APPS ON WHEELS

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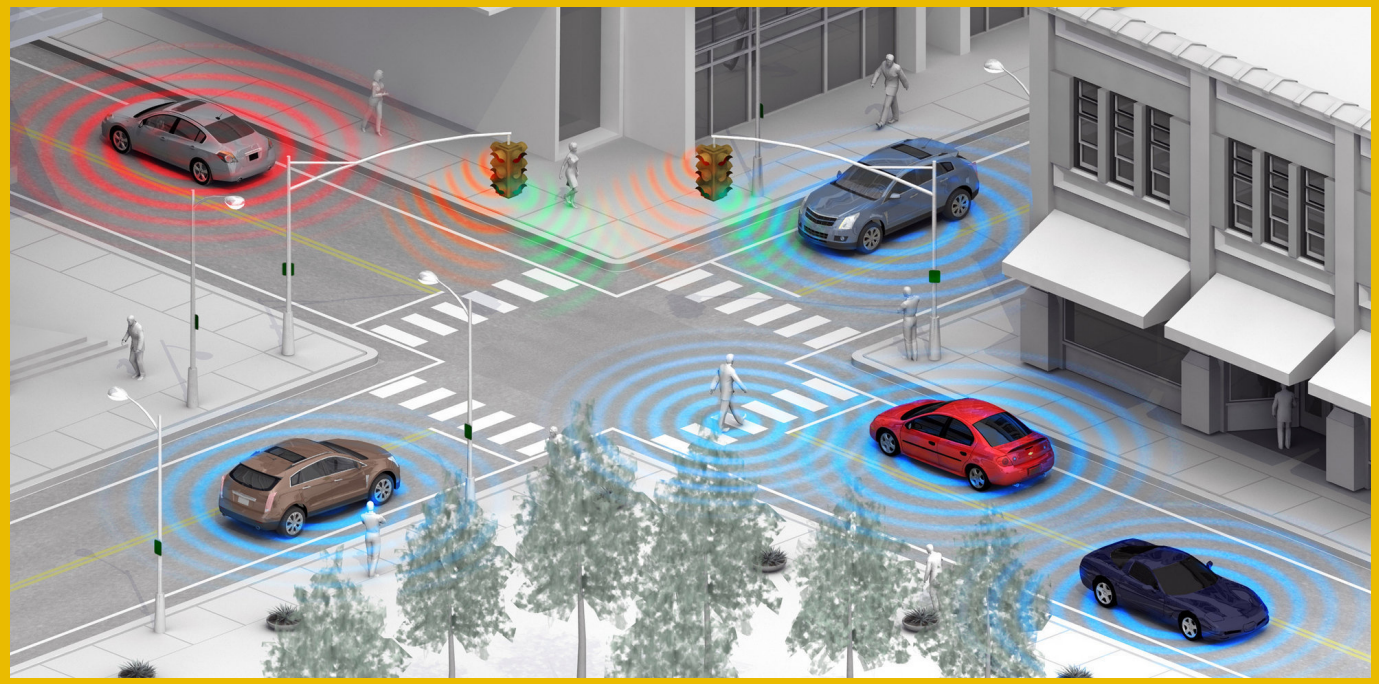
PROJECT BRIEF

"Apps on Wheels" is a project about the future of mobility. The future of mobility comprises a wide variety of subjects: future technology, future society in relation to mobility and transportation, and social interaction in future mobility amongst many other subjects.

The project brief was to envision future mobility in your own way. This means that it is up to the designer to come up with a theme within future mobility and accordingly state a design problem.

The design problem for this project was as follows:

Regarding future mobility, automated mobility is a hot topic. Car manufacturers are experimenting with autonomous cars in both test labs and real life. Before these cars can enter the real world, they need to be very safe. Where human drivers can interpret difficult situations, computers need to be preprogrammed to show similar behavior. Besides the technicalities, there is an issue on human-computer interaction level. How does the autonomous car blend into a realm of simple yet rich, straight-forward yet complicated communication?



In normal traffic situations, traffic laws will suffice, but in more complicated traffic situations there is need for communication between traffic participants. Where human traffic participants will communicate through signals like blinking the lights, horning the claxon or waving hands, the autonomous car does not yet have a proper means of communication implemented, rather than lights and claxons, which it is most likely not programmed to use in these situations.

There should be a means of giving signals to other traffic participants when being situated in a difficult or confusing traffic situation.

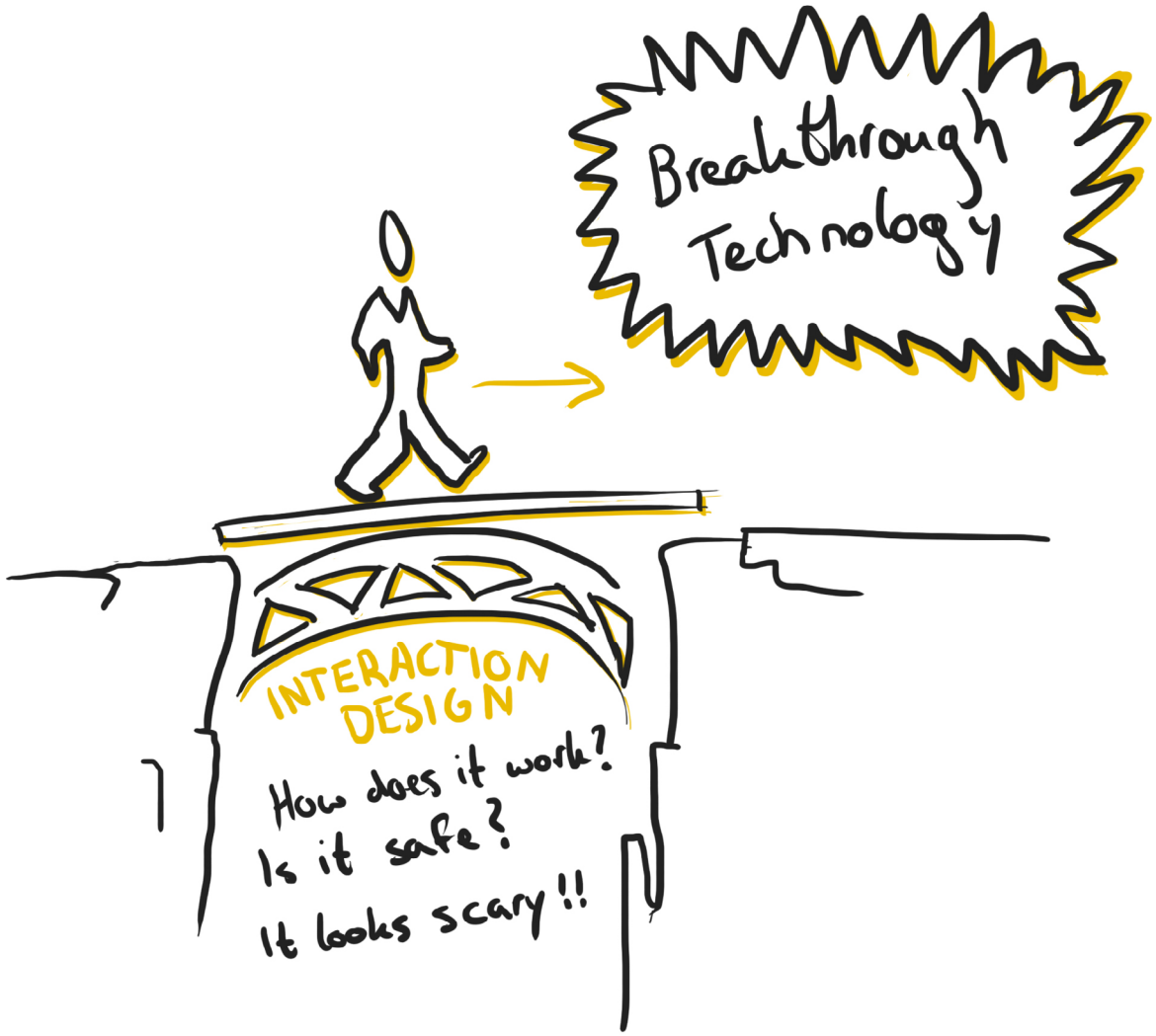
IDEATION

Vision

The project brief was defined with a vision in mind: in order to introduce new technologies into society, there needs to be a way of "easing the change". The end user needs to understand it, and sometimes the break-through concept needs to gain trust at the moment of introduction.

When looking at the concept of autonomous cars, there is a lot of controversy around it. At this moment, society does not completely trust the concept of automated mobility. For example, a human driver might have trouble to anticipate on the robot that is an autonomous car, especially if it does not communicate through signals in difficult situations. The fear for software bugs or the debate about liability in accidents or ethical choices in case of an inevitable (happening) accident do not contribute to faith into this technology.

This project aims at providing the autonomous cars with a means of communication in traffic that is suitable for difficult and confusing situations in traffic. This will make it easier to understand autonomous cars. In a time that automated driving is a minority, the cars should show human characteristics, to ease the acceptance.



IDEATION

Co-creation

After the first ideas and themes were defined for the project, a co-creation session was conducted. The goal was to generate new means of expression in traffic. The setup can be found in the appendices [A]. The participants of the session were mobility experts working at the government of Limburg. The session was set up in three brainstorms. During the first two brainstorms, it was important that the participants used body language.

The first one was a warming-up brainstorm aimed at using body expressions when solving a problem. The second brainstorm was about expressing signals in traffic with non-verbal communication. Descibing in words was not allowed. The third brainstorm aimed at trying to convert the then-generated ideas (body gestures, sounds, facial expressions, hand gestures) into signals that could be implemented onto a car.

The brainstorms were followed up by an idea review round. From the generated ideas (based on body gestures, sounds) the participants needed to consider them from their own expertise. Which idea do they deem best? Which idea do they find the worst? Why did they choose those ideas?

As it turned out, the concept and the project brief were too complicated and ill-defined by then to be used for generating ideas with outsiders. Besides, the setup of the co-creation session required both willingness to express through non-verbal communication, and the ability to empathize with the context. Both lacked to some extent during this session. So instead, the ideation should be done standalone. The expertise can be useful later on in the process, though.

As a result, they came up with a discussion point: should the autonomous car always follow the rules and give right-of-way? Or should the autonomous car break the rules at times that giving right-of-way is taking too long or creates confusion? What if the stream of pedestrians at a pedestrians' crossing is endless? After all, as a correct traffic participant, one follows the rules and gives right-of-way at pedestrians' crossings. But in order to be efficient, the traffic must flow. So there should be an interplay of expressions. This means an autonomous car should express both gentleness (giving right-of-way) and assertiveness (taking right-of-way).

