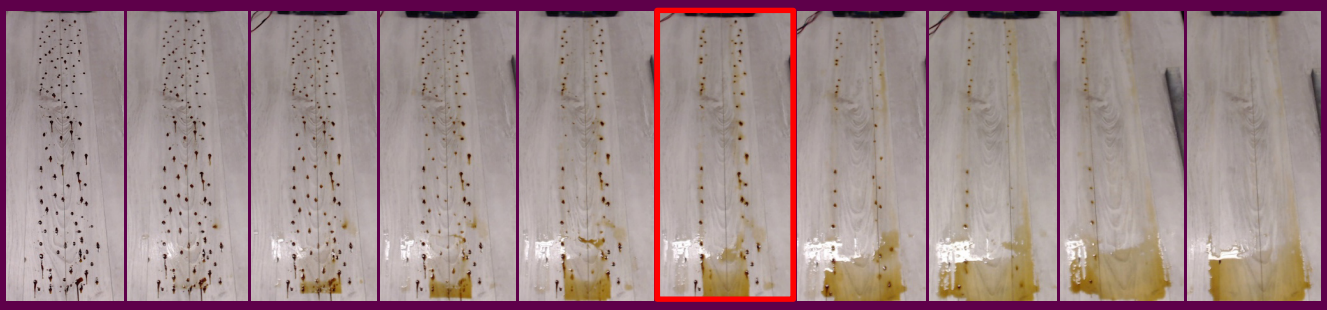
6 strokes | 7 strokes | 8 strokes | 9 strokes

TESTING THE IDEAS – SWEET SOY

Stains of sweet soy were generated by putting 4 ml in a syringe and generating drops along the laminate. The stains dried for at least 12 hours.

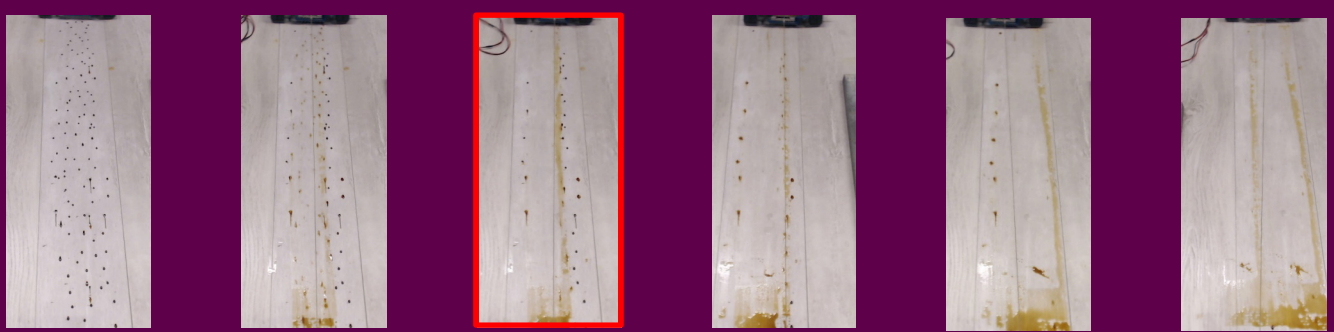
PICK UP MOP+BRUSH MID & HIGH FREQ 30% SPEED

MID FREQ



start | 1 stroke | 2 strokes | 3 stroke | 4 strokes | 5 strokes | 6 strokes | 7 strokes | 8 strokes | 9 strokes

HIGH FREQ

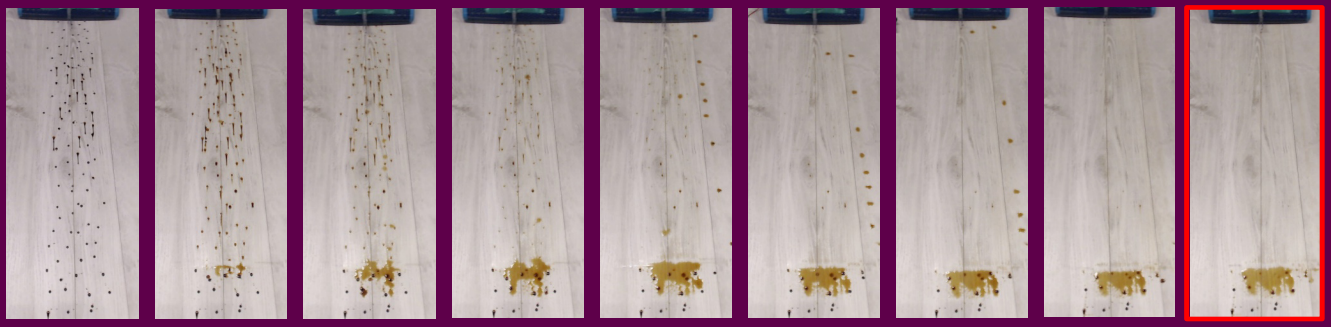


start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes

AQUA TRIO 30% & 50% SPEED

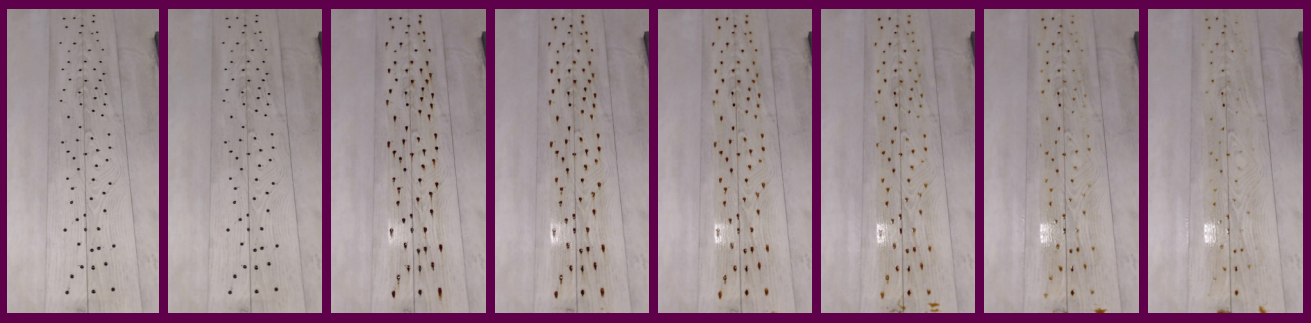
30% SPEED

50% SPEED



WATER TANK+MOP 30% & 50% SPEED

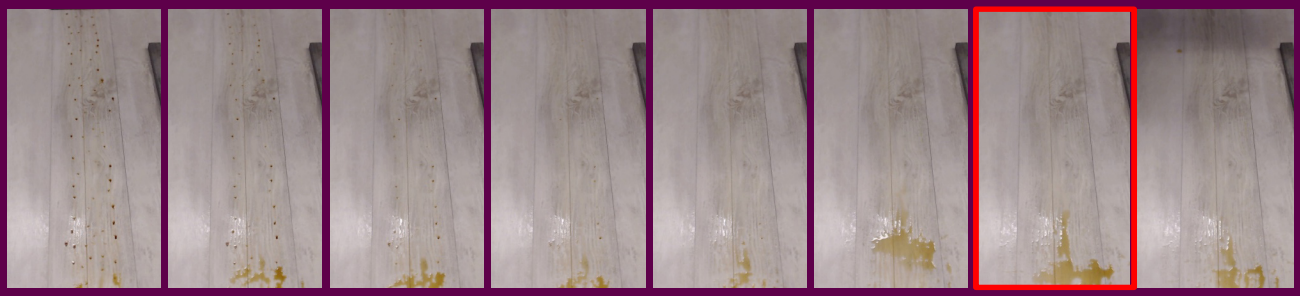
30% SPEED



WATER TANK+MOP 30% & 50% SPEED

50% SPEED

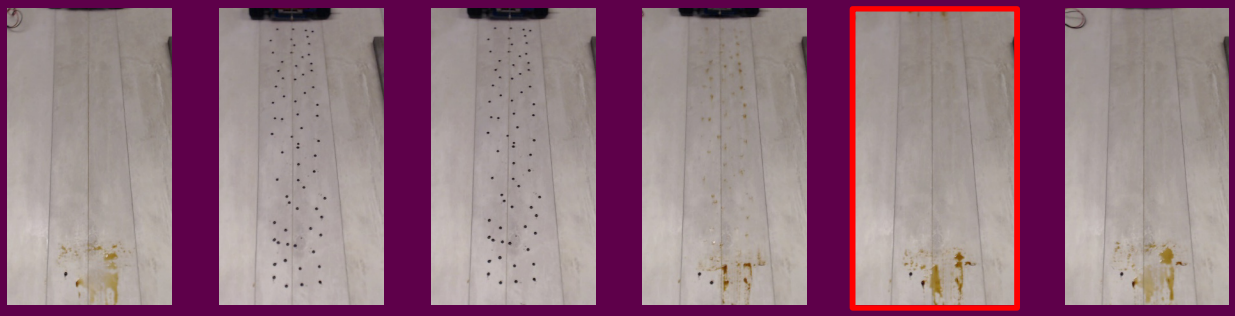
start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes | 6 strokes | 7 strokes



8 strokes | 9 strokes | 10 strokes | 11 strokes | 12 strokes | 13 strokes | 14 strokes | 15 strokes

WATER TANK+MOP+BRUSH 30% & 50% SPEED

MID FREQ

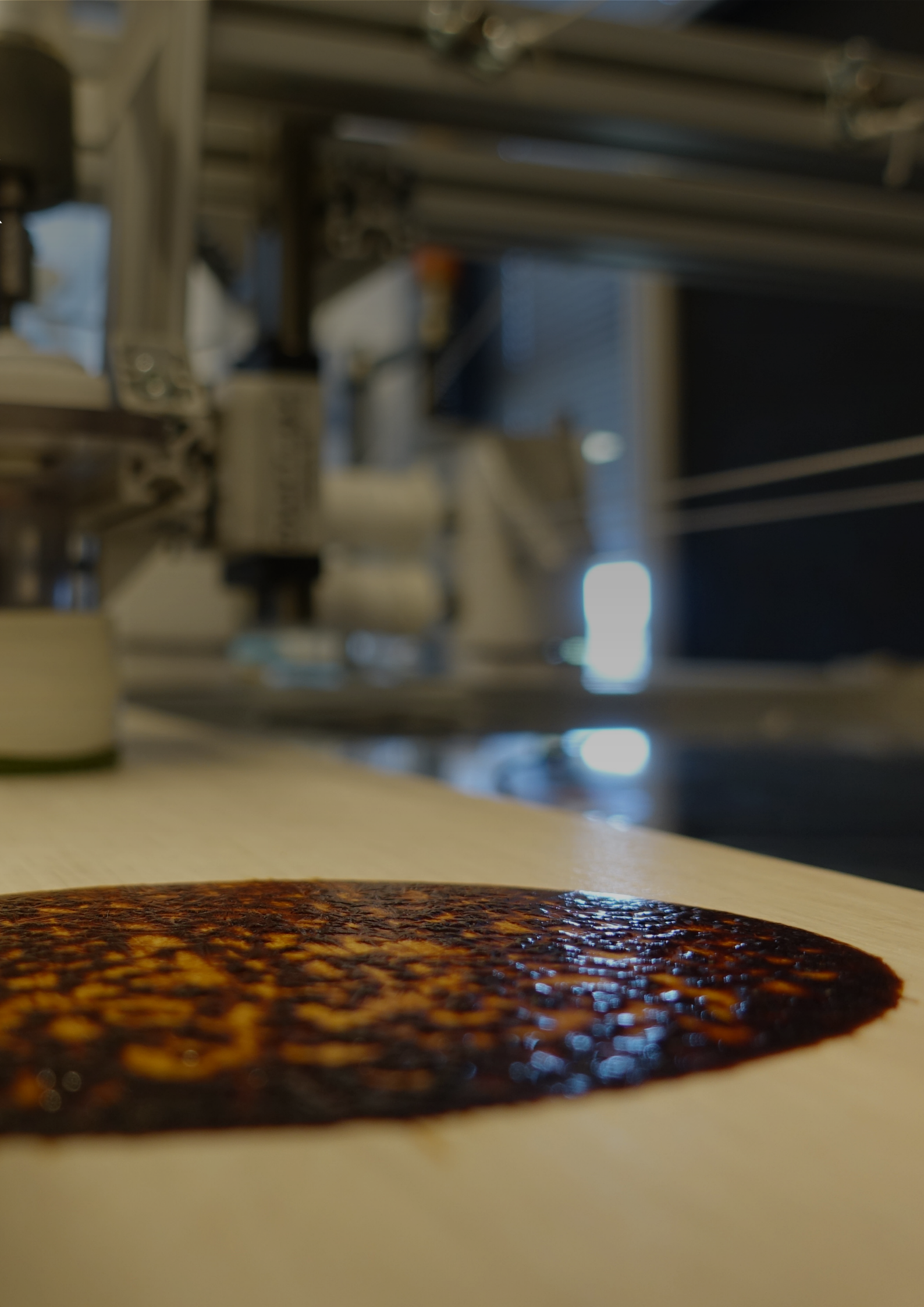


start | 1 stroke | 2 strokes | 3 strokes | 4 strokes | 5 strokes

HIGH FREQ

start | 1 stroke | 2 strokes | 3 strokes | 4 strokes

2. APPENDIX

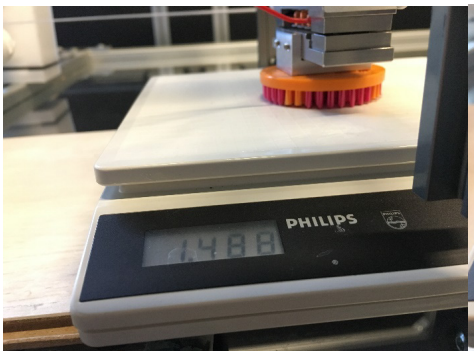


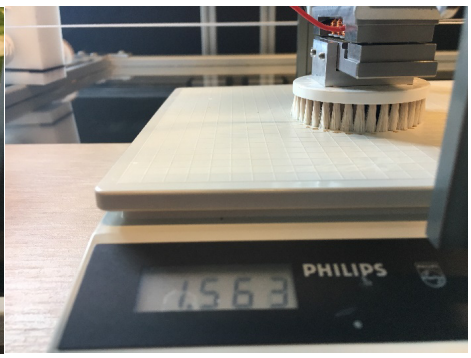
APPENDIX

2.1 Motion Analysis Visual Cleaning

MOTION ANALYSIS – Visual Cleaning

A first test has been performed in order to get some insights about the behavior and connections of the different parameters. On this test, no special setup was used focusing more on observation and understanding. The test consisted on generating a soy sauce stain on a piece of laminate and use the different motions while the whole process was recorded. The water left on the laminate will be dried using a window cleaner. A pressure of 1,5 Kg will be applied to the brushes and different soaking times will be used. It has been observed that long bristles tend to bend when the product moves.