ENVISIONING CONCEPT

Initial concept definition

The project brief definition was part of the ideation, and served as a framing for generating ideas. The first idea was inspired by some expressive automotive examples: the BMW Gina and the movie "*Cars*". Both are very animating, which contributes to a strong expressiveness.

That is why initially physical shape-changing was envisioned for making cars expressive. The cars should end up with frowns, aggressive lines, or no lines at all and a more timid stance. This has a relation with the animal kingdom: where right-of-way is compared to dominance. Either give it (being gentle, or in this case timid) or take it (being assertive, or in this case dominant).

↑ ***Top to bottom:*** a fragment from the movie "Cars" and the BMW Gina concept.

→ ***Top to bottom:*** a car's neutral state, a cars friendly state and a car's aggressive state, respectively.

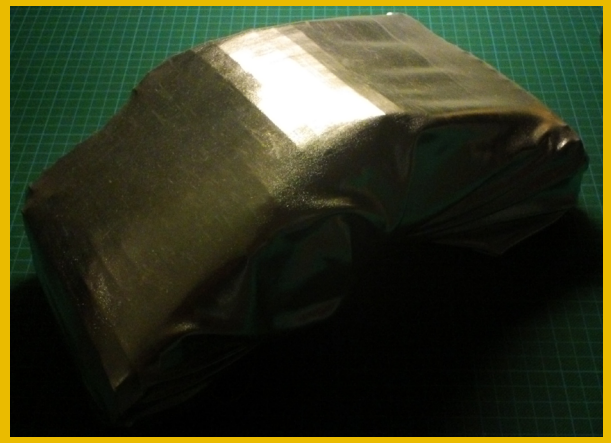
ENVISIONING CONCEPT

Material consideration

To get familiar with shape-shifting, some experimentation was done. First of all, the exterior material was explored. By using Lycra and a wireframe, the inspiration for material choice came directly from the BMW Gina concept. Its flexibility enables the body the change shape. The Lycra is wrapped around the wireframe tightly, creating a shape on its own.

← ***Left:*** The first iteration; Lycra over a wireframe.

→ ***Right:*** The second iteration; Lycra over wiremesh.



There were some pros and cons to this idea, namely the following:

Pros:

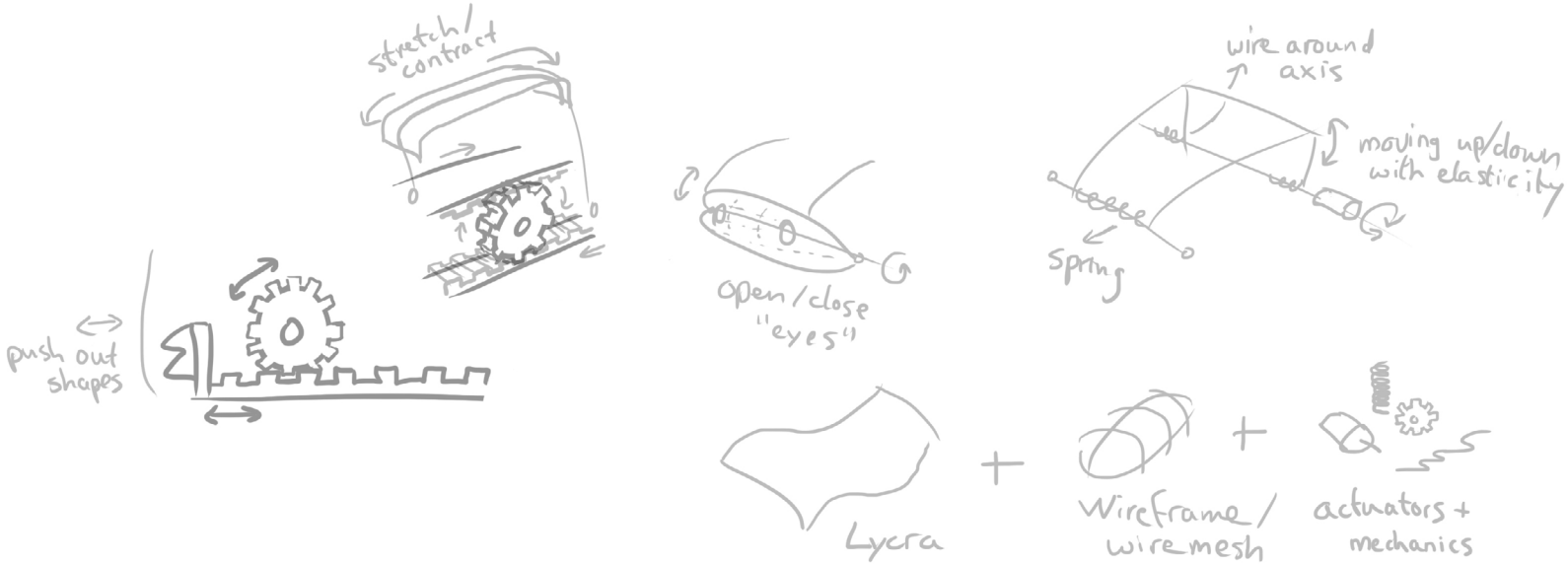
- The skin is very flexible, it moves along with the construction it is wrapped over.
- The shape is defined by itself, there is no need to fill it up.
- Shape-changing is easy: the material stretches easily, but maintains tension once it is released.

Cons:

- In order to make a proper car shape, the wireframe needs to be engineered and constructed very well.
- The moving parts will need to be constructed perfectly, and making changes will be difficult.
- Some movements are harder than others. "Under-the-skin" expansion is easy, but widening "nostrils" or frowning headlights is quite harder to construct (powerful actuators, strong, but flexible construction).
- The shape that is created through stretching will only work with convex shapes, concave shapes will be covered entirely. To enable concave shapes, the model needs to be made out of segments. This makes building a seamless model nearly impossible.

Considering the pros and cons, the physical shape-changing seems less of a good idea. But the idea was not abandoned entirely. Instead of a wireframe from single wires, wire-mesh was used. The wire-mesh might give more control over the shape to be constructed. However, many of the pros and cons remained. But a new problem popped up. The wire-mesh appeared to be too weak to remain in a fixed shape once the Lycra was wrapped around it tightly. This shows that the idea of wrapping Lycra around a frame is too difficult for a project in such an early stage. Too much time will be spent constructing a frame and wrapping the Lycra. It is too challenging for the time that is available. There was still time left to come up with alternatives instead.

REALIZATION RESEARCH



Technological feasibility

When shedding light on both the pros and cons of the physical shape-changing concept, it seemed a little too far-fetched. This means that, in order to come up with a realistic design proposal, a slightly different concept should be envisioned. The expressiveness in autonomous cars is still the main goal for the project, but the physical shape-changing is a little too far-fetched.

There are some objections against using physical shape-changing,also from realization perspective. The technology to implement it (both for prototyping and real implementation) is going to be very complicated. It will cost a lot of money to actually engineer it in a compact way, which makes it unattractive to car manufacturers. The BMW Gina was a one-off, rather than a realistic mass-production example. Making a similar design will not be a realistic design proposal.

In order to test the concept, mockups should be easy to make or designed digitally. Physical shape-changing comes with huge challenges for making a proof-of-concept prototype, but also digital footage is hard to make. Validating and discussing the concept will be hard if there is no footage/prototype/mockup.

Due to these objections, alternatives were considered. Light signals might provide the right flexibility and might have more possibilities regarding expressiveness. Where the shape-changing is probably limited to what is feasible (sticking-out shapes from under the skin, expanded parts, moving elements), the light signals can be designed with more freedom.

REALIZATION RESEARCH

Intertraffic conference

The Intertraffic conference is a conference about mobility in general. Mainly the seminars of technologies and visions on the future of mobility by prominent companies and experts in this field were of interest for the project. It gave the vision on the design problem some perspective. Attending these seminars, reseulted in a few learning points:

- Automated driving will not be available for at least 15 to 20 more years. The technology is still in development. However, many luxury-features like lane-assistance, automated traffic jam driving, digital navigation and the start of car-to-car communication are valuable technologies that are all pieces of the puzzle that is the fully autonomous car.
- Automated driving is yet to gain trust and acceptance amongst both car manufacturers and society. This means that the car manufacturers are slowly testing technology, but not yet implementing fully autonomous technology into cars. Concerning the end-user, there is a consensus that "computers controlling your car" is not reliable enough. There is a fear for bugs or misinterpretations in the system. Besides, losing interaction with the car from a pedestrians' or cyclists' viewpoint is also unappealing to some.

It is interesting to see that the experts view the transition towards automated driving as the biggest challenge. The concept anticipates on this issue, as it can make the interaction between the autonomous traffic and the human traffic more clear. This can make the autonomous cars seem more social, more human. This is important, as it might improve acceptance of automated driving among society.

REALIZATION RESEARCH

Context awareness approach

In order to find out what kind of expressiveness is most effective, a co-constructing stories session had to be conducted. It is a way to make outsiders familiar with both the design context and the concept that is designed (*Buskermolen, Terken, 2012*). Being in a phase that the concept is still a bit vague, but with a context already defined, a means of getting insight from outsiders is desirable. But insights from a specific scenario that is designed for can't be directly asked from them. The concept is still too vague to be discussed standalone. But the insights from the context were be very important, so there had to be a way of involving the context to both build a foundation for the concept, and to get insight how to improve it.

"Co-constructing stories: a participatory design technique to elicit in-depth user feedback and suggestions about design concepts"
(Buskermolen, Terken, 2012)

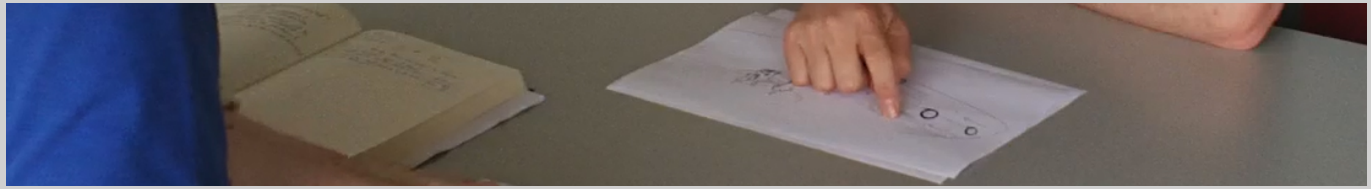
ADAPTING TO CONTEXT

Co-constructing stories session

The previous context awareness session did not have the desired results. A potentially better approach is explanation through storytelling. This is more suitable for discussing the concept with outsiders. Expressiveness of cars is not that much of a clear theme.

The co-constructing stories session was aimed at discussing a specific context scenario. The ideas of this project were placed into these scenarios. This engaged the outsiders into discussion about various ideas for the concept. The ideas were printed on paper, and discussed one after another. The setup of the session can be found in the appendices **[B]**, along with the sketched scenarios.

The static images did speak to the imagination, but still required quite some explanation. As the concept is about animation, the static images do not carry the same value as animations would. Instead, videos or GIF animations should be used in future sessions. Some results from the co-constructing story session were as follows.



- Light signals were experienced to be more prominent and effective than physical shape-changing. Physical shape-changing could be linked to personal preference; one might like an aggressive look, another might like a friendly look. Light may carry a more consistent message.
- Regarding shape-changing, the power really lies in the transition. A static shape has no effect, an moving shape is more expressive.
- Positioning light signals in the headlights was a little confusing. Green could mean being gentle but also ready to go. Whereas red could mean being assertive and idle. If the light signals were part of an ambient lighting exterior, instead, it would be more effective.
- Some found an aggressive, provocative car less effective. They thought that provocative behavior does not deserve right-of-way. Instead, the behavior should be apologetic.
- Projecting light on the hood is less effective. If it would really be facing you as a traffic participant, the message might come easier across, as the hood is not entirely visible.
- Multiple colors / signals simultaneously is confusing: what is meant for you? What is meant for others? A unambiguous signal should be sent. Besides, a constant color might be less clear than an animation of colors.
- Using the light for giving feedback was regarded as a good way to address each traffic participant individually. However, it must be unambiguous. In addition, it should prevent confusion.

Light signals were considered clearer than physical shape-changing. As a result, the concept changed. Instead of sticking to the physical shape-changing, the light signals were chosen for implementing expressiveness in cars.

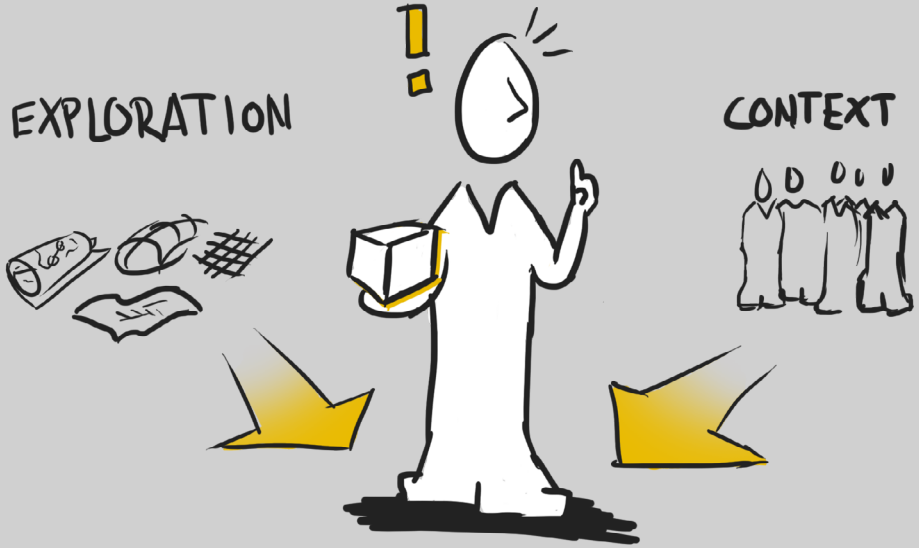
ADAPTING TO CONTEXT

Consequences for the concept

After the co-constructing story session, I found that the expressiveness should be done with light, or color in general. The expressions could show varying patterns, which can be determined by color, movement and extent of dynamics amongst other things.

Light signals will have some variables that can strengthen and weaken the concept, so these variables should be tested throughout the process. Building it with a framework (namely, LED-matrices) leaves quite some flexibility from a technical perspective. Performing user tests can happen simultaneously with building and improving a prototype. Changes will be easy to implement.

On the contrary, movement of the car body requires building it first, or animating it. User tests might result into having to make a total rebuild of the entire prototype. Besides, envisioning a functioning prototype is harder when it comes to physical movement and shape-changing.



Visual presentation

The first idea was to build a shape-shifting model with iron wire mesh. After a first iteration for exploring the possibilities and limitations, I found some objections against using the materials of choice, or at least the way I use them. The wire mesh frame "shined through" the material, as it was stretched over the frame. This showed to me that stretching Lycra over a wire mesh frame does not give the right results.

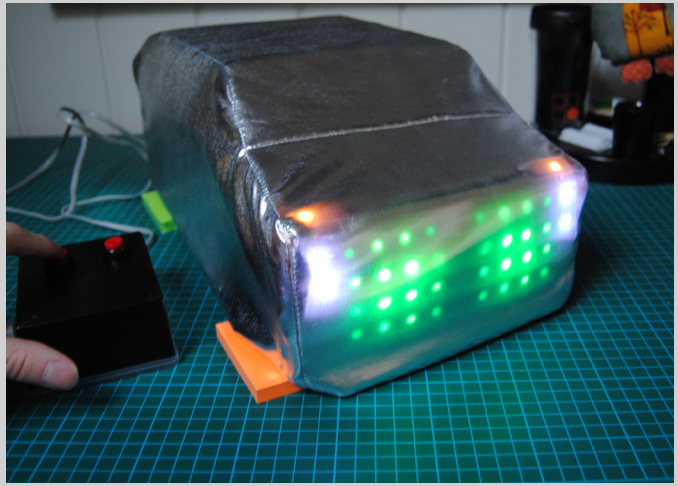
Next to that, the wire mesh is far from flexible. It does not allow for too much manipulation. A basic wire mesh shape was constructed, the more complicated a shape is, the harder it is to maintain the shape while stretching the Lycra. It requires you to use the material in more complex ways. Possibly, the Lycra should be divided up into segments, to be stretched separately. Sticking to a simple shape first will enable me to (at least) show the concept on an basic car model.

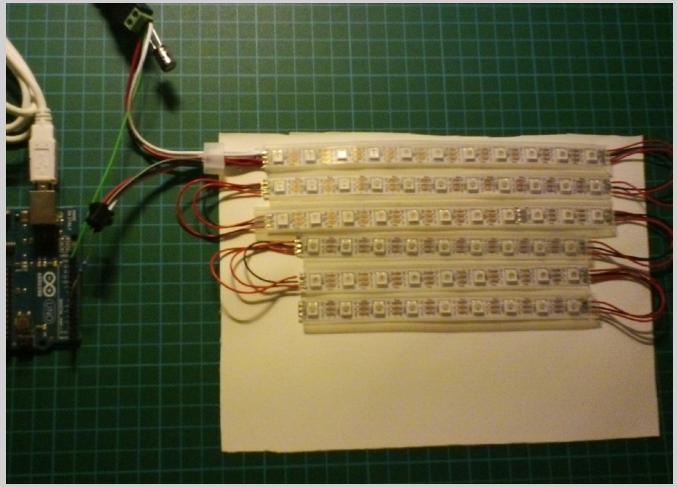
ADAPTING TO CONTEXT

First presentational prototype

The choice for building a presentational prototype was based on the effort it would take to make an actual prototype for testing. The expressions could be tested, validated and discussed in various ways, which does not require a full-size car with the expression built into it. But to make the idea tangible, there should be a physical model after all. Scaling it down to 1:10 scale leaves enough room in the project to build a presentational prototype, but to also improve the expression by means of validation and discussion.

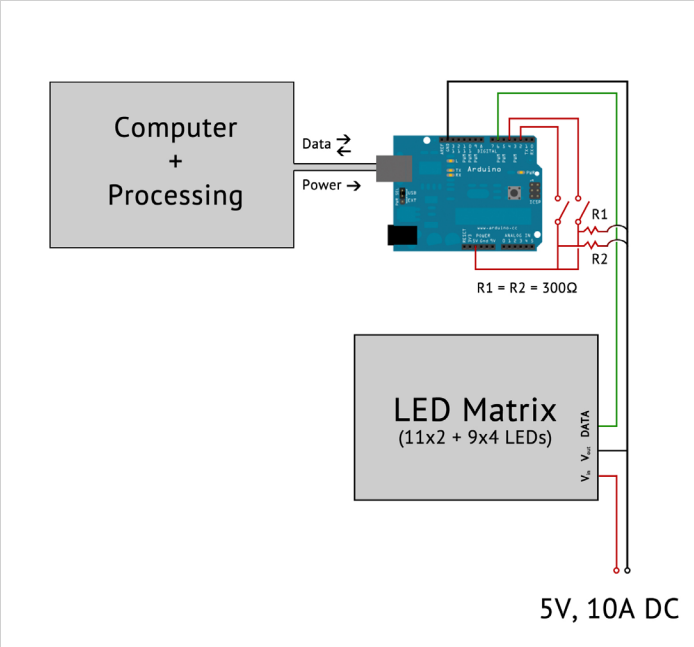
The prototype was built from a wire-mesh structure. Lyra was loosely wrapped over it, being sewn into a tight cover. A RGB LED strip was used for constructing a LED matrix. It is fully programmable, and controllable through the computer, via an Arduino. Before I was able to use computer-generated images onto the LED matrix, I had to face some challenges. These challenges are documented in the appendices [C].





↑ **Left to right:** the functional LED matrix prototype, the LED matrix with Arduino before implementation, respectively.

→ **Right:** a schematic overview of the prototype.

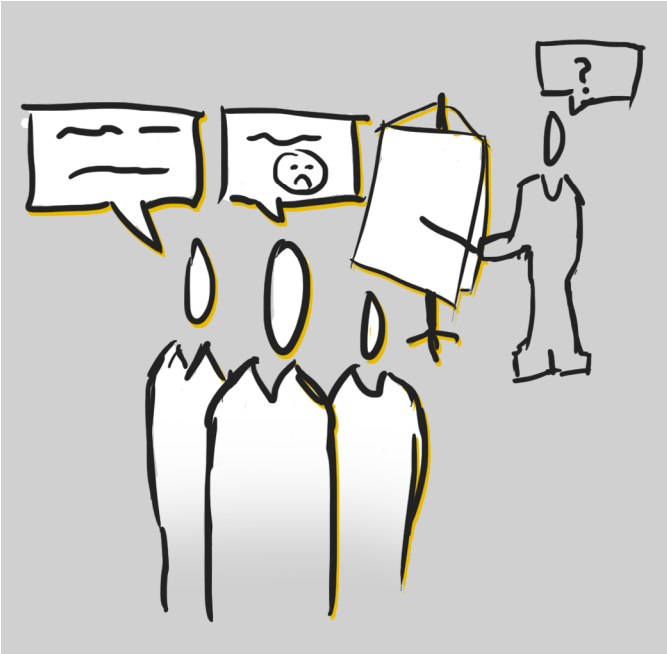


CONTEXTUAL DISCUSSION

Goal of confrontation

In order to gain more insight from the context, the concept had to be discussed with the context. The goal was to find out the impact of the expressions on traffic. By focusing on qualitative information, the objective was to find out what was behind the initial thoughts. Rather than finding out that a person "might not like it", finding out why this person thinks so is more valuable information. This will be input for a redesign of expressions.