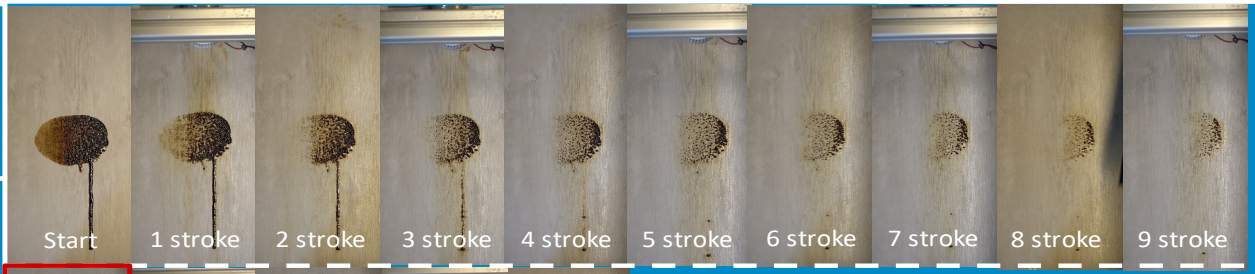




Linear motion

NO SOAKING TIME

10,2 mm



4,2 mm

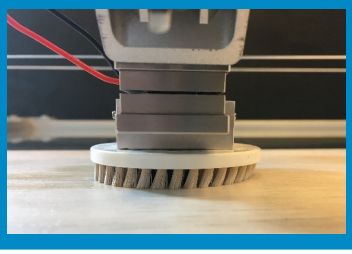
HARD

NO SOAKING TIME

10,2 mm

4,2 mm

HARD

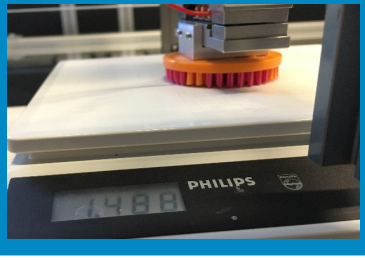


NO SOAKING TIME

10,2 mm

4,2 mm

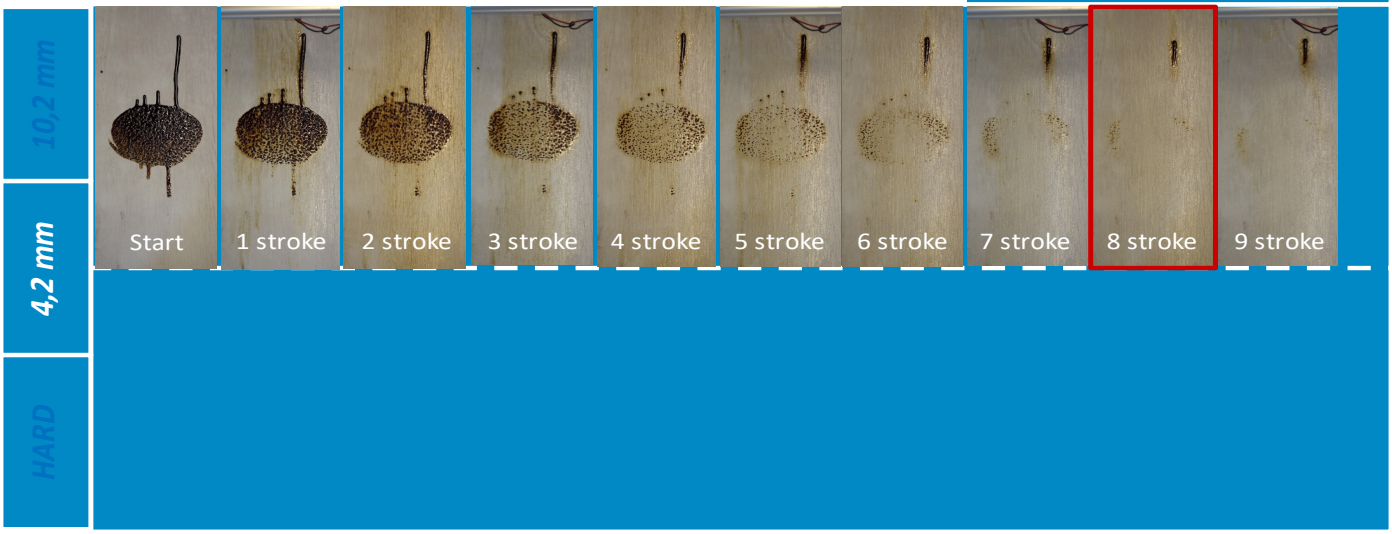
HARD



Linear motion

10" SOAKING TIME

10" SOAKING TIME

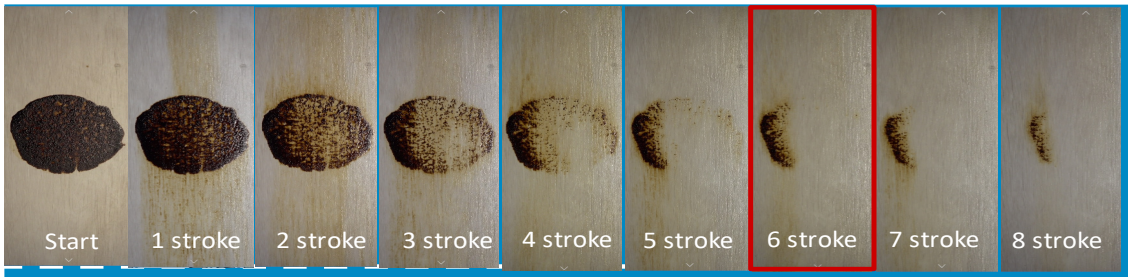


10" SOAKING TIME

Rotation

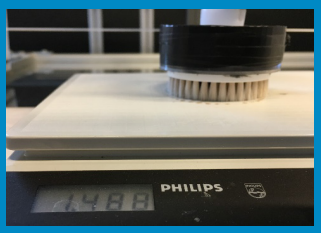
NO SOAKING TIME

10,2 mm



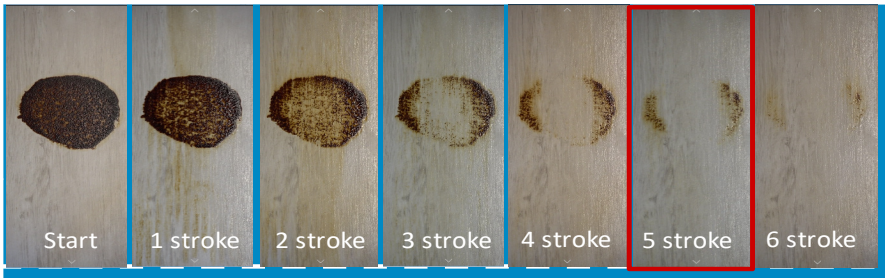
4,2 mm

HARD



NO SOAKING TIME

10,2 mm



4,2 mm

HARD

NO SOAKING TIME

10,2 mm

4,2 mm

HARD

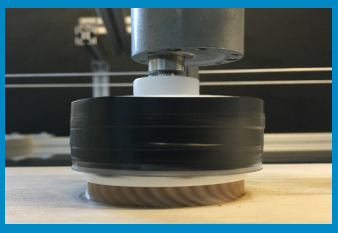
Rotation

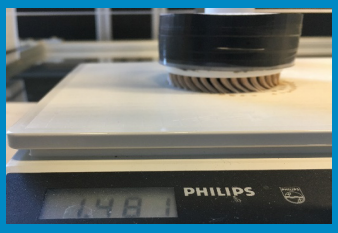
10" SOAKING TIME

10,2 mm

4,2 mm

HARD





10" SOAKING TIME

10,2 mm

4,2 mm

HARD

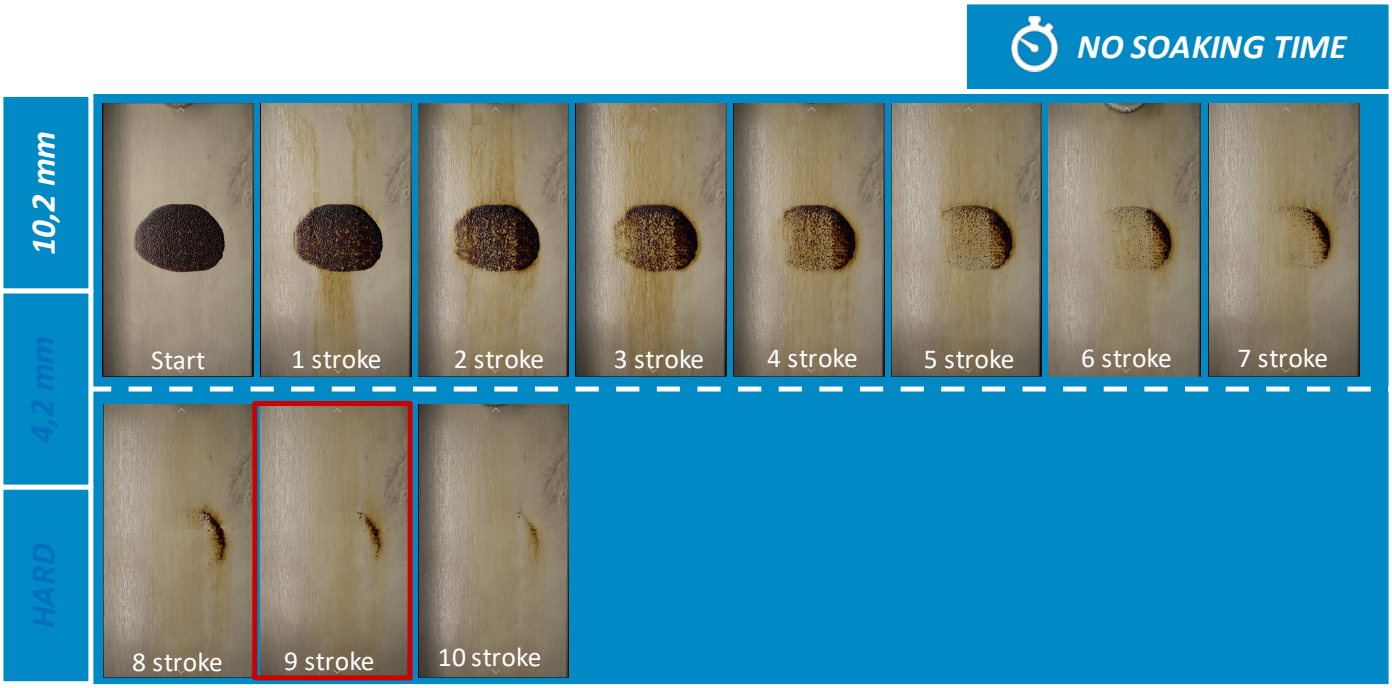
10" SOAKING TIME

10,2 mm

4,2 mm

HARD

Circular oscillation



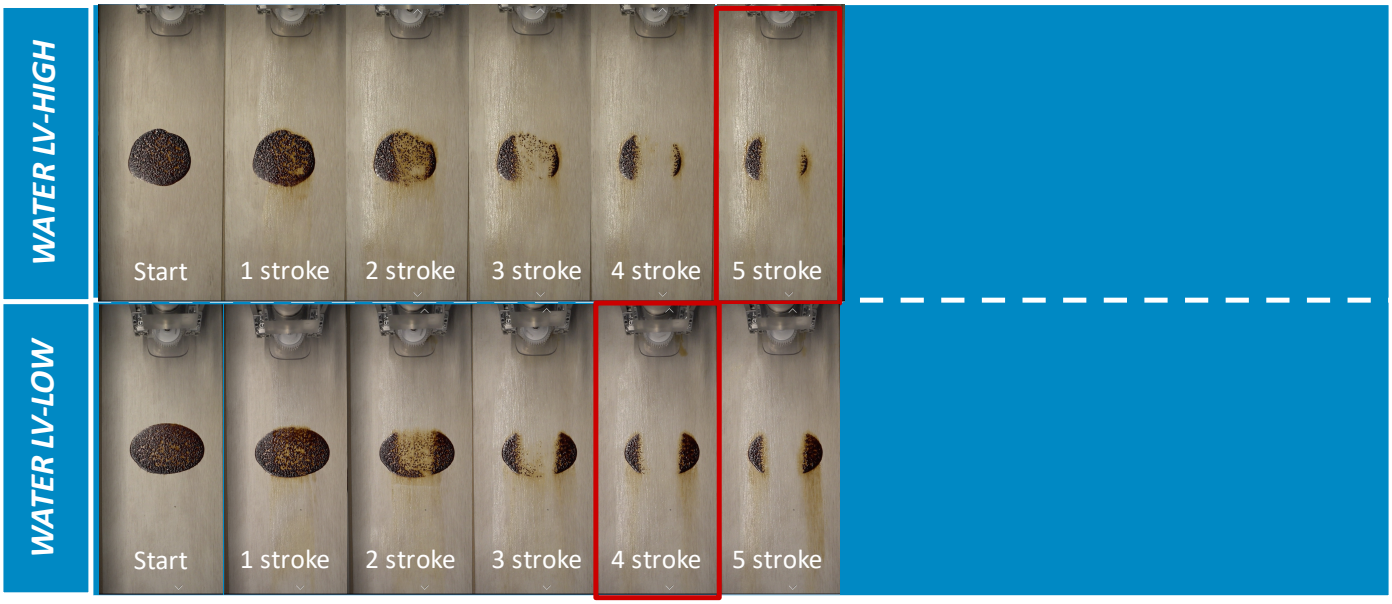
*The rest of pictures related to circular oscillation have not been found. Probably due to the use of the shared camera or hard drives of the lab. The data about the number of strokes was registered after every test so the information is still relevant.