However, the last time a similar session was conducted with mobility experts, it was hard for them to engage with the context of the project, as well as to relate with the concept. That is why a co-reflection setup will be used. Currently, the concept is better defined, with more tangible ideas. This can make the entire session more tangible for the participants. The co-reflection was a discussion about the various designed expressions, to what extent they are effective, clear, and to what extent they evoke the right feeling. The feedback on the expressions also gave insight into how new expressions could be designed that are easier to understand and more effective.



Co-reflection

The co-reflection was held with the same mobility experts. They were be able to give both input from a "regular" traffic participant's perspective as well as from their own fields of expertise. These fields of expertise are human behavior in traffic, infrastructural design and influencing human behavior in traffic. The setup of the co-reflection can be found in the appendices **[D].**

Initially, the most explicit and most typical expressions were expected to be most effective. But this was not the case. The extremes were regarded too extreme. The most gentle expression was regarded too vague and unreliable. The most assertive expression was regarded aggressive and egocentric. Both are undesirable in traffic.

Besides, the most subtle expression that I designed was regarded not effective. Placed on the lower-half of the front bumper, it is hardly visible. Next to that, the expression was regarded too small; it was easy to miss, and not very explicit.

That means the choice fell for the middle ground. The expressions that are explicit enough, but do not evoke the negative associations that the extremes do. However, the assertive expression evoked some feeling of negativity to it in all the cases. Some traffic participants might react differently to this assertive expressions than others, ranging from actually giving right-of-way to finding the expression unacceptable, and not giving right-of-way. The full list of results can be found in the appendices **[E]**.

CONTEXTUAL DISCUSSION

Redesigning expressions

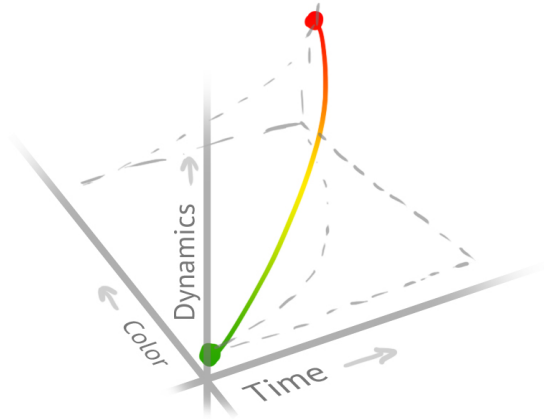
The results from the co-reflection created a design opportunity. Redesigning the standalone expressions was not the only solution here. The signals still sparked some misunderstanding. The expressions were designed standalone, but could possibly transition into one another. A transition from gentle to assertive might improve understanding in this case.

First of all, when designing a transition, the moment of transition should be determined. The moment of choice was after having waited a while at a pedestrians' crossing, or after too much hesitation at a crossroads where traffic from all directions hesitates to take right-of-way. Initially, the autonomous car should give right-of-way, and be gentle, for better understanding and a positive impression.

But after a while (think of an endless stream of pedestrians, or too much hesitation at a crossroads), the autonomous car should transition into an assertive state, and claim right-of-way for itself. A gradual change in expression for the timespan it waits will show that it has been waiting for a while already, and that it is slowly becoming impatient. Instead of being regarded as aggressive and ego-centric, it rather evokes understanding from the other traffic participants.

There are three variables: color, dynamics and time. The expression should change over time. In this case the transition from gentle to assertive will result in a color shift from green to orange through yellow. Besides, the dynamics will become wilder. However that a transition from green to orange seems a little too generic, the colors should be suggestive. In traffic, everything needs to be clear from a first glance, hence choosing green and orange. The transition in between is important. Is the color pulsing? Is it linearly shifting to each state, or is there distortion/delay? Is the expression having one uniform color, or is it containing several colors simultaneously?

The variables result into a specific gentle expression and a specific assertive expression.



↑ **Green** = gentle state | **Red** = assertive state

Assertiveness:

- → Orange color
- → Many pulsing movements
- → Fast and frequent movements
- → Big in size

⩾ Gentleness:

- → Green color
- → Calm, slow movements
- → Small in size

STEP INTO REALIZATION

Technological feasibility

LEDs are great for displaying the concept, but in practice, this technology might not be really that suitable for actual implementation of the concept. The light source is a single dot, and if you make a matrix with a resolution that is big enough to support a pixel-based animation, the light intensity is rather big. Imagine looking at a LED-screen besides the road. They are very light-intensive, and staring at them is very bothersome. This technology should not be used for projecting animations onto the car. Instead, some alternatives were considered. Throughout the process, several technologies were discovered for changing the color of the car paint dynamically.

These techniques are:

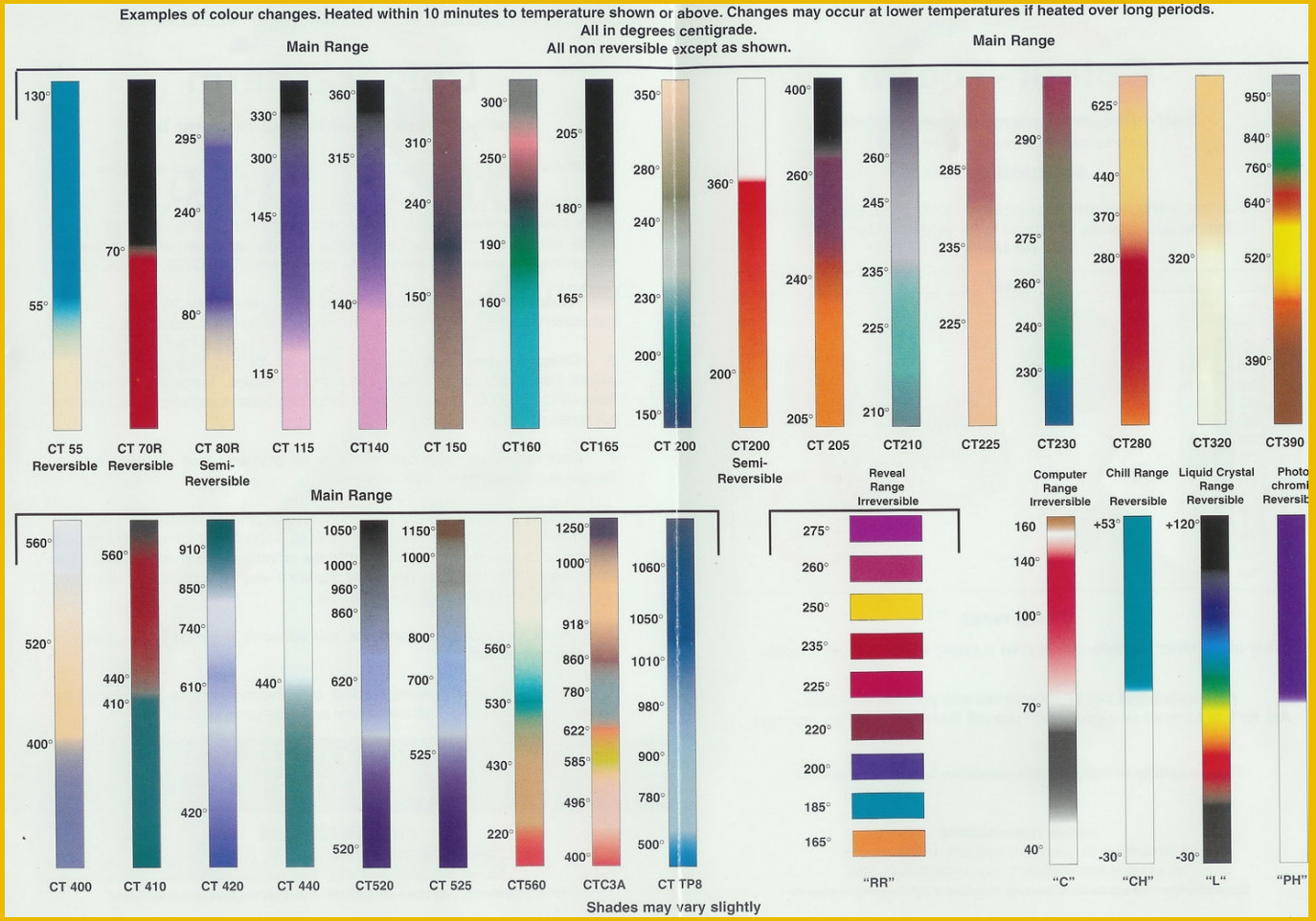
- Thermochromic paint
- Bioluminescence or radioluminesence
- Magnetochromatic microspheres

All of these techniques have their pros and cons. Each of these has been considered, and the pros and cons were taken into account for finding the best option of implementation. The best option out of these alternatives, was the magnetochromatic paint. This technology does have its pros and cons, but the downsides and the risks of using the others made this alternative the best one of the list.

STEP INTO REALIZATION

Thermochromic paint

The thermochromic paint is already widely available, in a great variety of colors. This type of paint is triggered by means of temperature. Some paints are reversible, some are not. The reversible paints are the only option. Ideally, there should be a paint that shifts into a variety of colors. Most of the paints, however, shift from one color to another, maybe with a third color in between. However, one manufacturer that had a wide variety of thermochromic paints, including a paint that shifts into multiple colors over a wide range of temperatures. The type that has the most potential for the project, is the "liquid crystal reversible" in the diagram from this manufacturer. One can see that the temperatures range from ±7 °C up to ±100 °C. Especially the colors that correspond to the higher temperatures are unsafe for use in traffic. Imagining touching a car body that heats up to 100 °C. There are some exceptions in this diagram, with paints that shift color at milder temperatures. But many paints exclusively change color at dangerous temperatures. So that makes thermochromic paint less of a good option.