APPENDIX

2.2 Water Supply Analysis Visual Cleaning

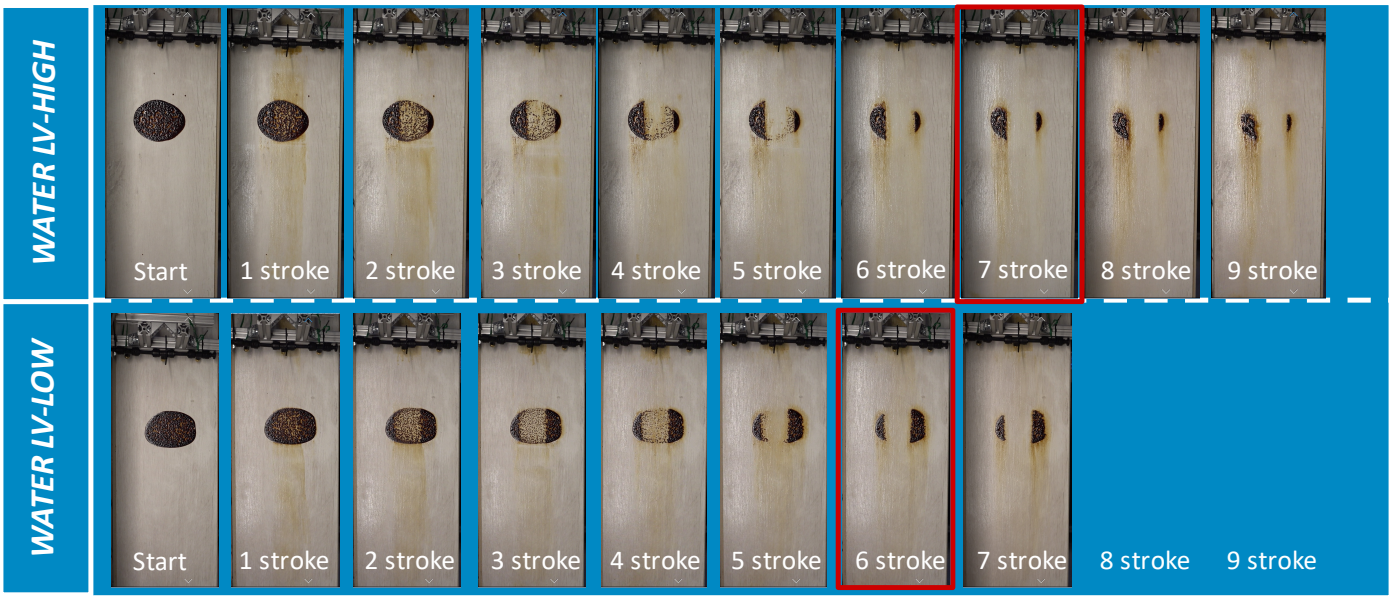
Mop

Rotational Mop

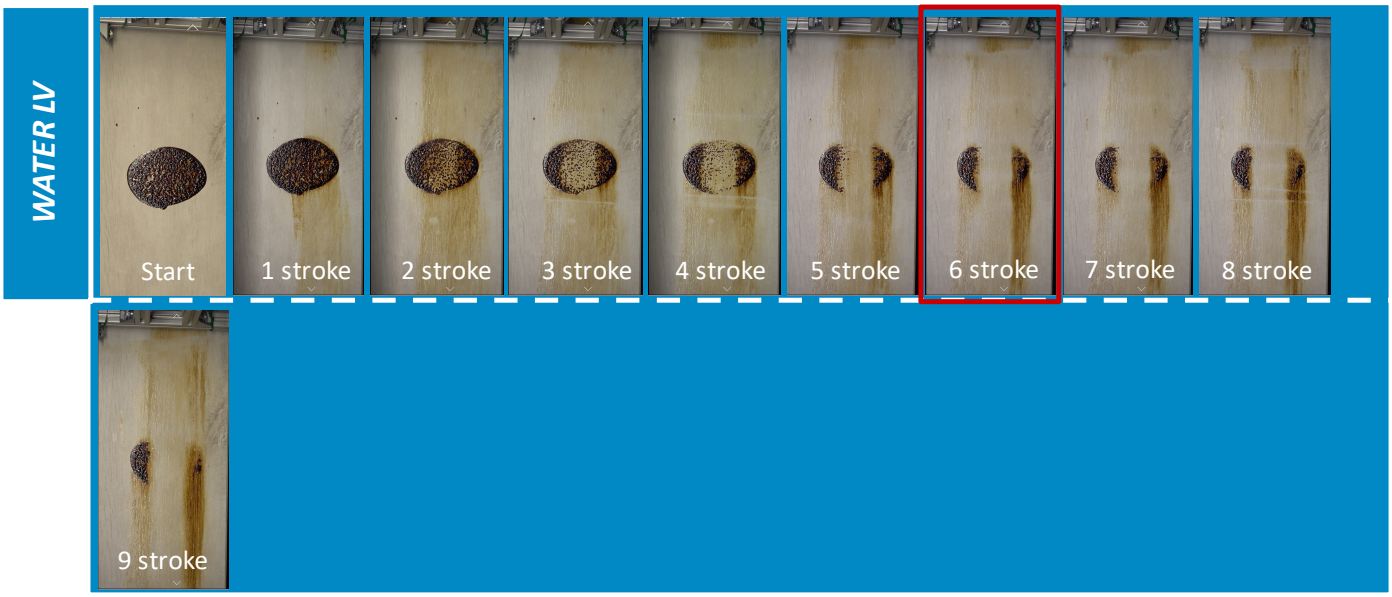


Droplets

Atomiser

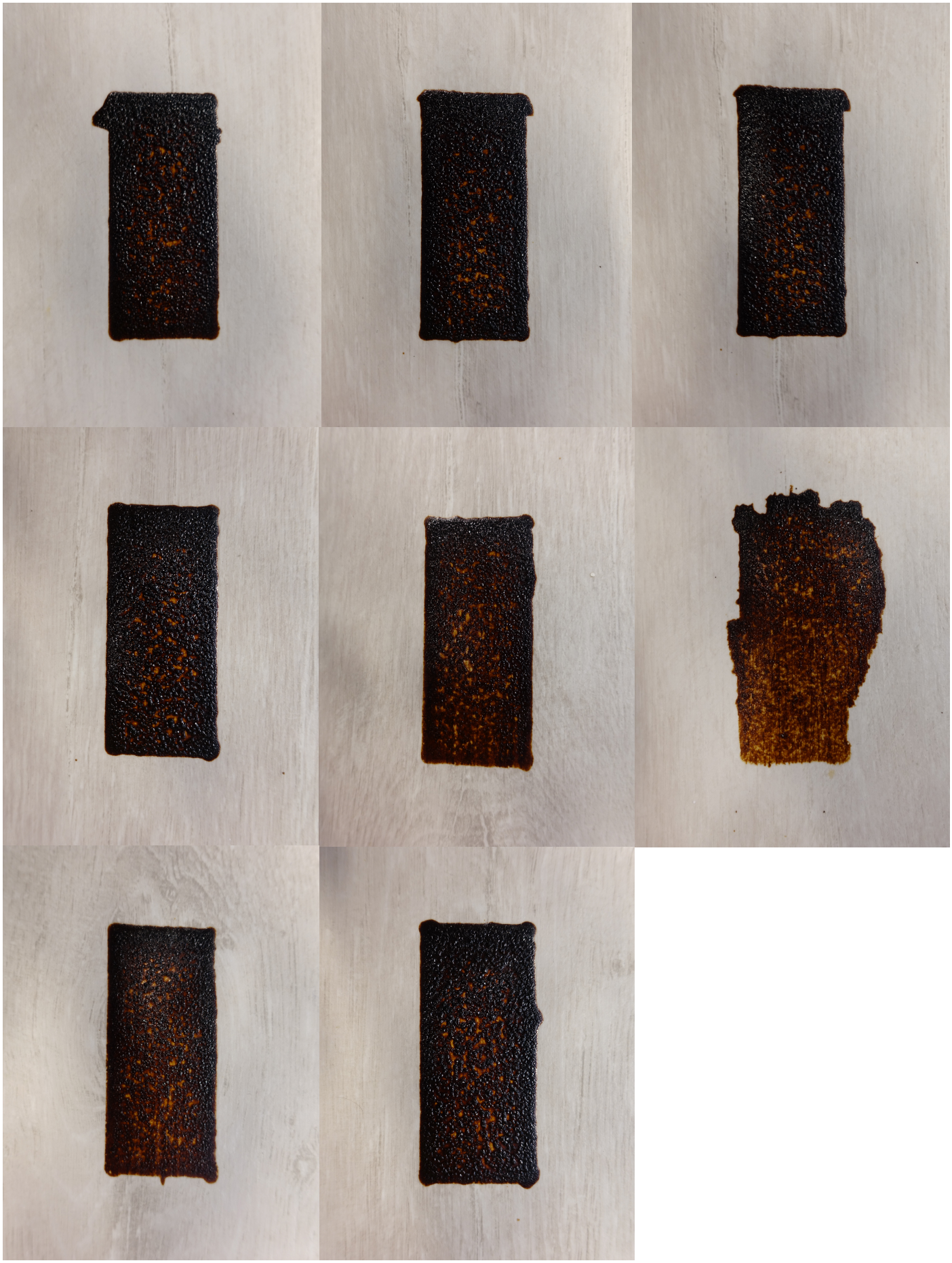


Air floss


WATER LV
Start
1 stroke
2 stroke
3 stroke
4 stroke
5 stroke
6 stroke
7 stroke
8 stroke
9 stroke

APPENDIX

2.3 Stain Prototcol Creation
Stain Images



APPENDIX

2.4 DoE Combinations

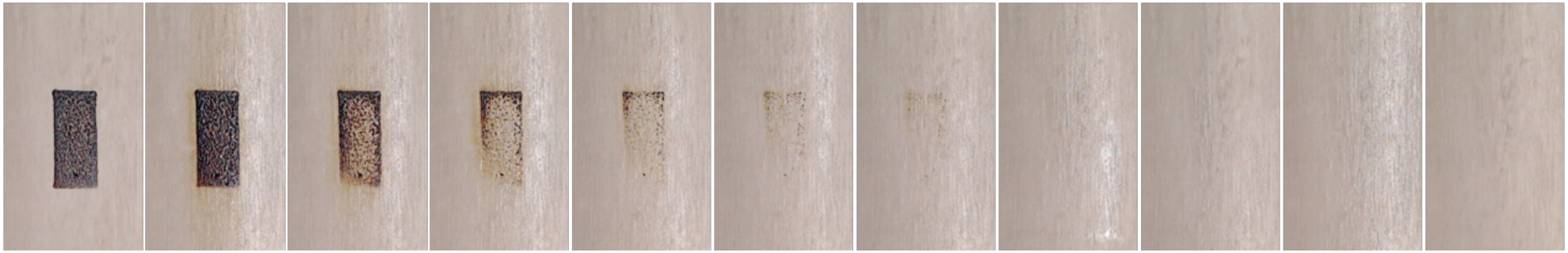
DOE RAW DATA

StdOrder	RunOrder	PRESSURE (KG)	SPEED ROBOT (CM/S)	SPEED ROTATION (RPM)	SIZE OF BRUSH (CM)	AMOUNT OF WATER (ML/MIN)	LENGTH OF BRISTLES (MM)	NUMBERS OF STROKES	TEMPERATURE	HUMIDITY
13	1	0.5	10	1500	5.4	10	3	7	24.2	51.5
31	2	0.5	25	1500	5.4	40	3	9	24.2	51.5
9	3	0.5	10	0	5.4	10	8	10	24.2	51.5
24	4	2.5	25	1500	3.8	40	3	8	24.2	51.5
21	5	0.5	10	1500	3.8	40	3	6	24.2	51.5
34	6	1.5	17.5	750	4.6	25	5.5	7	24.2	51.5
7	7	0.5	25	1500	3.8	10	3	9	22	41
1	8	0.5	10	0	3.8	10	3	12	22	41.5
27	9	0.5	25	0	5.4	40	8	11	22	41.5
11	10	0.5	25	0	5.4	10	3	14	22	41.5
6	11	2.5	10	1500	3.8	10	3	9	22	41.5
16	12	2.5	25	1500	5.4	10	3	11	22	41.5
30	13	2.5	10	1500	5.4	40	3	8	22	41.5
25	14	0.5	10	0	5.4	40	3	11	22	41.5
19	15	0.5	25	0	3.8	40	3	13	22	41
12	16	2.5	25	0	5.4	10	8	11	22.6	40
15	17	0.5	25	1500	5.4	10	8	11	22.6	40
5	18	0.5	10	1500	3.8	10	8	10	22.3	50.5
22	19	2.5	10	1500	3.8	40	8	8	22.3	50.5
18	20	2.5	10	0	3.8	40	3	10	22.65	40.5
4	21	2.5	25	0	3.8	10	3	12	21.8	53.5
14	22	2.5	10	1500	5.4	10	8	8	21.8	53.5
2	23	2.5	10	0	3.8	10	8	9	22	46
10	24	2.5	10	0	5.4	10	3	10	22	46
26	25	2.5	10	0	5.4	40	8	7	22	46
8	26	2.5	25	1500	3.8	10	8	10	22	46
23	27	0.5	25	1500	3.8	40	8	10	22.5	49.5
35	28	1.5	17.5	750	4.6	25	5.5	11	22.5	49.5
33	29	1.5	17.5	750	4.6	25	5.5	9	22.5	49.5
20	30	2.5	25	0	3.8	40	8	11	22.5	49.5
28	31	2.5	25	0	5.4	40	3	9	22.5	49.5
17	32	0.5	10	0	3.8	40	8	9	22.5	49.5
29	33	0.5	10	1500	5.4	40	8	8	22.5	49.5
32	34	2.5	25	1500	5.4	40	8	10	22.5	49.5
3	35	0.5	25	0	3.8	10	8	10	22.5	49.5

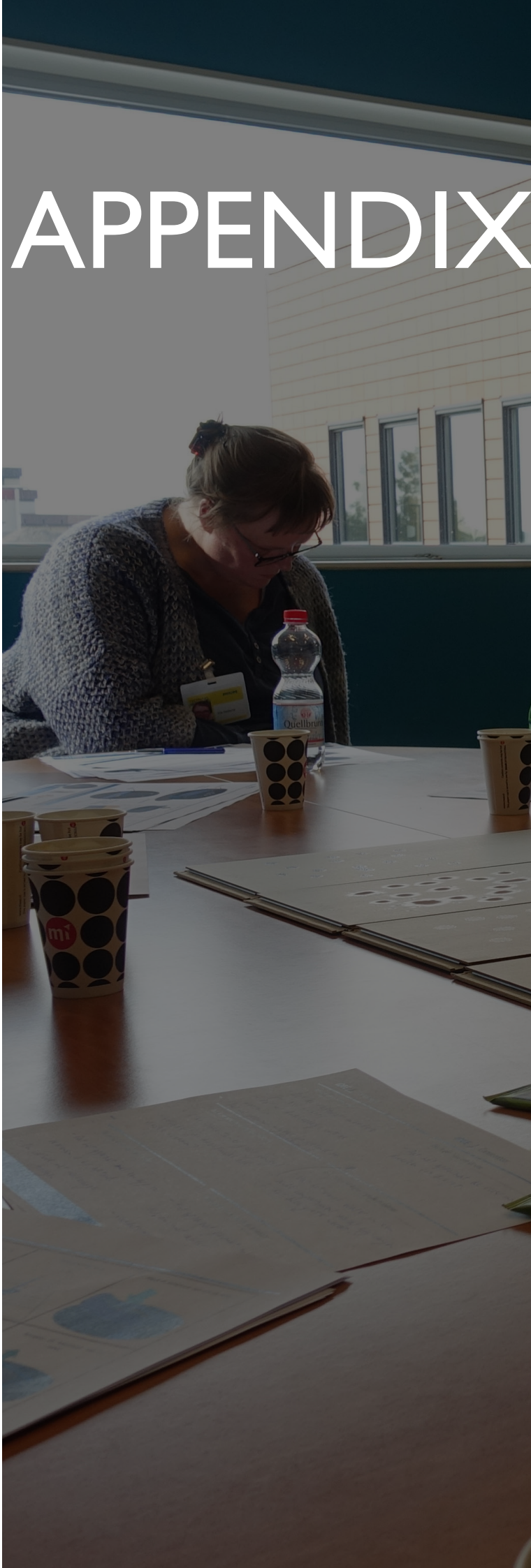
BASELINE TEST DAY 6

COMBINATION 19

COMBINATION 19



3. APPENDIX

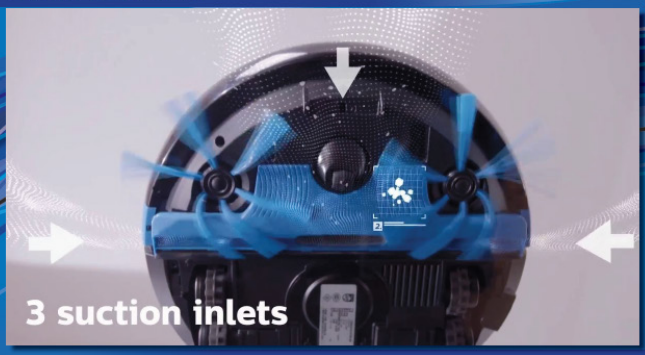


APPENDIX

3.1 Ideas Presentation

IN THE LAST DECADE, A LOT OF COMPANIES HAVE ENTERED INTO THE ROBOT VACUUM CLEANERS MARKET

A LOT OF TECHNOLOGIES HAVE BEEN DEVELOPED TO MAKE THESE PRODUCTS SMARTER



NUMEROUS FUCTIONS AND ELEMENTS HAVE BEEN DEVELOPED TO MAKE ROBOTS MORE EFFICIENT

Slides to introduce the topic: Wet robot vacuum cleaners

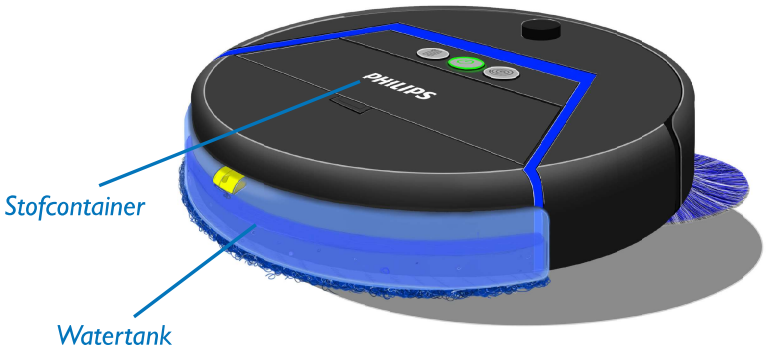
THESE INNOVATIONS HAVE ALLOWED ROBOTS TO REACH EVERY SPOT

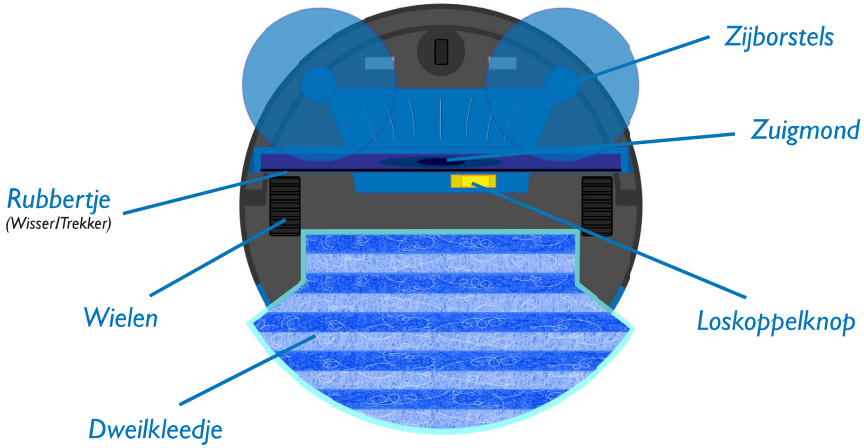
AND IN THE LAST FEW YEARS THE NEXT STEP STARTED, WITH ROBOTS THAT NOT ONLY VACUUM BUT ALSO....

VACUUMING THE DUST FROM EVERY SURFACE OF YOUR HOUSE

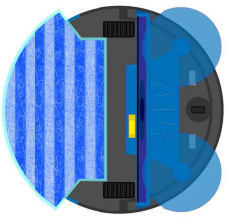
MOP YOUR FLOOR FOR YOU !!!

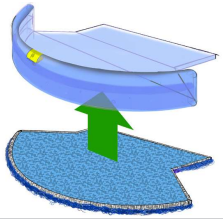
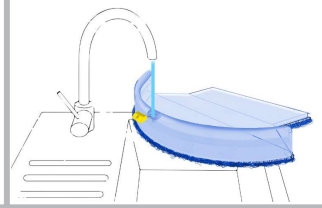
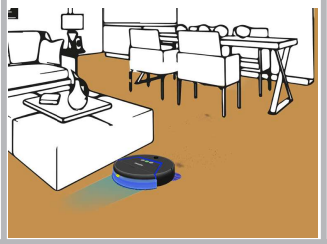
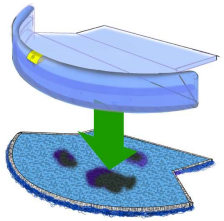
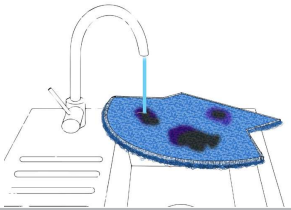
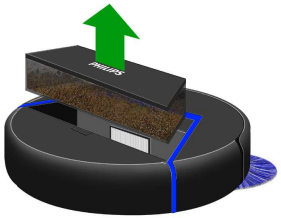
IDEE I



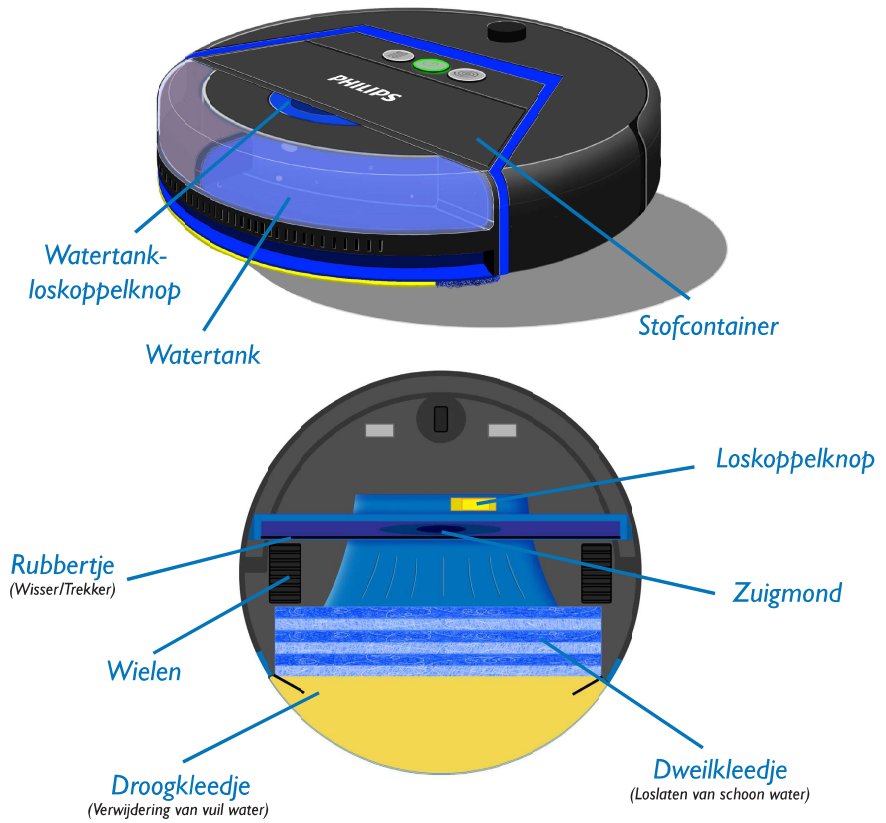


EERSTE SCHOONMAAKFASE

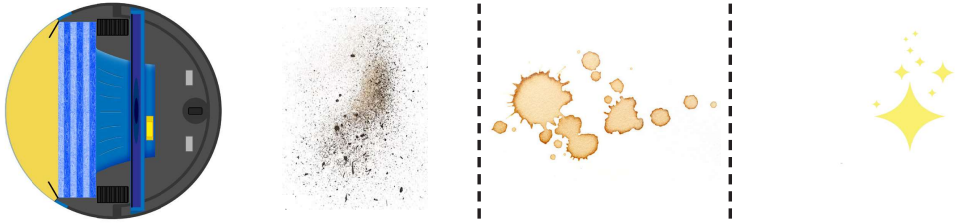
Stofzuigen	Bevochtigen
 	

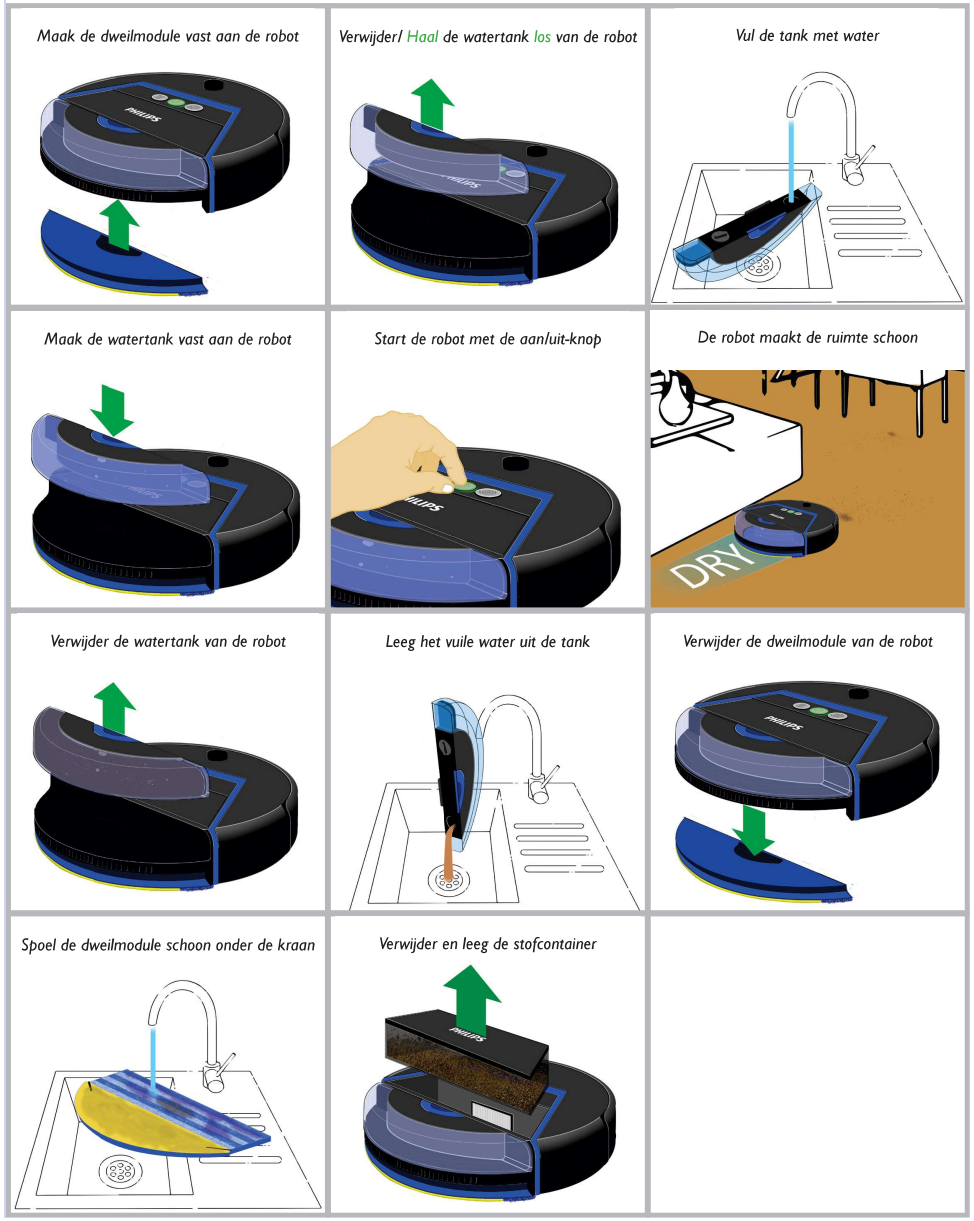
Maak het dweilkleedje vast aan de watertank 	Vul de watertank met water 	Maak de watertank vast aan de robot 
Start de robot met de aan/uit-knop 	De robot maakt de ruimte schoon 	Verwijder de watertank van de robot 
Verwijder het dweilkleedje van de watertank 	Spoel het dweilkleedje schoon of was hem in de wasmachine 	Verwijder en leeg de stofcontainer 

IDEE 2

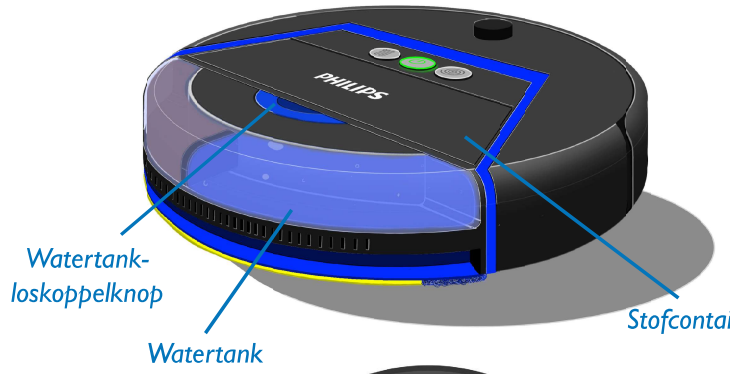


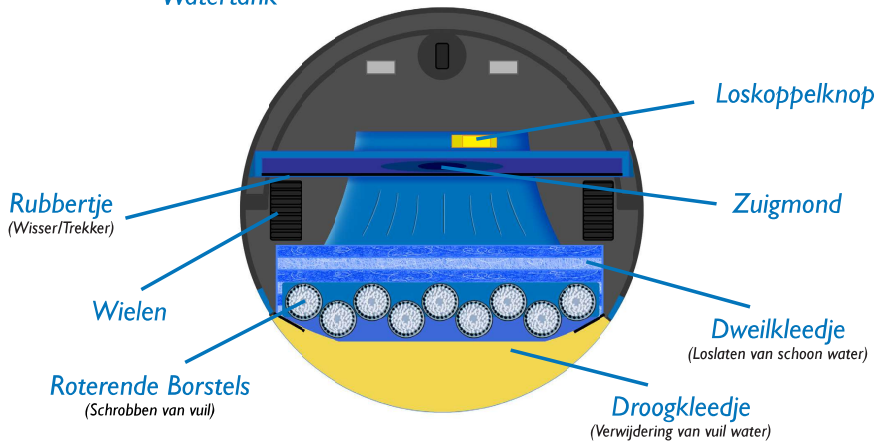
EERSTE SCHOONMAAKFASE		
Stofzuigen	Bevochtigen	Drogen