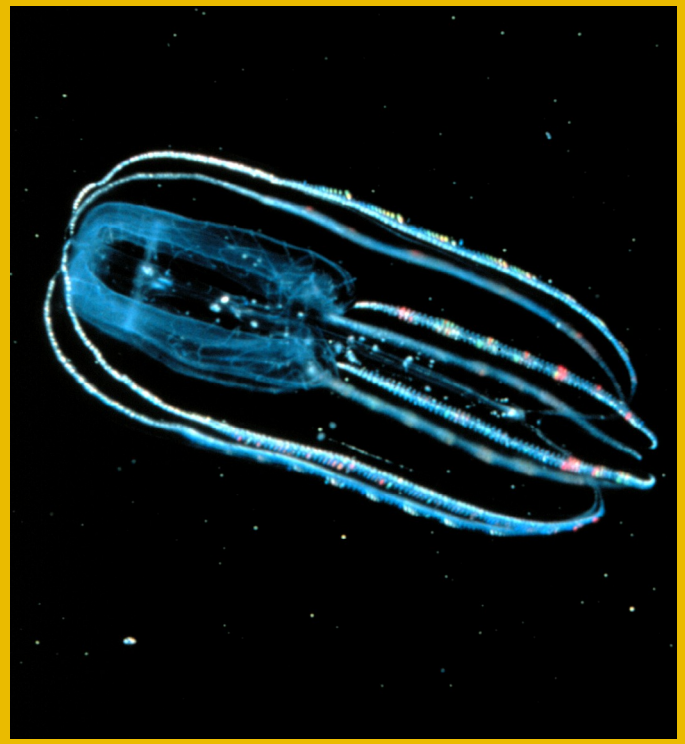
↑ Chart of available thermochromic paint from a industrial-grade paint manufacturer.
Source: http://www.indestructible.co.uk/thermochromic-paint/thermochromic-paint.htm

STEP INTO REALIZATION

Bio- / radioluminescence

An interesting feature in nature is bioluminescence. This phenomenon enables lighting of surfaces more passively than with LEDs. Possibly, also more continuously. However, there is not yet a technological alternative for this. There are materials that illuminate by themselves. Materials like radium and tritium have been used for creating a radioluminescent effect. The radiation it transmits is converted into light by means of fluorescent paint/covers, which responds to both light and radiation from the aforementioned materials. Throughout the years, these materials have become safer for both use and production. But the radiation, and thus the illumination, are continuous; they can't stop or be interrupted. This makes it hard to create an animation of expressions onto the car body. Besides, radioluminescence is still rather unsafe; the radiation will remain harmful to some extent. These objections make this alternative less of a good option.

↑ An example of radioluminescence, in this case: Radium with fluorescent cover.



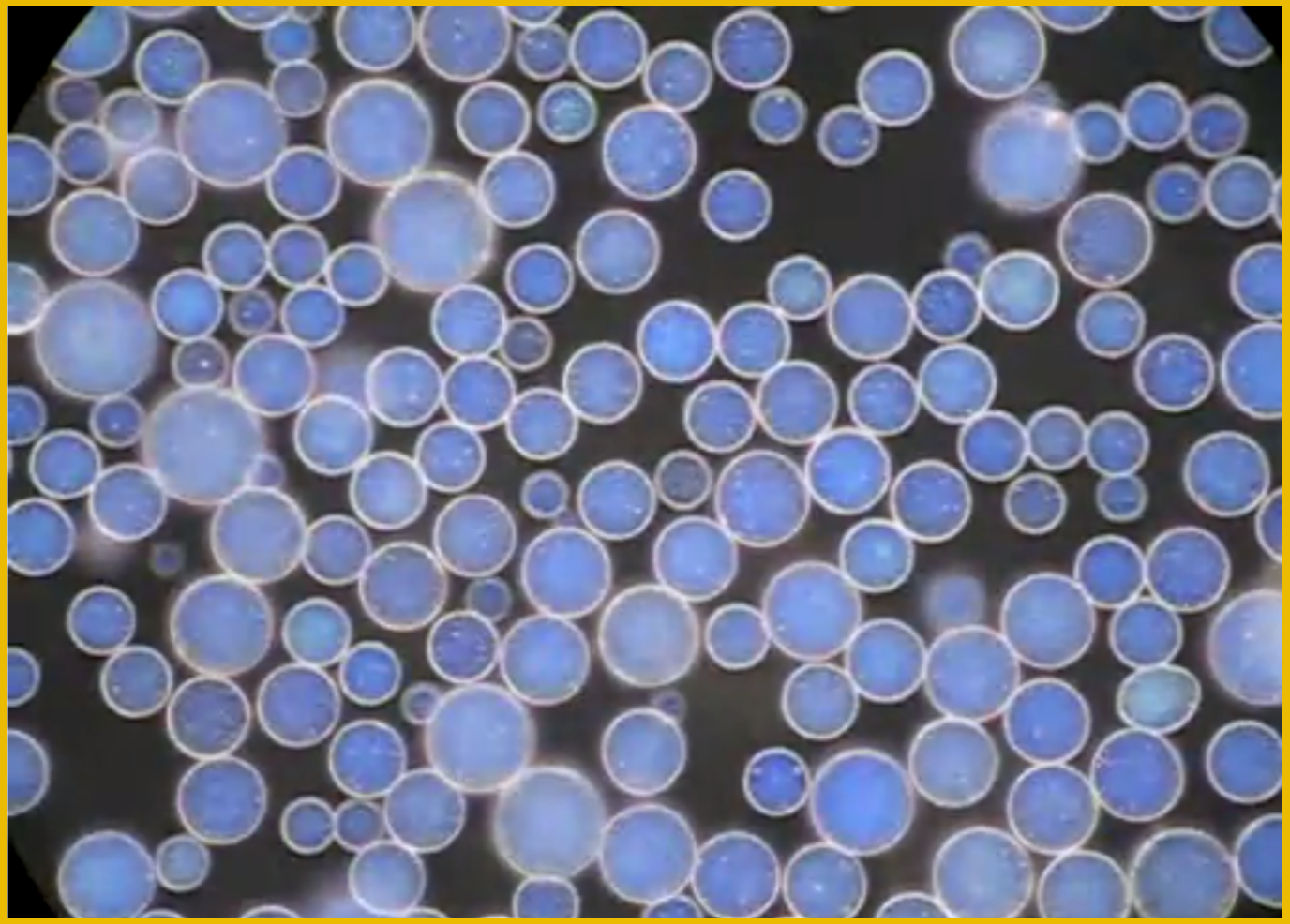
→ Bioluminesence in nature: deep-see life commonly uses bioluminescence to attract prey. In this case, it would serve as a passive light source, like the radioluminescence.

STEP INTO REALIZATION

Magnetochromatic microspheres

This technique works with pigments on nano scale. These pigments can be manipulated by means of magnetic fields. The principle is similar to the technique for e-paper: the pigments are placed into microspheres, and these are manipulated by means of electrical current.

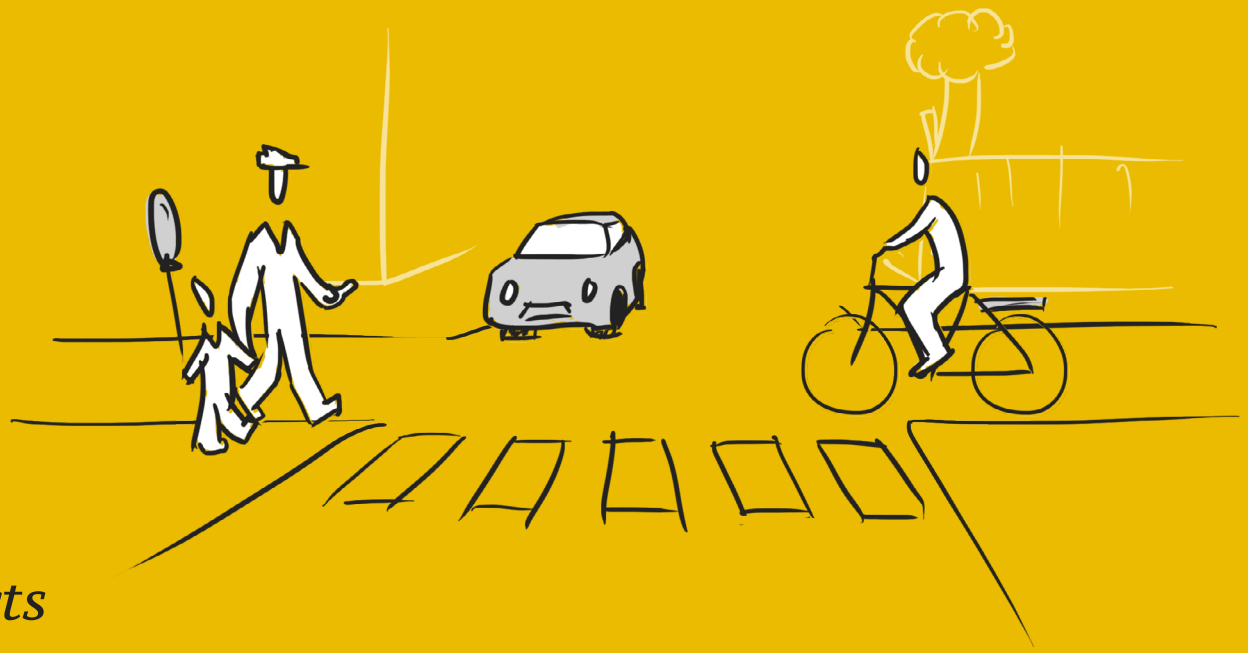
This technology is still in development. It is part of a research project on Riverside University of California. The current state of this technology is that the microspheres are still placed into a liquid solvent, and it is only possible to shift from an "off-state" to a single color [1]. This technology only uses pigments, rather than light. It is more applicable for daytime traffic than nighttime traffic, because at night, these pigments will be less visible after all. This is a major downside, but it still is the best alternative, considering the possibilities and the fact that it does not seem to be dangerous. Hypothetically speaking, this would be the best option for this concept, besides the LEDs.



↑ Magnetochromatic microspheres, a research project from UCR, University of California.

[1] = "*New Fabricated Material Changes Color Instantly In Response to External Magnetic Field*" (http://newsroom.ucr.edu/2124)

STEP INTO REALIZATION



Societal prospects

The concept was designed for a context that includes both autonomous cars and human-controlled cars. The autonomous cars are still work-in-progress, so the context was placed in the near future. The autonomous cars will be designed to blend in with human traffic, but the introduction of these robot cars will still require some societal change. For example, trust in autonomous cars and the interaction between autonomous and human traffic. Building an extra infrastructure is probably too extensive in this case, however that autonomous highway lanes are a reasonable option. But in urban areas there is still need for more human characteristics in the autonomous cars. The autonomous cars need to be able to communicate their intentions with the human traffic participants, signaling giving or taking right-of-way.