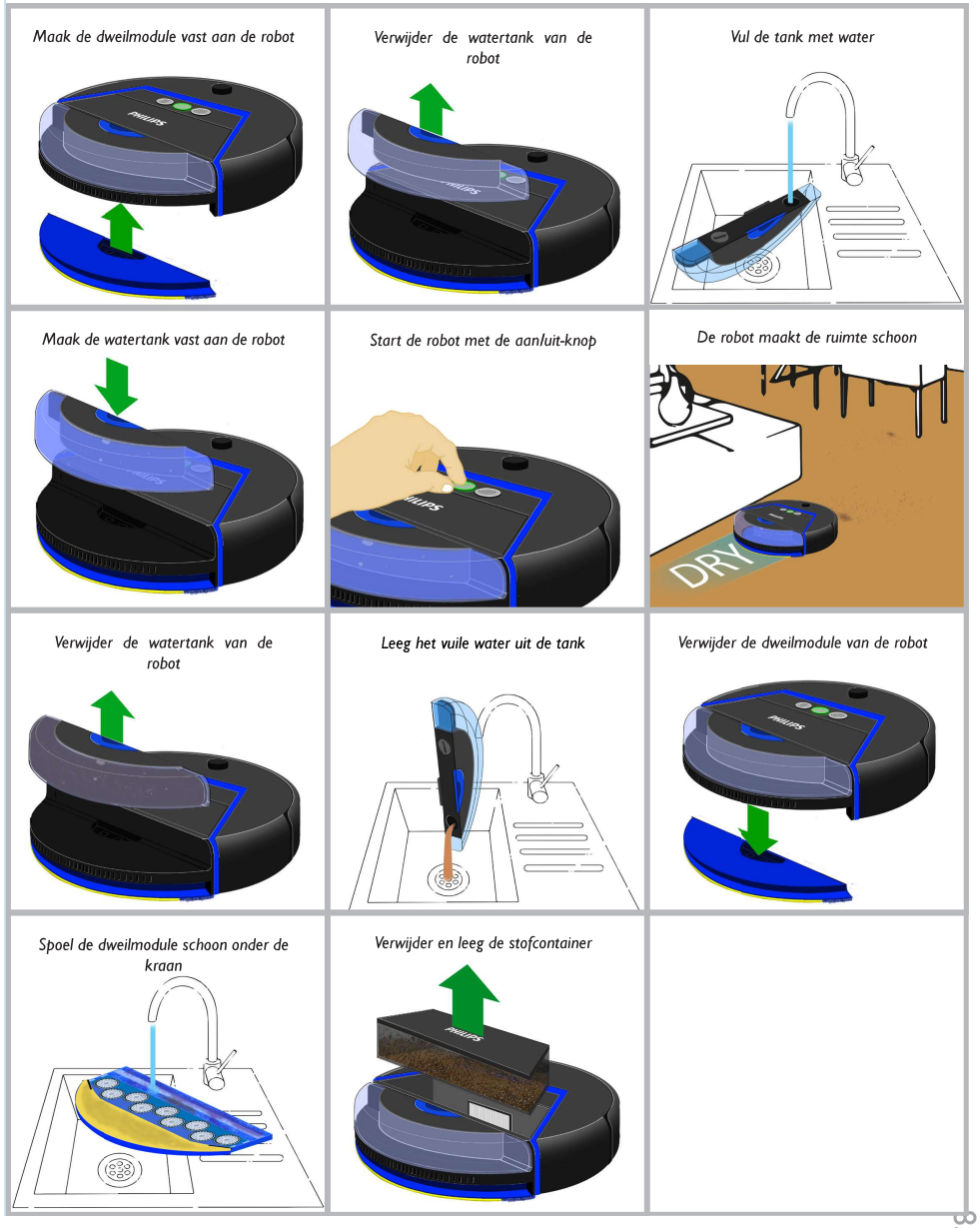


IDEE 3

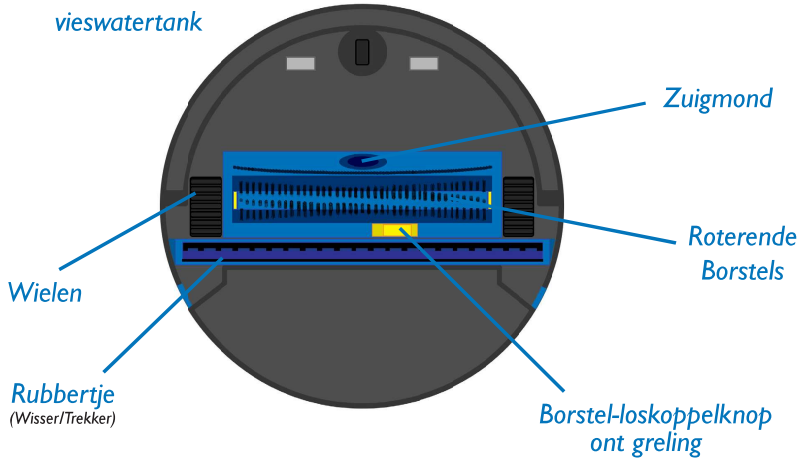




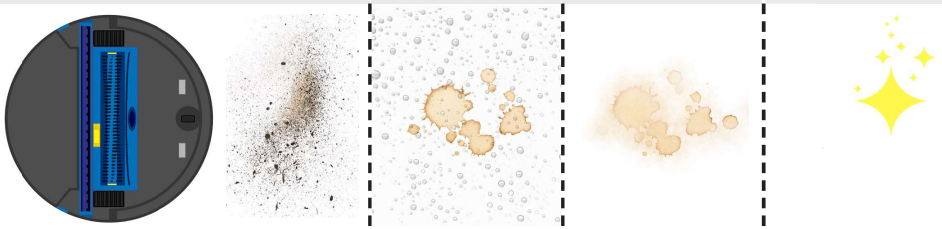
EERSTE SCHOONMAAKFASE		
Stofzuigen	Bevochtigen & schrobben	Drogen

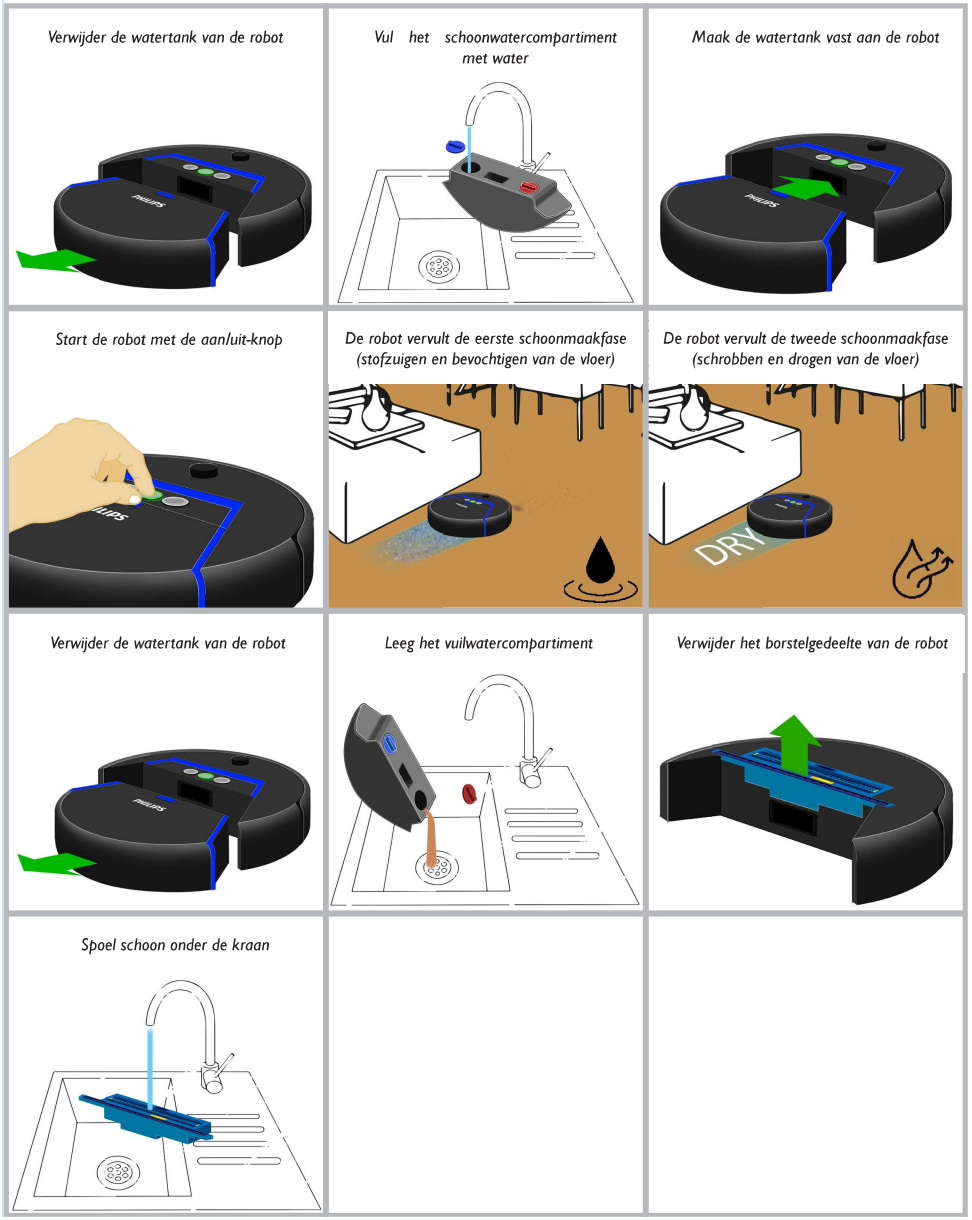


IDEE 4

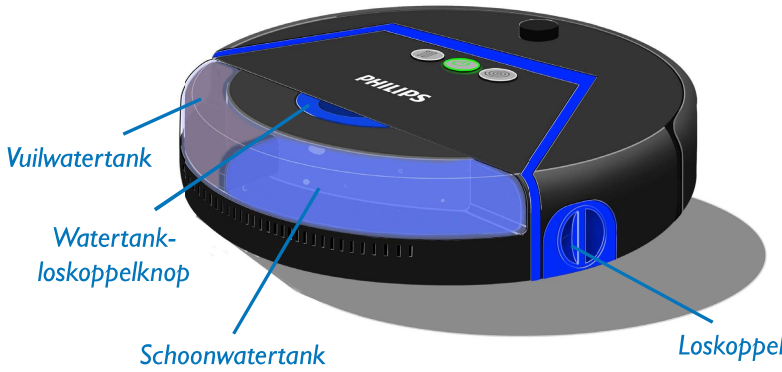


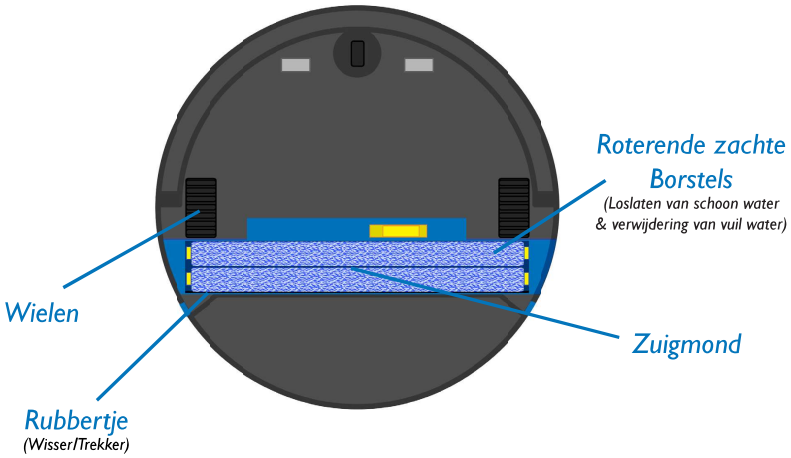
EERSTE SCHOONMAAKFASE		TWEEDE SCHOONMAAKFASE	
Stofzuigen	Bevochtigen	Schrobben	Drogen