Ideally, the expressions speak for themselves, but as driving lesson theory already discusses how human drivers should signal, the autonomous car expression can be integrated into the driving lesson theory as well. However, it also applies to other traffic participants like cyclists and pedestrians. So instead, the traffic exams at primary schools can also cover this. Informal traffic education by parents ("look son, this car is green, so we can cross the road now") can be part of the societal integration as well.

Partially because the autonomous car needs to be accepted by society, but also that the sign-language needs to gradually be understood, the safest option is to start with the gentle expression in any traffic situation that requires communication, before taking a more assertive attitude.

STEP INTO REALIZATION

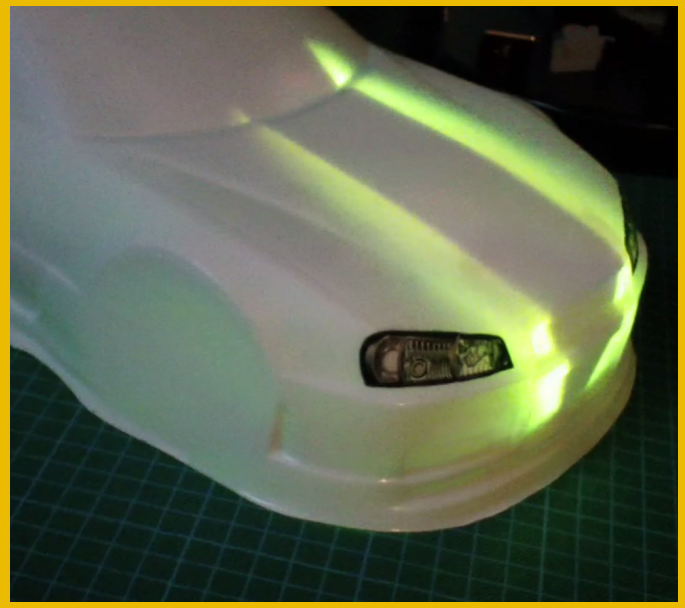
Presentational prototype

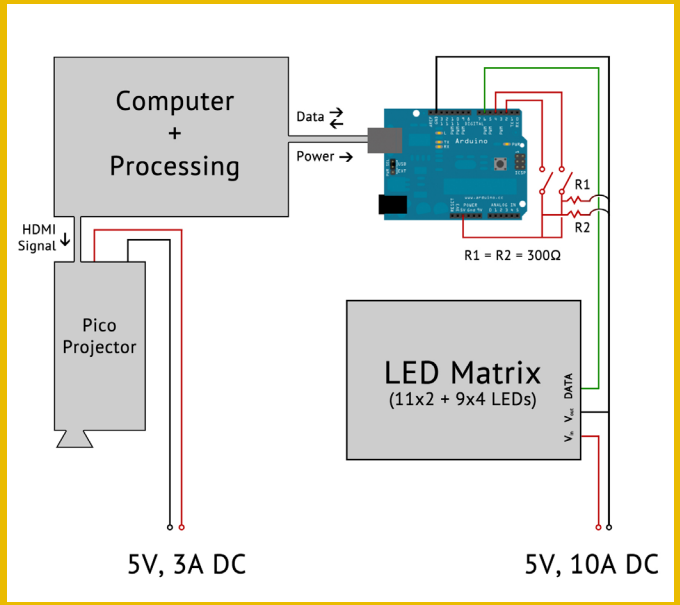
The prototype that was developed earlier on in the process, is not quite related to the project. It does include signals by means of LEDs, but first of all, the signal is not fluid and continuous, second of all, it does not cover the entire model.

Instead, a different technique for presenting the concept was considered, namely projection. This technique enables more of a continuous and fluid type of animation. I could project onto bigger parts of body of a scale model car than just lighting a single plain. I chose to light the model from inside out, so that no light source would be visible. This would create a representation that comes closer to the concept. Besides, it adds to the magical experience that is aimed for at the Next Nature theme, the host of this project.

However, the other prototype could still be displayed at the exhibition, as it is an iteration of mine which reflects how I went through the process of designing the expressions.

The second presentational prototype has been built with the following components.





- A semi-transparent scale model of a car.
- A pico-projector, attached to a fish-eye lens, to spread out the light into a wider angle. This would enable a shorter projection distance. Initially, 360 degrees projection was aimed for, but this would not be feasible. As the front and the sides are the most important surfaces to be projected with the expression, and 360 degrees spherical projection is not possible, the priority lays with projecting on the front and the sides.

Concerning the curvature of the scale model, the animation might require some warping. This requires some experimentation, to find the right distance from the pico-projector, and to find out how the projected image gets distorted by the curvature of the scale model.

The pico-projector will be used as a second screen of a laptop, and a fullscreen processing sketch will be projected on it. The two prototypes have been combined; the Arduino/Processing/LED-matrix combination is used in addition to the fullscreen projection.

FINAL CONCEPT

Context and final idea

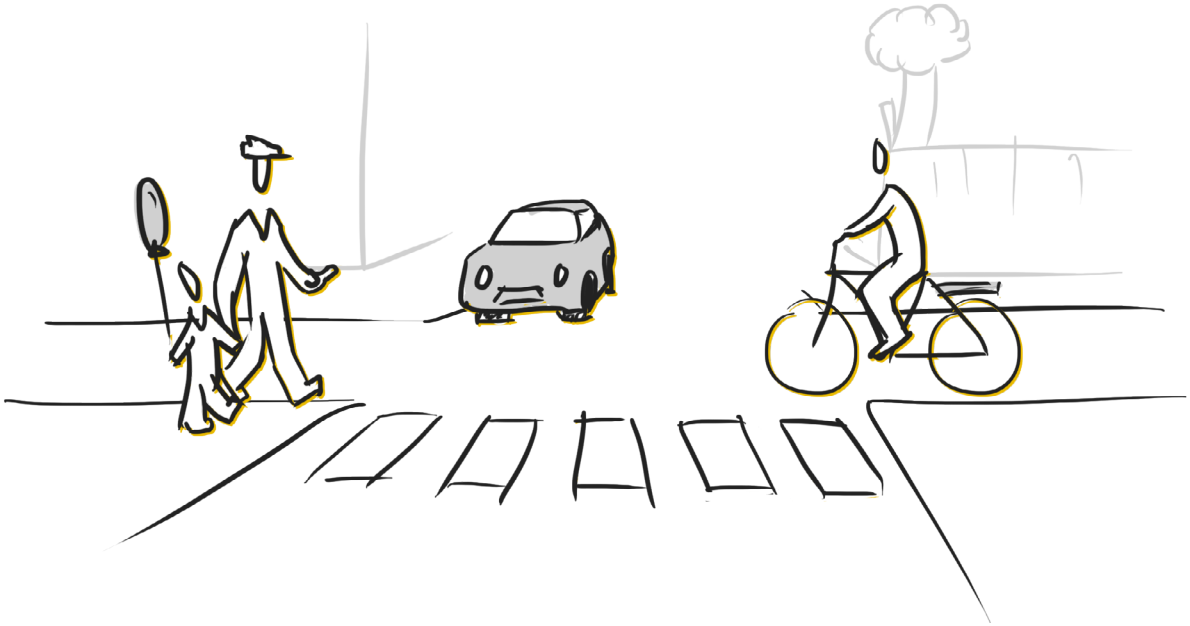
The final concept is A.C.E., which means Autonomous Car Expressiveness. By the time that the first autonomous cars are introduced to daily traffic, there will be an issue with respect to the interaction between the robot traffic participants and the human traffic participants. The human traffic participants probably won't be able to "read" the intentions of the autonomous cars as they are built now. The robot traffic participants will lack a means of clarifying themselves. A.C.E. aims at providing this means of communication between the autonomous cars and human traffic drivers, through a gentle and an assertive expression. The expression will be a color and/or light animation, projected on the front and the sides of the car. These are the plains that face the traffic which requires this type of communication.

FINAL CONCEPT

Target group

The target group of this concept is human traffic participants. This does not include the passengers of the autonomous car itself, as they do not act as traffic participants until they take over control of the car.

The target group extends beyond car drivers. Pedestrians, cyclists and motorists are all participating in traffic, and thus they will all eventually have to interact with autonomous cars. Because "traffic" is such a wide-spread group, this includes people from nearly all ages and nationalities. As earlier documented in this report, this will have consequences for education in traffic in various ways. How will people learn about the meaning of the expressions? Will they have to learn about it after all? The expressions are designed to be generic and easy to understand. But as it will be a new element in traffic that many will encounter, it could be part of the traffic-related education on all the levels: parental education, primary school education and driving lesson theory education.