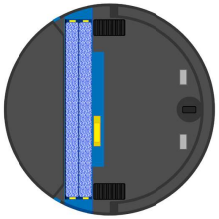
IDEE 5

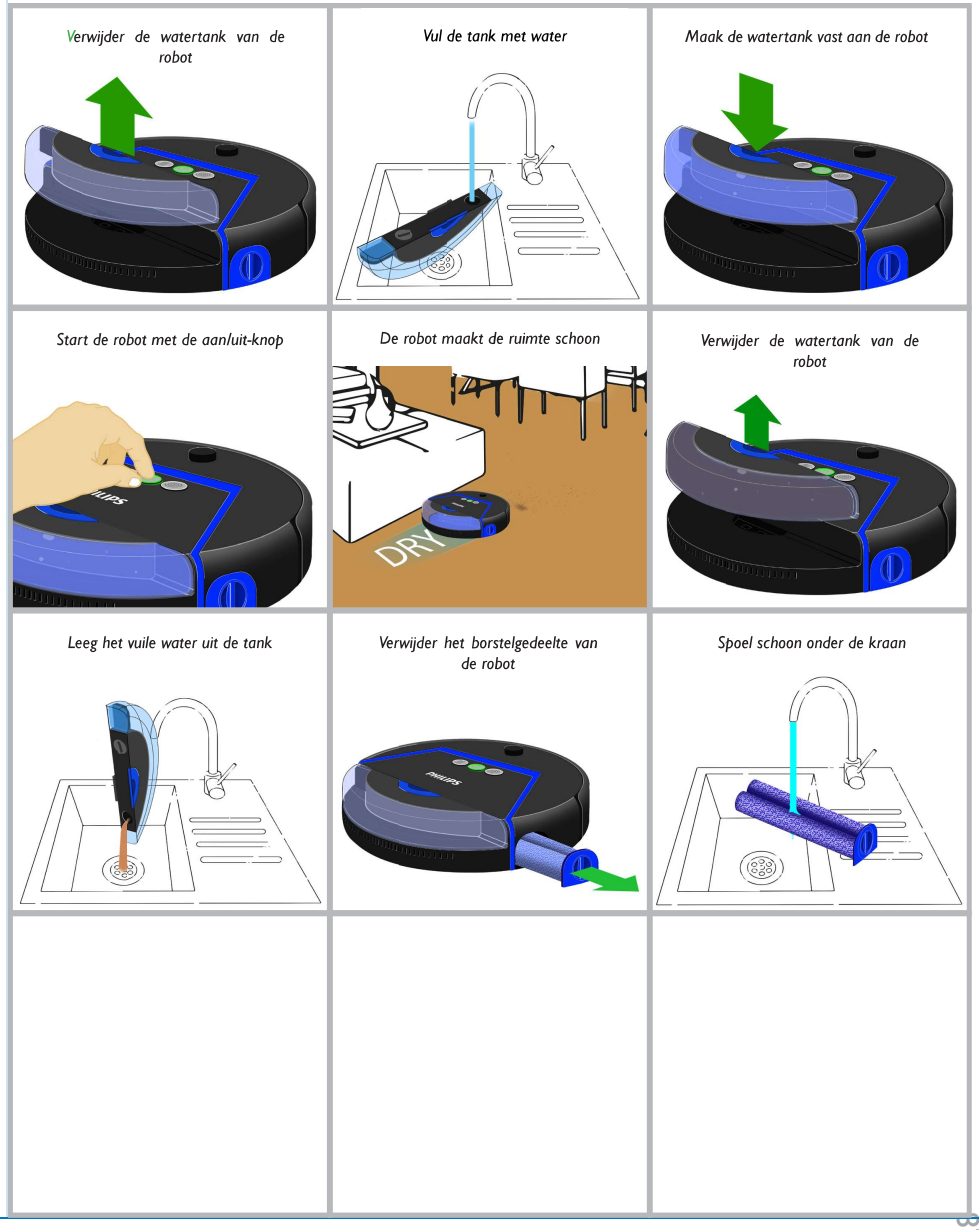




EERSTE SCHOONMAAKFASE

Stofzuigt, dweilt, schrobt en droogt in 1 beweging





APPENDIX

3.2 Comments

Comments Paper

PROPOSITION ___ Comments

Positive Comments

Negative Comments

Improvements/Observations

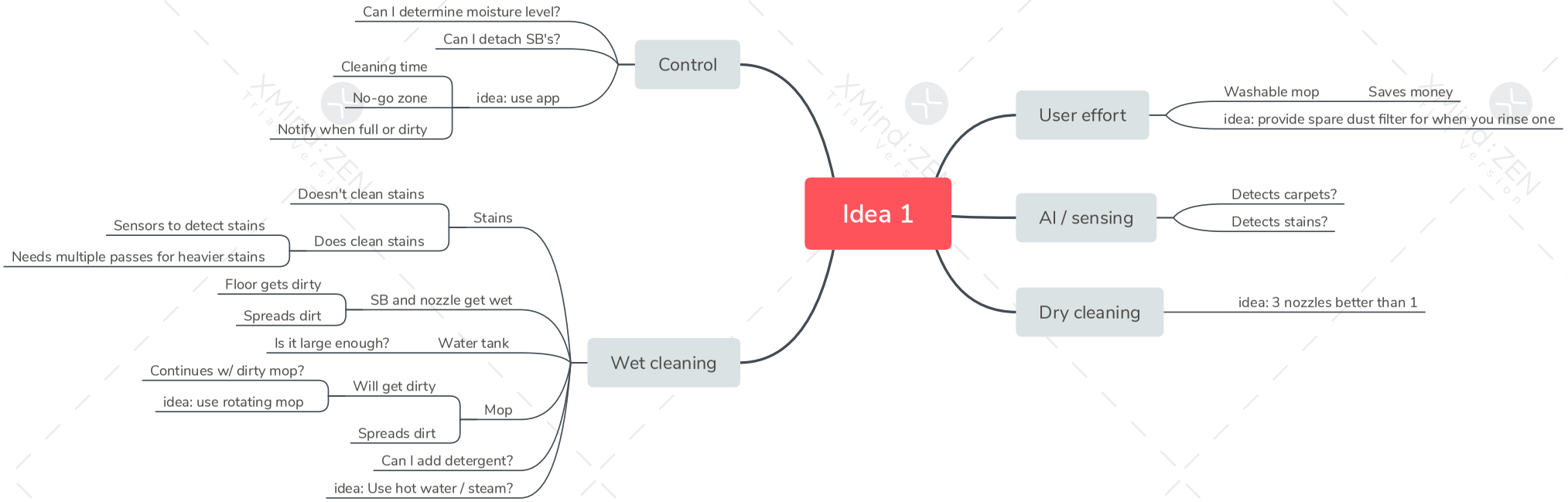
PROPOSITION ___ Comments

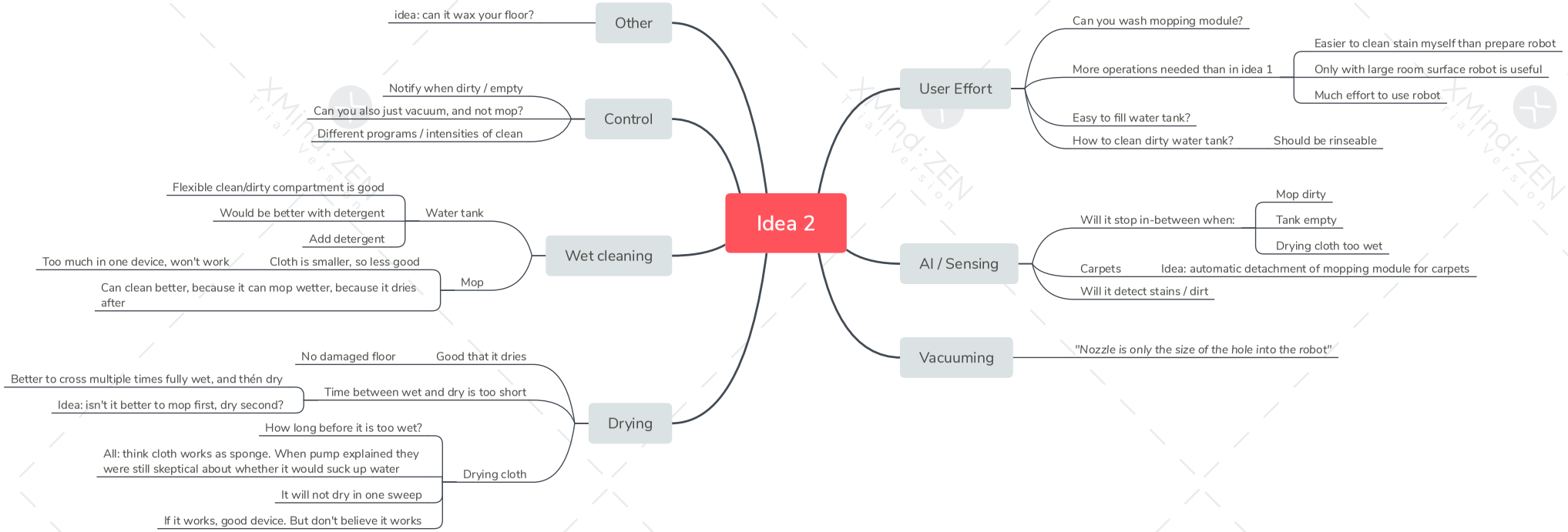
Positive Comments

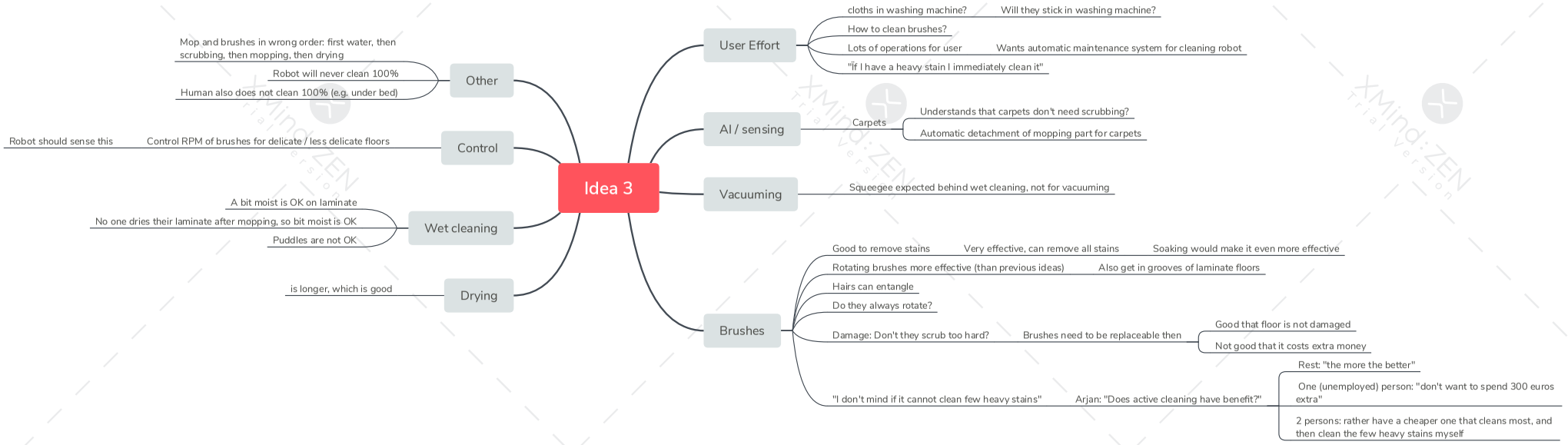
Negative Comments

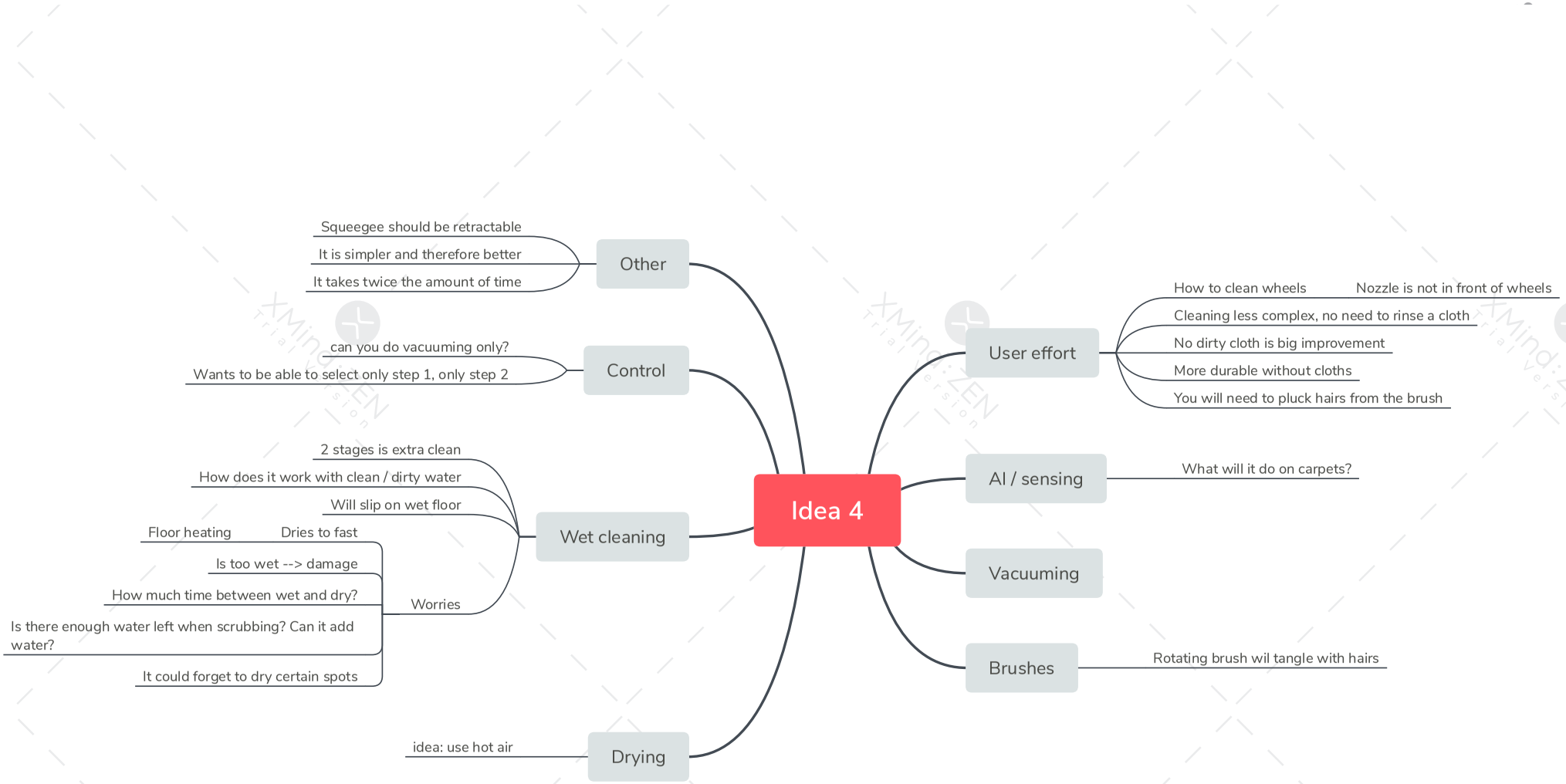
Improvements/Observations

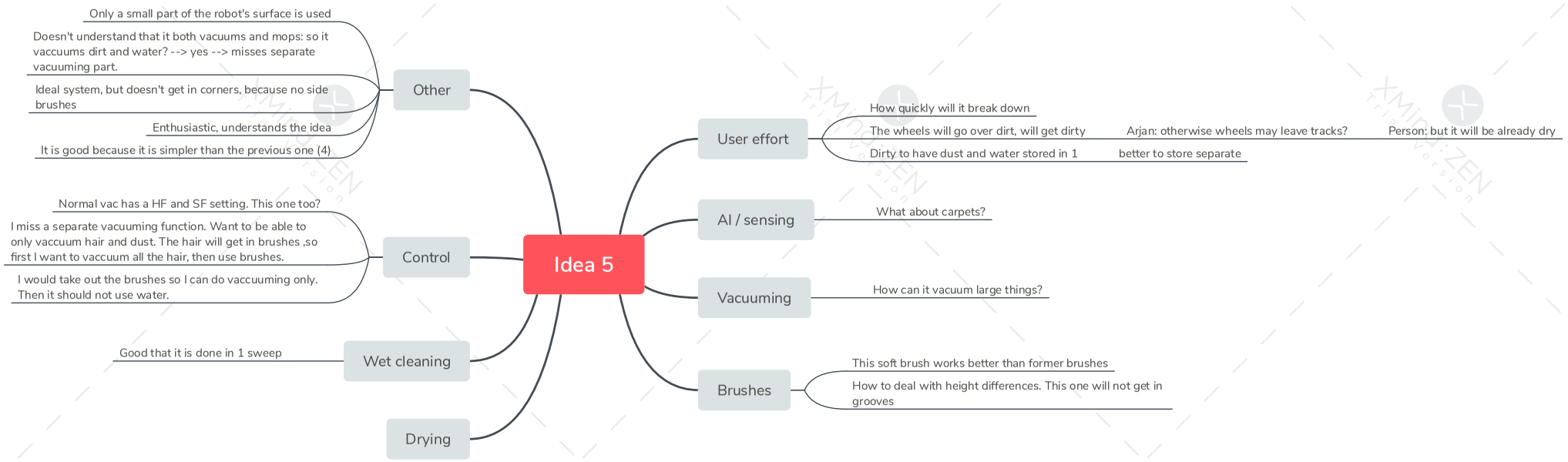
The participants had to fill a paper like the one above for every proposition. The idea with this paper was to collect the different thoughts about each idea in a way that they could be analyze afterwadrs.After conducting both focus groups the comments were translated by one of my colleagues at the office. Once all the comments were translated a serie of mind maps were created to look at the different topics covered by those comments. In the following pages the mind maps are going to be presented.


Idea 1
Control
Can I determine moisture level?
Can I detach SB's?
idea: use app
Cleaning time
No-go zone
Notify when full or dirty
Wet cleaning
Stains
Doesn't clean stains
Does clean stains
Sensors to detect stains
Needs multiple passes for heavier stains
SB and nozzle get wet
Floor gets dirty
Spreads dirt
Water tank
Is it large enough?
Mop
Will get dirty
Continues w/ dirty mop?
idea: use rotating mop
Spreads dirt
Can I add detergent?
idea: Use hot water / steam?
User effort
Washable mop
Saves money
idea: provide spare dust filter for when you rinse one
AI / sensing
Detects carpets?
Detects stains?
Dry cleaning
idea: 3 nozzles better than 1


Idea 2
User Effort
Can you wash mopping module?
More operations needed than in idea 1
Easier to clean stain myself than prepare robot
Only with large room surface robot is useful
Much effort to use robot
Easy to fill water tank?
How to clean dirty water tank?
Should be rinseable
AI / Sensing
Will it stop in-between when:
Mop dirty
Tank empty
Drying cloth too wet
Carpets
Idea: automatic detachment of mopping module for carpets
Will it detect stains / dirt
Vacuuming
"Nozzle is only the size of the hole into the robot"
Other
idea: can it wax your floor?
Control
Notify when dirty / empty
Can you also just vacuum, and not mop?
Different programs / intensities of clean
Wet cleaning
Water tank
Flexible clean/dirty compartment is good
Would be better with detergent
Add detergent
Mop
Too much in one device, won't work
Cloth is smaller, so less good
Can clean better, because it can mop wetter, because it dries after
Drying
Good that it dries
No damaged floor
Time between wet and dry is too short
Better to cross multiple times fully wet, and thén dry
Idea: isn't it better to mop first, dry second?
Drying cloth
How long before it is too wet?
All: think cloth works as sponge. When pump explained they were still skeptical about whether it would suck up water
It will not dry in one sweep
If it works, good device. But don't believe it works


Idea 3
User Effort
cloths in washing machine?
Will they stick in washing machine?
How to clean brushes?
Lots of operations for user
Wants automatic maintenance system for cleaning robot
"If I have a heavy stain I immediately clean it"
AI / sensing
Carpets
Understands that carpets don't need scrubbing?
Automatic detachment of mopping part for carpets
Vacuuming
Squeegee expected behind wet cleaning, not for vacuuming
Brushes
Good to remove stains
Very effective, can remove all stains
Soaking would make it even more effective
Rotating brushes more effective (than previous ideas)
Also get in grooves of laminate floors
Hairs can entangle
Do they always rotate?
Damage: Don't they scrub too hard?
Brushes need to be replaceable then
Good that floor is not damaged
Not good that it costs extra money
"I don't mind if it cannot clean few heavy stains"
Arjan: "Does active cleaning have benefit?"
Rest: "the more the better"
One (unemployed) person: "don't want to spend 300 euros extra"
2 persons: rather have a cheaper one that cleans most, and then clean the few heavy stains myself
Other
Mop and brushes in wrong order: first water, then scrubbing, then mopping, then drying
Robot will never clean 100%
Human also does not clean 100% (e.g. under bed)
Control
Robot should sense this
Control RPM of brushes for delicate / less delicate floors
Wet cleaning
A bit moist is OK on laminate
No one dries their laminate after mopping, so bit moist is OK
Puddles are not OK
Drying
is longer, which is good


Idea 4
User effort
How to clean wheels
Nozzle is not in front of wheels
Cleaning less complex, no need to rinse a cloth
No dirty cloth is big improvement
More durable without cloths
You will need to pluck hairs from the brush
AI / sensing
What will it do on carpets?
Vacuuming
Brushes
Rotating brush wil tangle with hairs
Drying
idea: use hot air
Wet cleaning
2 stages is extra clean
How does it work with clean / dirty water
Will slip on wet floor
Worries
Floor heating
Dries to fast
Is too wet --> damage
How much time between wet and dry?
Is there enough water left when scrubbing? Can it add water?
It could forget to dry certain spots
Control
can you do vacuuming only?
Wants to be able to select only step 1, only step 2
Other
Squeegee should be retractable
It is simpler and therefore better
It takes twice the amount of time


Idea 5
Other
Only a small part of the robot's surface is used
Doesn't understand that it both vacuums and mops: so it vaccuums dirt and water? --> yes --> misses separate vacuuming part.
Ideal system, but doesn't get in corners, because no side brushes
Enthusiastic, understands the idea
It is good because it is simpler than the previous one (4)
Control
Normal vac has a HF and SF setting. This one too?
I miss a separate vacuuming function. Want to be able to only vaccuum hair and dust. The hair will get in brushes ,so first I want to vaccuum all the hair, then use brushes.
I would take out the brushes so I can do vaccuuming only. Then it should not use water.
Wet cleaning
Good that it is done in 1 sweep
Drying
User effort
How quickly will it break down
The wheels will go over dirt, will get dirty
Arjan: otherwise wheels may leave tracks?
Person: but it will be already dry
Dirty to have dust and water stored in 1
better to store separate
AI / sensing
What about carpets?
Vacuuming
How can it vacuum large things?
Brushes
This soft brush works better than former brushes
How to deal with height differences. This one will not get in grooves

APPENDIX

3.3 Ranking Papaers

Makkelijk te gebruiken (Inclusief onderhoud)	Degelijkheid	In staat om je vloer schoon te maken
	1	1
	2	2
	3	3
	4	4
	5	5

Beste resultaat op moelijke vlekken	Favoriet	Geschatte prijs
	1	1
	2	2
	3	3
	4	4
	5	5

APPENDIX

3.4 Ranking Scores

In this activity the participants had to order the ideas in position from 1 to 5 being the position number 1 the best score possible. Afterwards a numerical score was assign to each position in order to process the data. In the following pages the scores given by the participants are going to be presented.