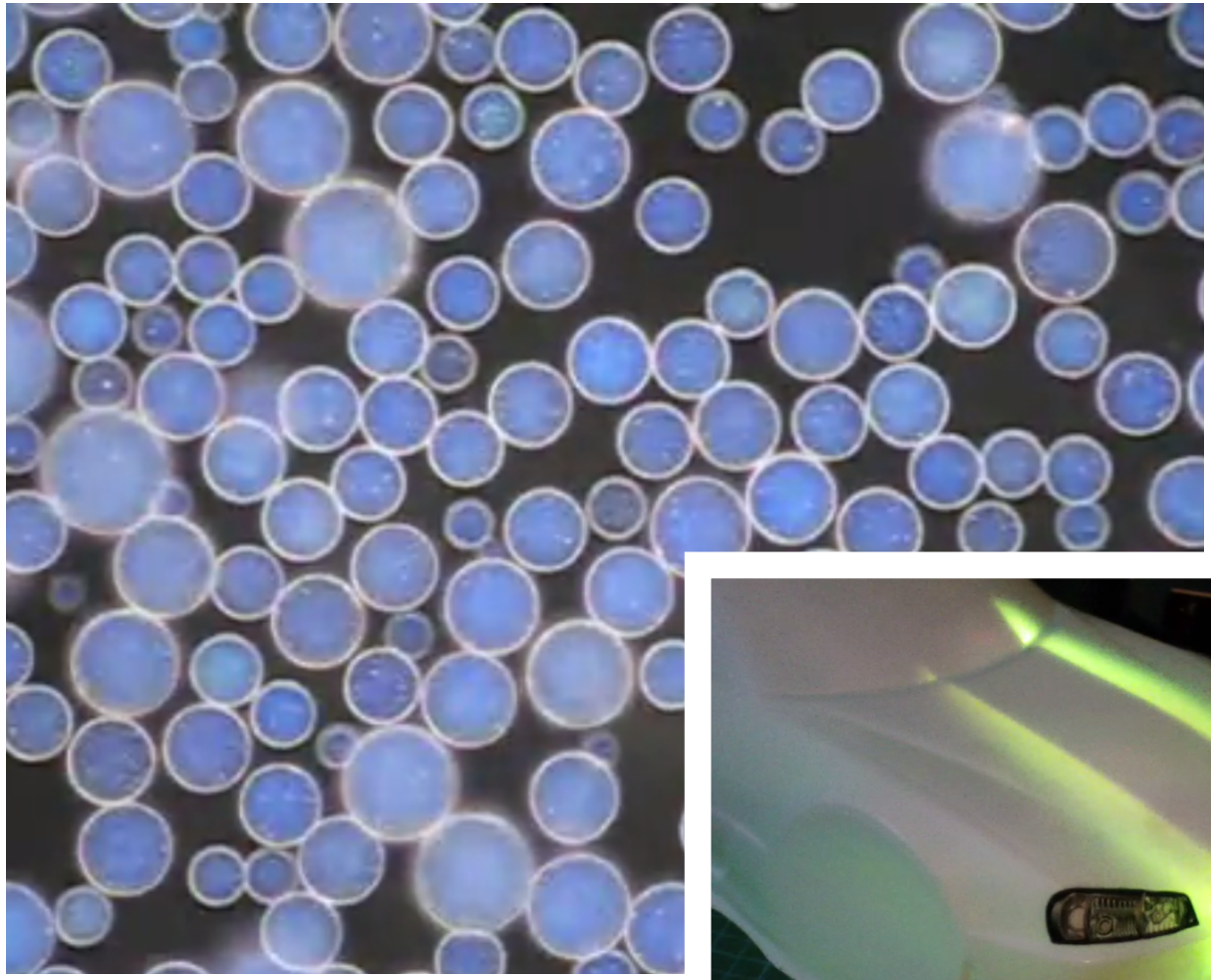


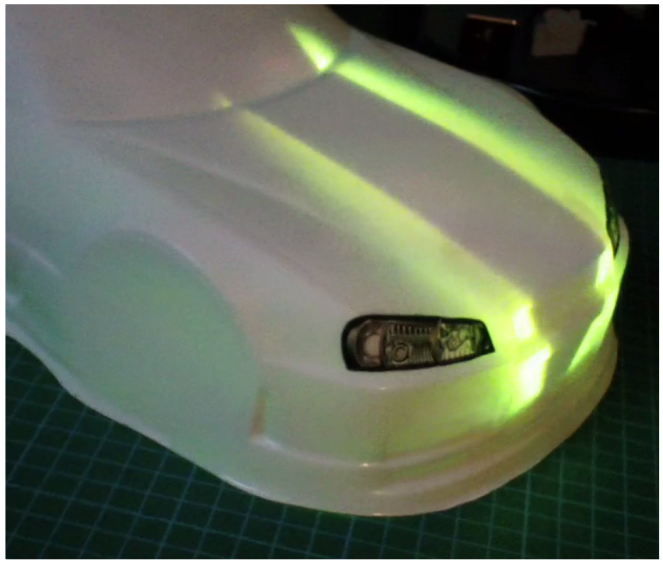
FINAL CONCEPT

Technology

The concept might not be feasible yet, as the envisioned technology is still in development. Besides, the envisioned technology has some limitations. For example, LEDs packed into a screen on the entire front and sides can be annoying for a person's sight; the intensity can be way too high. Lowering the LED intensity might help, but LEDs still have a certain size. In order to make the animation more fluent and continuous, different ways of projection should be used. The magnetochromatic paint is an example of that, but it lack light. This means it is visible in daytime, but not in nighttime.

Ideally, there would be a luminescent paint that would light up and shift color according to the animation that is assigned to it. It would function as a display that stretches all over the covered plains of the car body, but it would not have limitations like resolution, invisibility in bright daylight or intense power consumption. Besides, the light intensity should not be too high: it should remain comfortable to view at both daytime and nighttime.





LOOKING BACK ON PROCESS

Coming back from a great experience at Océ as an interaction design intern (B3.1), my vision changed. My ambitions changed, as I am now interested in becoming an interaction designer.

This is reflected into my B3.2 project; because of my vision, I had a certain goal in mind, and I shaped my project brief early on in the process. I had a direction that I liked to take, which enabled me to focus on the relevant competences and activities for striving after my ambitions.

Compared to before the internship, I definitely made some progress. The depth level of execution I reached during the internship, was achieved this semester as well. I was able to perform more iterations, and the overall process was more integrated with the different steps that one takes as a designer. As a whole the design process covered the different aspects of a final design proposal (prototype, social aspects, visual form giving) in the various iterations that I did throughout the semester. Every aspect now fits more into the design as a whole.

Because the design was highly conceptual and visionary (idea for future appliances), the principles and underlying ideas had to be adjusted to the context, where validation was perhaps less useful. In this case, the concept benefited more from involving the context itself into a discussion about the idea in practice. Here I learned gaining in-depth insight into the context; it was more valuable for process of designing this concept.

Whereas I developed proof-of-concept prototypes in most of the design processes I did, this semester I based the concept on technology that is yet to be developed. So instead, the prototype focused on presentation.

APPENDICES

[A] *Brainstorm with State officials (19-03-2014)*

Aim

The aim for this session is to generate inspiration for developing an expressive shape and form language for the project. I want to communicate three expressive phases. Each of these phases are for different situations in traffic. For the first part of the brainstorm, I would like to use body language, facial expressions, sound and movement for expressing the following phases:

- Gentle:
  Being patient, yielding right-of-way, being friendly and letting other people pass.
  Willing to yield or wait.
- Assertive:
  "Now it's my turn". Pushing yourself through.
  Do not mind or take into account other traffic participants.
  Unwilling to yield or wait.
- Shock:
  Scare-response: "Whoa! Look out!". Alarming other traffic users for their mistakes.
  Waiting, but not wholeheartedly.

Steps

First, there will be a warming up for expressing through body language.

Afterwards, there will be brainstormed about expressions that suit different traffic situations, from different positions. Afterwards, there will be thought of how to implement this into cars.

Finally, the participants will be able to look into the ideas and indicate which idea they like the best, or what they deem safest or most dangerous. From their own perspective, I would like them to explain what they think is good or bad about ideas.

- Warming up: on a boat somewhere on a lake. **The mast breaks, what do you do?**
  - → Come up with solutions.
  - → Only gestures/body language allowed!
- 1st brainstorm: traffic situations: spark gentle, assertive and shock reactions.
  - → Express in different ways than speech or writing. Sound are allowed.
- 2nd brainstorm: think of these expressions, and try to implement them into cars.

Final round: idea review.

- Pick the idea you deem best: why? (from your own expertise?)
- Pick the idea you deem worst: why? (from your own expertise?)

[B] *Co-constructing stories session*

This session was set up in a way that the concept would be understood, and that the participants could be engaged into a discussion about the concept and the various forms of expression.

Specifics

The sessions were held at the TU/e, with 3 students in individual session. It was meant to be a fast way to get input for the project. 8 expressions were shown by means of scenario sketches, along with the neutral state (normal car aesthetics). The expressions (and the neutral state) were discussed in a specific traffic situation. This situation was as follows: a busy pedestrians' crossing at Eindhoven Central Station. In this situation, the participant was asked to view it from a pedestrian's point of view. From each expression they were asked what they would do: cross the crossing, or wait for the car to pass. Besides, discussion was started for why they chose one option or the other.

For the students who possessed a drivers' license, an extra situation was discussed. In the extra situation, they were asked to imagine a situation in which they would approach the same pedestrians' crossing from a car drivers' perspective. They were asked what they would do if they had to cross the pedestrians' crossing.

Setup

The setup consisted out of two steps: constructing the story, and then discussing the various expressions. The session was set up as follows:

- Story construction:
  Imagine you are at the Eindhoven Central Station. You are heading for the TU/e, and you are leaving the station at the northern entrance (facing TU/e). There is a busy pedestrians' crossing over there. You are about to cross the crossing. At that very moment, a car approaches the crossing.
- First discussion:
  <without any expressions applied to the car>
  What would you do: cross the road or wait for the car to pass? Why?
- Expression discussion (iterating through all of the expressions):
  <showing a new scenario sketch, each were "overlaid" with an expression on the car>
  What would you do: cross the road, or wait for the car to pass? Why?
- Extra situation construction:
  Imagine you picking someone up from the Eindhoven Central Station. You are driving a car, and once you picked this person up, you have to drive off and get away from the station. That means you have to cross a very busy pedestrians' crossing.
- Extra situation discussion:
  How would you make your way through the pedestrians' crossing?

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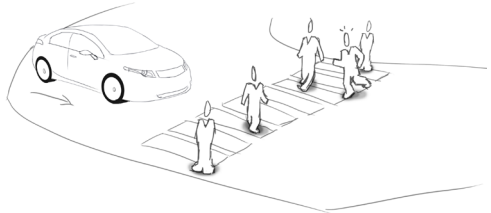
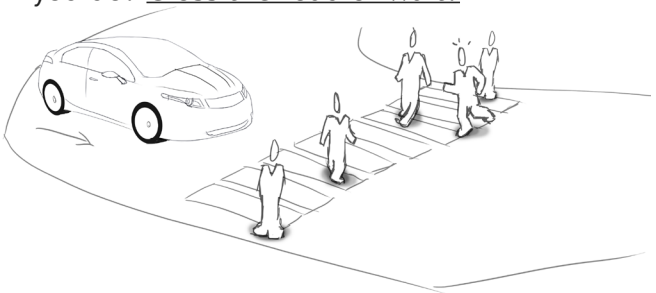
APPENDICES

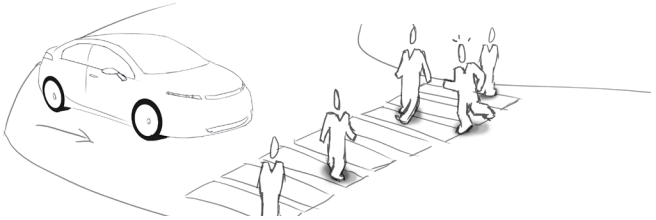
[B] *Co-constructing stories session*



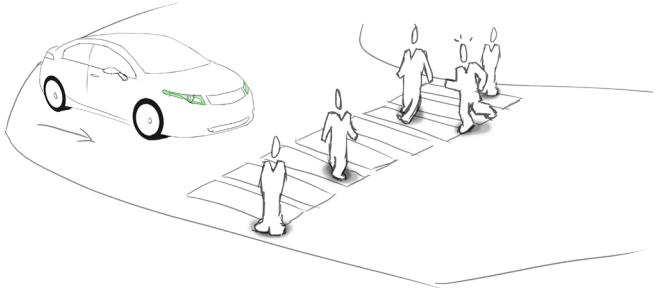
- **Scenario #1:** you're crossing a pedestrians' crossing. A car waits to get through. What do you do? Cross the road or wait?