Participants in the focus group 1

Participant 1: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	5	5	5	4	5	5
2	4	1	4	5	4	4
3	1	2	3	3	3	3
4	3	4	2	2	2	2
5	2	3	1	1	1	1

Participant 2: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	4	4	4	4	4	3
2	5	5	3	3	3	4
3	1	1	2	2	1	2
4	2	2	1	1	2	1
5	3	3	5	5	5	5

Participant 3: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	4	4	3	3	3	3
2	1	1	4	4	4	0
3	5	3	2	2	2	0
4	2	2	1	1	1	0
5	3	5	5	5	5	1

Participant 4: man

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	5	5	5	5	5	3
2	4	1	4	4	2	0
3	2	2	3	3	3	0
4	1	4	2	2	4	0
5	3	3	1	1	1	1

Participant 5: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	4	4	3	3	4	3
2	1	1	4	4	2	4
3	5	2	5	5	5	5
4	3	3	2	2	3	2
5	2	5	1	1	1	1

Participant 6: man

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	5	5	3	3	5	3
2	4	4	4	5	4	4
3	3	3	5	4	3	5
4	1	1	2	2	1	2
5	2	2	1	1	2	1

Participant 7: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	4	3	5	5	5	5
2	3	4	4	4	4	2
3	5	5	2	2	2	3
4	1	1	1	1	1	4
5	2	2	3	3	3	5

Participant 8: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	4	4	4	3	4	4
2	1	5	3	5	3	5
3	5	1	5	4	1	3
4	2	2	2	2	2	2
5	3	3	1	1	5	1

Participants in the focus group 2

Participant 1: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	2	4	4	4	3	4
2	1	3	3	3	4	5
3	4	5	5	5	5	3
4	5	2	2	2	2	2
5	3	1	1	1	1	1

Participant 2: man

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	4	4	3	3	3	3
2	1	5	5	5	2	5
3	2	2	4	4	1	4
4	5	3	1	1	5	2
5	3	1	2	2	4	1

Participant 3: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	1	4	1	4	1	4
2	4	1	4	5	2	5
3	5	5	5	3	4	3
4	2	2	3	2	5	2
5	3	3	2	1	3	1

Participant 4: man

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	4	4	1	3	3	5
2	5	1	4	4	4	4
3	1	2	5	2	2	3
4	2	3	3	5	5	2
5	3	5	2	1	1	1

Participant 5: man

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	1	1	3	3	3	3
2	4	2	2	2	1	2
3	2	4	1	4	2	5
4	3	5	4	1	4	4
5	5	3	5	5	5	1

Participant 6: woman

POSITION	EASY TO USE	DURABILITY	IN STATE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE
1	1	4	4	4	2	5
2	2	1	5	5	1	2
3	3	2	3	3	5	4
4	5	5	2	2	3	3
5	4	3	1	1	4	1

Total Scores

Averaged Scores

PROPOSITION	EASY TO USE	DURABILITY	ABLE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE	AVERAGE
IDEA 1	2.43	2.79	4.00	4.64	3.50	4.92	3.71
IDEA 2	3.71	3.57	3.86	3.64	3.00	3.42	3.53
IDEA 3	4.29	4.00	2.50	2.00	2.57	2.50	2.98
IDEA 4	1.79	1.71	1.93	1.93	2.57	2.33	2.04
IDEA 5	2.79	3.00	2.86	2.79	3.21	1.83	2.75

Now, the reversed averaged scores are going to be introduced. In order to generate a logical spider graph the following operation has been performed:

Highest possible score "5"+1-Averaged scored

By doing this operation the spider graphs are turn over showing those points with a lower averaged, which means the product was in better positions, as a higher score.

Reversed Averaged Scores

	EASY TO USE	DURABILITY	ABLE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE	AVERAGE
IDEA 1	3.57	3.21	2.00	1.36	2.50	1.08	2.29
IDEA 2	2.29	2.43	2.14	2.36	3.00	2.58	2.47
IDEA 3	1.71	2.00	3.50	4.00	3.43	3.50	3.02
IDEA 4	4.21	4.29	4.07	4.07	3.43	3.67	3.96
IDEA 5	3.21	3.00	3.14	3.21	2.79	4.17	3.25

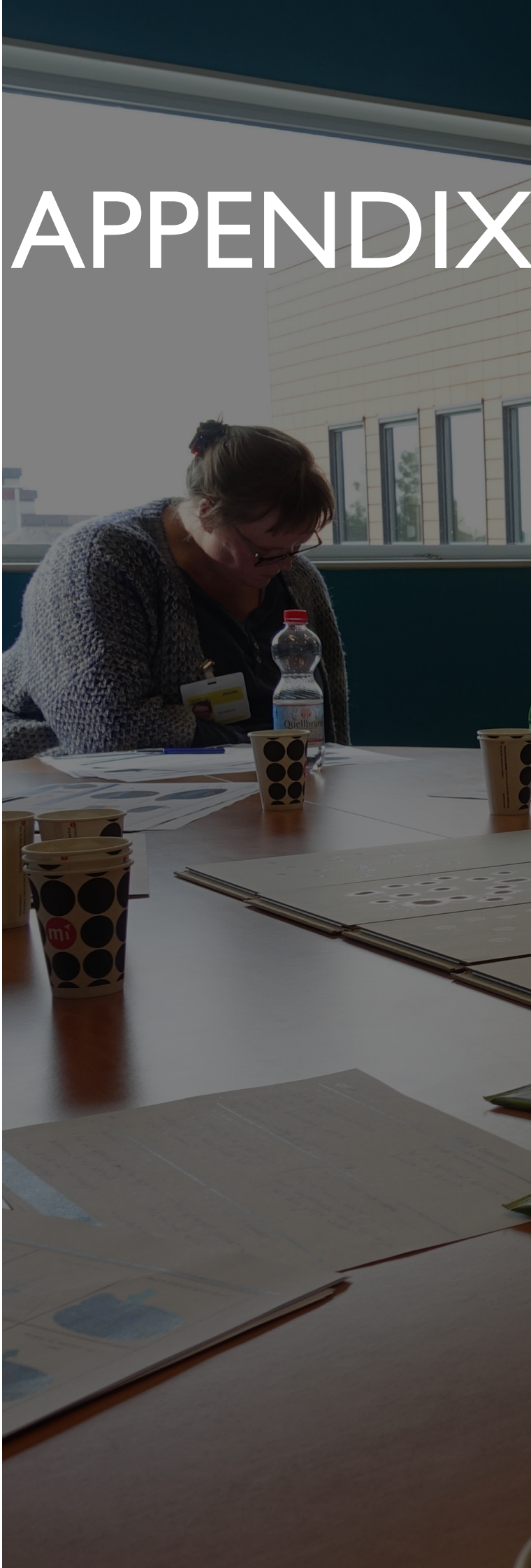
Reversed Men Averaged Scores

	EASY TO USE	DURABILITY	ABLE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE	AVERAGE
IDEA 1	3.57	3.21	2.00	1.36	2.50	1.08	2.29
IDEA 2	2.29	2.43	2.14	2.36	3.00	2.58	2.47
IDEA 3	1.71	2.00	3.50	4.00	3.43	3.50	3.02
IDEA 4	4.21	4.29	4.07	4.07	3.43	3.67	3.96
IDEA 5	3.21	3.00	3.14	3.21	2.79	4.17	3.25

Reversed Women Averaged Scores

	EASY TO USE	DURABILITY	ABLE TO CLEAN YOUR FLOOR	BEST RESULTS ON HARD SPOTS	FAVOURITE	ESTIMATED PRICE	AVERAGE
IDEA 1	3.78	3.22	1.78	1.33	2.67	1.13	2.32
IDEA 2	2.22	2.22	2.22	2.33	3.00	2.63	2.44
IDEA 3	1.78	2.11	3.22	3.67	3.00	2.67	2.74
IDEA 4	4.11	4.56	4.44	4.44	3.89	4.33	4.30
IDEA 5	3.11	2.78	3.11	3.22	2.67	4.33	3.20

4. APPENDIX

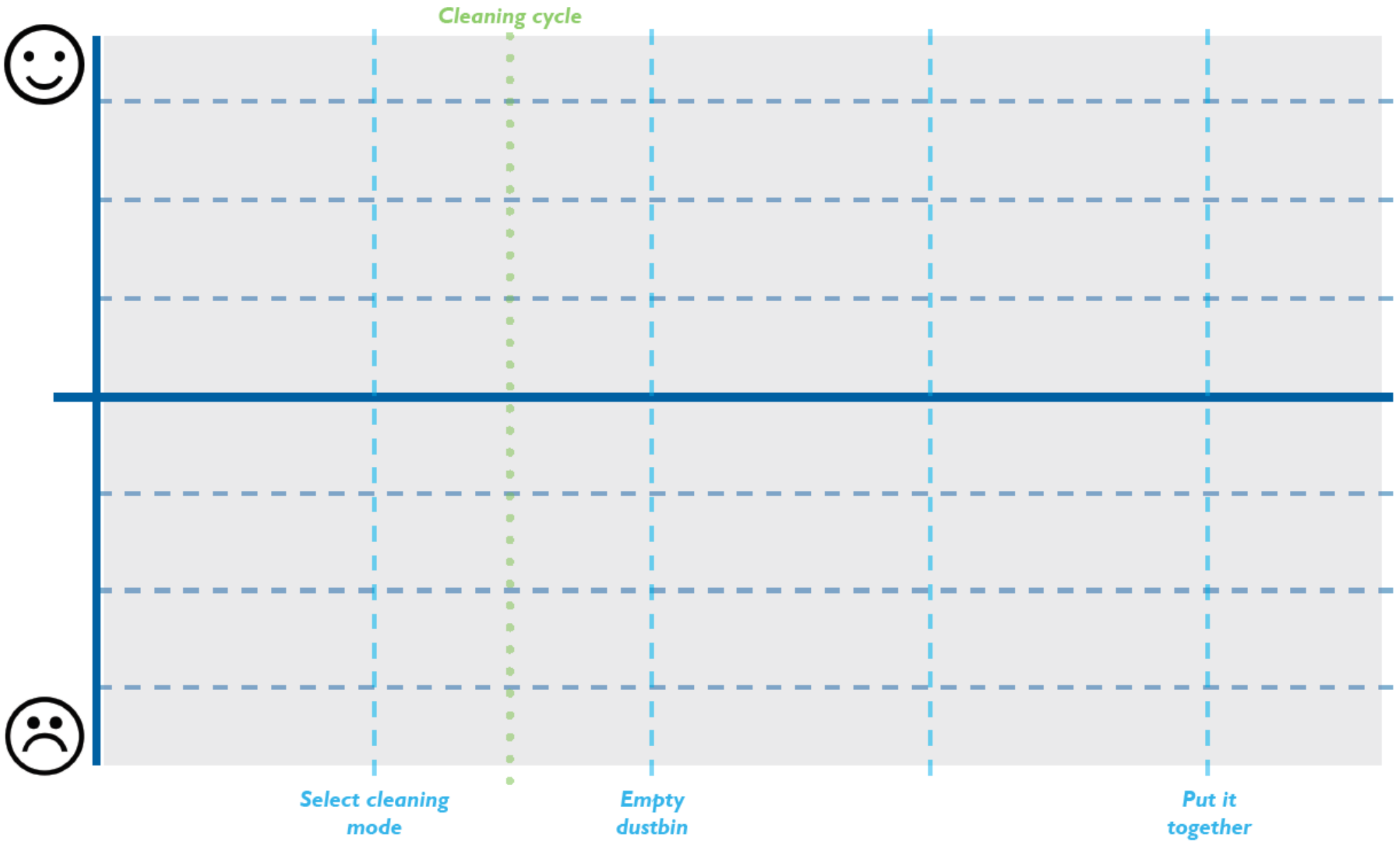


APPENDIX

4.1 Holistic Experience Scan Papers

USE STAGES EVALUATION : Dry Cleaning

Participant Number :



USE STAGES EVALUATION : Wet Cleaning

Participant Number :

Cleaning cycle

Fill the water tank

Attach mopping pad

Attach water tank

Select cleaning mode

Empty dustbin

Empty water tank

Remove mopping module

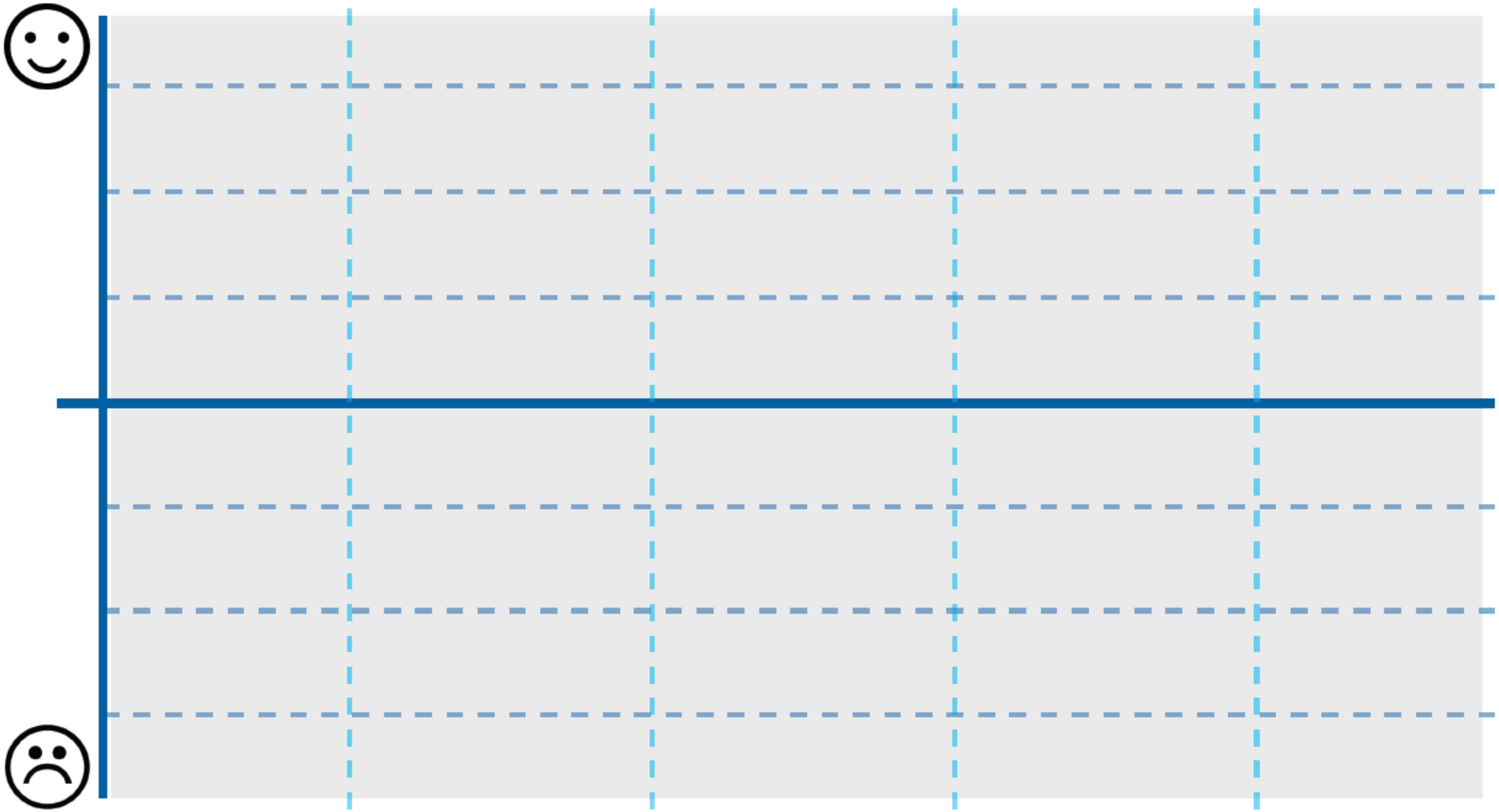
Remove mop

innovation you

PHILIPS

USE STAGES EVALUATION : Maintenance

Participant Number :



Remove dustbin

Remove & clean filter

Remove & clean water tank

Detach mopping pad & brushes

APPENDIX

4.2 Holistic Experience Scan Scores

	DRY CLEANING		WET CLEANING								MAINTENANCE			
Participant	Select Cleaning Mode	Empty Dustbin	Fill the water tank	attach mopping pad	Attach water tank	Select Cleaning mode	Empty dustbin	Empty water tank	Remove mopping module	Remove mop	Remove dustbin	Remove& clean filter	Remove & clean water tank	Detach mopping pad and brushes
1	3	3	-2	3	3	3	3	3	3	-2	3	3	3	-1
2	2	3	2	3	3	3	3	2	3	1	3	3	2	-1
3	3	3	3	3	3	3	3	2	3	3	3	3	2	3
4	1	3	-1	0	1	2	2	-3	0	1	2	0	0	0
5	2	3	2	0	2	2	2	2	2	3	3	3	1	-2
6	2	1	1.5	2.5	2.5	3	1	2	3	1.5	3	3	2.5	1.5
7	-3	2	-3	-1	2	-3	-3	0	3	-1	3	3	3	0
8	-1	3	-3	3	2	0	3	-3	3	3	3	3	-2	3
9	2	2	-1	3	3	3	-1	-1	2	3	3	1	1	2
AVERAGE	1.222222222	2.555555556	-0.166666667	1.833333333	2.388888889	1.777777778	1.444444444	0.444444444	2.444444444	1.388888889	2.888888889	2.444444444	1.388888889	0.611111111

APPENDIX

4.3 Interviews Notes

P1 Broke her nail

- Blue handle DB easy to understand
- Water tank: add sign for clean and dirty water
  - Too small now
- Nail broke when pushing brushes
- Nice button
- Likes opening DB on top
- Very easy to empty DB
- Difficult: mop
  - How to disassemble?
  - Pushing brushes difficult: takes force
  - Detaching mop with the rubber is easy
- Brushes and mop in different color? Yes good idea
- When you see the screws, you think you cannot remove it
- The drawing fermi made was a good idea
- Write 'remove' on he brushes part

P2 (has robot)

- Gonna lose the ramp
- Vinegar in water tank
- Mop never gets dry, where to put it so it doesn't drip
- Wants to rinse the DB with soapy water
- Throws away filter in trash
- Likes when it clicks, otherwise not sure it's connected
- Dirt gets in ridges on top
- Likes to turn it around on its back. Doesn't like when the button is sticking out. Now uses towel so robot lies soft.
- Many holes where dust can accumulate
- Impossible to get wheels out, wants to take out to clean
- Understands front side
- Bumper should be longer
- Square shape looks faster
- Make it balck, looks smaller
- Shape is aerodynamic
- Different colors for dirty and clean water lids
- Needs to look fancy
- Likes to see robot in the room
- Attached her dock with duct tape to floor
- Suction cap to secure dock?
- Uses the 'buttons' to remove the brush
- Doesn't like to push hard
- Doesn't want to choose modes, just clean everything, but doormat extra
- Carries her iRobot to doormat for spot clean. Thinks it knows when it is finished.
- Brushes renew your doormat
- When you have wet hand you don't want to touch the button anymore
- (she's careful of damaging the robot, needs to look nice)

- Bumper can look softer, so doesn't damage furniture. Rest glossy.
- Like a car, also nice color

P3 Guy with robot

- Water tank is DB
- Saw DB and thought no this is DB
- Recognized on /off button
- Would rinse DB
- Turns robot upside down for attaching mop
- Doesn't understand ramp, does attach correctly
- Thinks DB not used when wet cleaning
- Expected a main brush
- Clean filter every 1 or 2 weeks
- He cleans the wheels
- Identifies bumper as front part
- He cleans sensors too
- Ridges will get dirty, the smoother the robot, the better
- No brush in this, not as good as Roomba
- Will not clean edges, not wide enough (vacuum nozzle)
- Thinks side brush is useful to clean edges
- Recognizes wetting and drying part of mop
- More focused on wet clean this design
- Doesn't know if useful to combine wet and dry
- Mopping would be nice, but should avoid his carpet
- Doesn't see problem with square back. Round front useful when turning
- Doesn't use spot clean mode. Uses handheld small vac for small stuff
- Uses robot at night
- Has robot > 5 years, 3 batteries replaced
- Bounce and Z-mode he likes, doesn't understand why to have other modes
- One button is better, easier to understand, certainly with screen
- Wet cleaning not every day, dry every day
- Letting the robot attach / detach mop by itself would be too expensive, only wet cleans once in a while
- Adjusted his house for the robot, cables and such. Needs to be tidy for robot to work
- Robot is visible, for docking purposes
- Uses robot upstairs, needs to find it there after use. Doesn't bother him
- Would he set a timer for cleaning? He wouldn't know how to estimate required time. Like now is fine. Maybe light and hard clean, but keep it simple.
- If you clean every day already, it is not that dirty. Doesn't expect dirt in his house
- Thinks wet cleaning brushes will clean a lot
- At least 2 mops so you can exchange them
- Because you use it so much, don't make it glossy. Best to stay nice, but few scratches won't matter
- Idea: add a handle for going upstairs

P4 (Has aqua trio)

- Water tank is home base? No
- Hope DB does not have to empty all the time. Will wait for feedback light
- Does not understand how to fil water tank
- Water tank too small (compared to aquatrio)
- No problem if water gets in DB. Why not put dirty water and dust in 1
- Always residue of sand in water tank
- Prefers cleaning wet + dry at same time
- Should clean itself like aquatrio
- Change mop every 6 months
- Hairs gonna be stuck in brushes
- Hopes she can store it when it is still wet, Should not smell
- Trouble w/ disassembling mop. Lot of work. Doesn't want to do every time
- Now says cloth needs to be changed every time
- Thinks ramp is unnecessary
- Trouble attaching ramp
- Easier if ramp was integrated

MAINTENANCE

- Should clean itself every time
- Put mop in washing machine
- "Vacuum cleaners have more than 1 filter", where is other filter
- Filter should be rinsable
- Know front and back
- Cannot clean carpet
- Can replace her mop, but not along edges
- W/ aquatrio you sometimes need 6 strokes to clean something
- Robot should clean so I don't have to myself
- In Aquatrio she sees visual feedback dirty water
- Add detergent to water

INTERFACE

- Click wheel is complicated
- Prefers to use app
- Wants the option to choose for cleaning mode; in case robot does not clean well
- Robot should decide himself as much as possible
- Water tank will pollute itself
- Does not want to show robot, prefers to hide
- Less dirty upstairs, living room more important
- Doesn't care how it looks, doesn't want to see it, should work without you
- Water tank: prefers to have no movable wall, saves cleaning step, more robust
- Should not damage walls. Should have rubber protection.

P5

- Looks at water tank and ramp, doesn't know what for
- Tries putting ramp in front of nozzle
- Tries to 'click' robot on mop from the top. Mop positioned correctly though
- Idea: put arrow on mop slide in piece
- Does not understand ramp at all
- Thinks squeegee make everything dry
- Mop components stuck together, do not come loose

DISCUSSION

- Cleans very well
- Every time you should clean the mop, but you don't want to do that every time
- Cleaning after 1 month would be good
- Brushes do not have to be cleaned as often as mop
- Would use in entire house, apart from stairs
- Obvious what front is due to sensors
- Would hide the robot
- Dock downstairs
- Water on left part of tank

P6

- Squeegee is for wet cleaning
- Understands product well
- Not clear where to put clean water, expects left
- Brushes look fixed to mop module
- Space in between brushes, so stripes on floor
- Successfully dismantled mopping module
- Thinks sensors are lights, later knows they are sensors
- Dustbin lid is symmetrical, dustbin too. Better to do asymmetrical.
- Cleaning power
  - Wil keep house quite clean if you use 1x / week
  - But have to clean yourself every 6 months
  - Will handle footprints
  - Will not handle
    - ☐ Beer stain
    - ☐ Cola
    - ☐ Food
- Hair gets stuck in brush, e.g. when turning. Would be better if vacuuming part is closer to mop part
- Shape confusing, front and back. Thought front is flat, like millennium falcon
- Water vacuumed no big problem, but annoying when soggy/muddy
- Clean mop: once every 2 weeks, after 3 times use
- Brushes and mop last a year. Then buy new one
- Every night dry cleaning
- Wet 1-2 times per week
- Trusts dry clean

- Will check wet clean first, depends on floors
- Wants more control over wet clean

INTERFACE

- Blue/green colors good
- Don't rotate 360 degrees. Hand will be in way. Keep finger in one place and then stroke to turn
- Buttons better than circular knob
- Prefers LCD
- Dock not in sight but accessible
- Would not carry robot upstairs
- Dock in lower floor, gets dirtiest there. Upstairs not as needed
- Does not want to have to attach the (BLANK) (I think mop)
- Doesn't matter how long it takes, as long as it is clean
- Just wants to say go to the robot, nothing else
- Not worth putting in function to clean specific rooms, not worth money
- Mopping stripes in same direction would be nice
- Would like access to programming
- Other functionalities: serving beer

P7 hannie

- Thinks sensor is start button, after that pushes the actual start button
- Thinks water tank is battery
- Thinks ramp is to put on nozzle squeegee
- Robot upside down, tries to attach ramp. Knows it is for the mop though.
- Thinks it does only mopping or vacuum cleaning
- Clean wtare on left side
- Pushes brushes part correctly (on the motor connections though)
- Mop clean every time
- Filter is replaceable
- If possible dry and wet at the same time
- Mop replace every half year
- Store in kitchen
- Would use upstairs
- Would keep out of sight
- Integrate ramp
- 7x / week dry clean. 1x/ week
- Interface: described it right, so it is intuitive to her. Easy to use one button

P8

- Immediately presses on button
- Brushes could be used for dry cleaning to brush dust
- Ramp is wall mount, to store mop on
- Doesn't know what water tank is, thinks it is a battery because it is heavy
- Button on top may be a sensor?
- Sensors are on front, shape is aerodynamic

- Water tank: soap and water compartments
- Should notify when DB full
- Does not recognize to detach dustbin lid at corner
- Thinks filter is disposable
- Possible to put filter in upside down
- Dock should be flat and small, under couch maybe
- Clean water on left side
- Use indicators on water tank for the separation part; where to put it
- Cleans downstairs more often than upstairs, also no visitors (with shoes) upstairs
- Should be able to control mode: dry, dry + wet, wet
- Cleaning mopping module seems a lot of work
- Understands how to disassemble mopping module
- Wants to take out brushes individually
- 'click' missing when pushing brushes in
- Take off wheels to clean
- Would put cloth in washing machine, but distrusts attachment to silicon frame
- Would pre-clean brush before putting it in dishwasher. No problem to mix with spoons, forks and what not. Hot cleaning program though.
- Integrate ramp
- Cleaning power depends on force being applied on the mop, while still being able to move
- Add soap
- Tubes inside robot will get dirty
- "cleaning the robot more like a nice puzzle, better than cleaning your house". She likes maintaining her motorcycle also for instance.
- Button interface is intuitive
- Keep water tank attached always, even when dry cleaning only

P9

- Identifies button correctly
- Ramp unclear
- Thinks you can wet clean without mop
- Squeegee for wet cleaning, water comes out nozzle
- Really misunderstands everything
- Understands front and back
- Puts ramp upside down on mop, cannot attach ramp
- Right side for clean water, does not know why
- Only tries to pull the brushes out, does not try to push from other side
- Very slow
- Tries to assemble all parts of the mopping module at the same time

MAINTENANCE

- Does use corner of DB lid. Recognizes the filter
- This on also thought the dust was collected above the filter, and all the dirty water below the filter
- Replaces filter every 2-4 weeks, based on daily dry clean

DISCUSSION

- Hide robot in washing machine room
- Dry 3 times / week
- Wet 1 time / week
- Can clean almost everything, except stains like wine
- Wants to be there when it is used
- Is not bothered if it would make as much sounds as a vacuum cleaner
- Wet clean ground floor more often
- Would carry robot upstairs to use it there
- No real preference for wet + dry or separate

MOST IMPORTANT TOPICS:

- Likes when it clicks, otherwise not sure it's connected XX
- Water on left part of tank XXXX
- Many holes where dust can accumulate
- Impossible to get wheels out, wants to take out to clean XXX
- Doesn't want to choose modes XXX
- Recognized on /off button XXXXXX
- Expected a main brush
- Mopping would be nice, but should avoid his carpet
- Uses robot at night (DRY) XX
- Thinks wet cleaning brushes will clean a lot XXX
- Idea: add a handle for going upstairs
- Letting the robot attach / detach mop by itself would be too expensive, only wet cleans once in a while
- Should clean itself like aquatrio
- Hairs gonna be stuck in brushes XX
- Extra functions like auto attach detach mop may not be worth the money XX
- Brushes could be used for dry cleaning to brush dust


PHILIPS