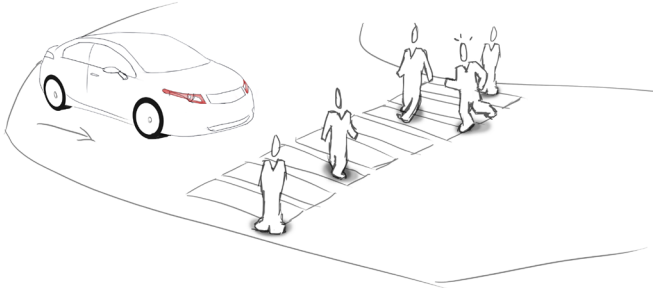
- **Scenario #2:** A waiting car changes shape; what do you do in this case?



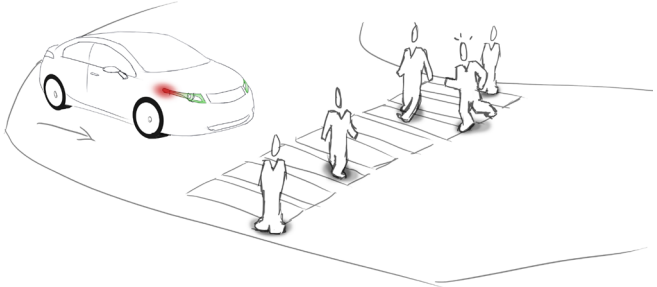
- **Scenario #3:** A waiting car changes shape; what do you do in this case?



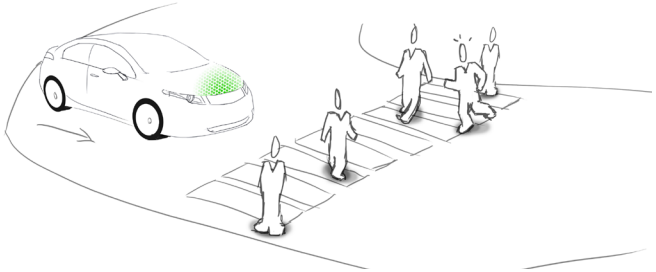
- **Scenario #4:** A waiting car changes headlight color; what do you do in this case?



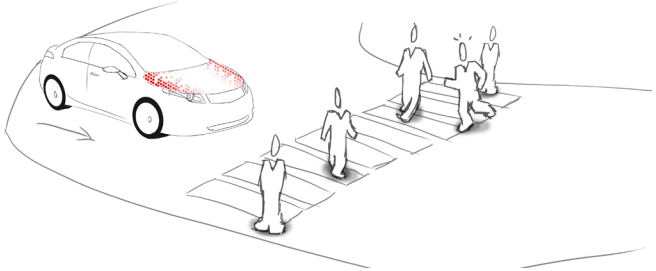
- **Scenario #5:** A waiting car changes headlight color; what do you do in this case?



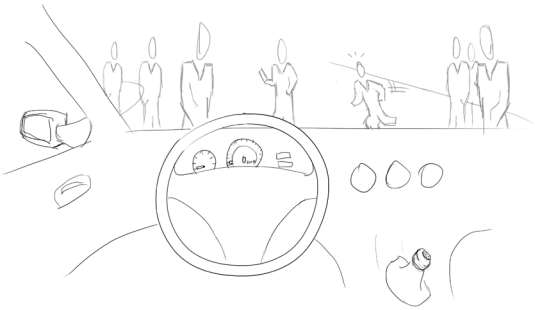
- **Scenario #6:** A waiting car changes headlight color; what do you do in this case?



- **Scenario #7:** A waiting car shows this ambient light signal; what do you do in this case?



- **Scenario #8:** A waiting car shows this ambient light signal; what do you do in this case?



- **Extra scenario:** What do you do to get through a stream of pedestrians at a crossing?

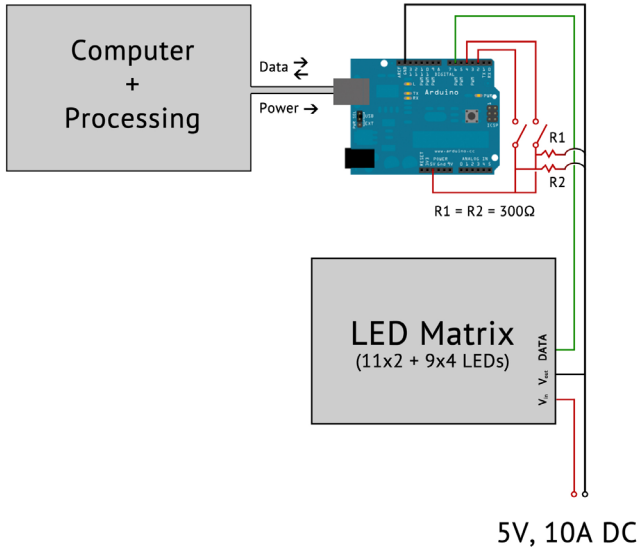
APPENDICES

[C] *First prototyping iteration: challenges*

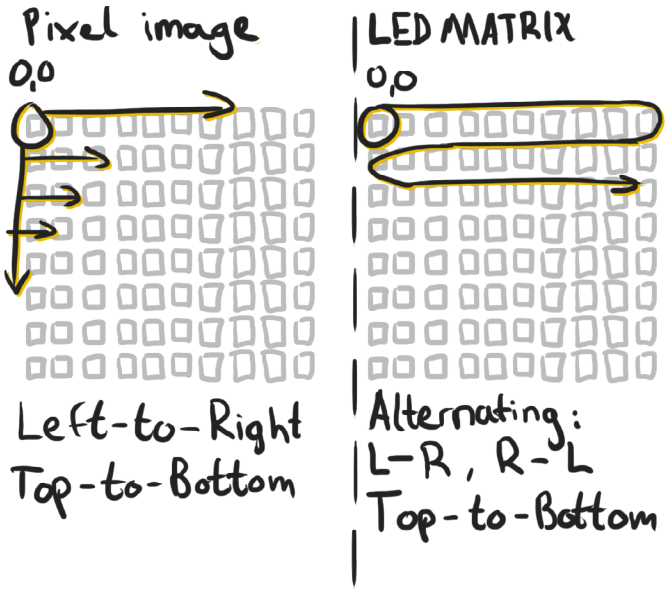
The first prototype was built with a LED matrix. This LED matrix was driven by an Arduino, which received the image data from a computer program called "Processing", through serial connection (USB). During the process of building this prototype, some challenges had to be faced in order to make it work.

First of all, the communication between computer and Arduino. I had to find a way to communicate the images with the Arduino. This small device can't perform image processing. Hard-coding the image data onto the Arduino is no possibility either. The Arduino has 2 kilobytes of RAM, so it completely fills up with data if it is hard-coded.So the image processing should be done before the data is sent to Arduino. By linking a computer to the Arduino, and running Processing to communicate with it, the computer analyzes and sends the image data to the Arduino.

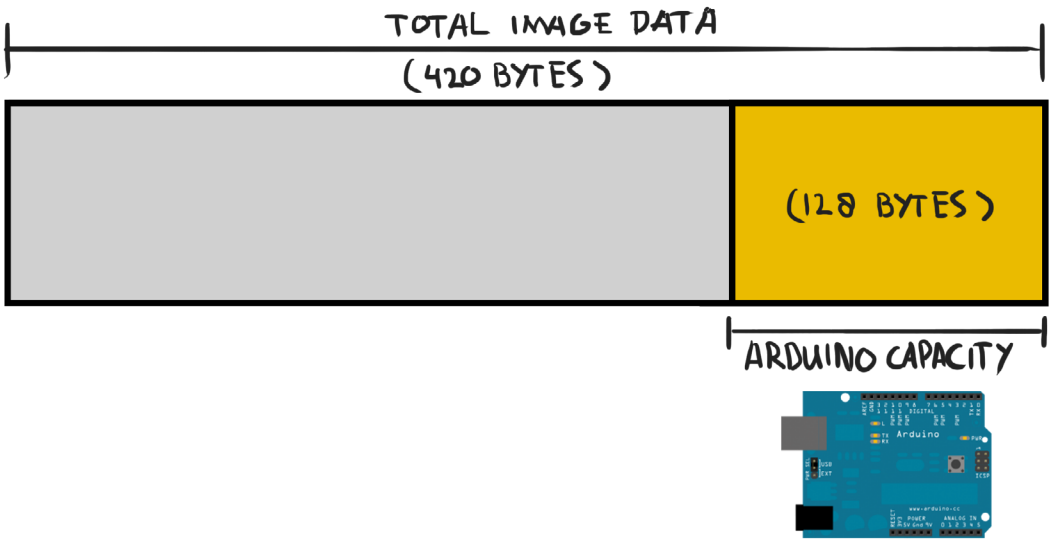
While building a prototype code for both Processing and Arduino, there were some challenges to be faced. The images had to be analyzed and processed into useable pixel data, the Arduino has limited memory, including the serial communication buffer, and serial communication is slow.



The first step in this process would be processing the image. The LED matrix is wired in an alternating way: left-to-right alternated by right-to-left, to decrease wire length. The LED matrix starts top-left, and runs to the bottom. This means the image (stored always top-bottom, left-right) must be analyzed differently. Every alternating row, the direction should be inverted. Another problem was image encoding. JPEG is small, but it does have intentional errors and compression. This compression distorted some of the images, and gave the image noisy artifacts. Instead, lossless data should be saved: BMP format was chosen for saving the pixel data, because it saves raw pixel-color encoding.



[C] *First prototyping iteration: challenges*



After that, the communication with Arduino was considered. Firstly, the data was sent in RGB values (0-255), which means three values per pixel (60 pixels). The problem is the length of the data. Sending it all at once flooded the serial buffer from the Arduino, as the buffer can only contain 128 bytes at a time. The data length is defined in characters (char and byte type are almost equal). The amount of characters per pixel ranges from 6 (0,0,0,) to 12 (225,225,225,). This means the total amount of data ranges from 360 bytes to 720 bytes. This variety is bad; it makes the total length less predictable. A different way of writing the data is required; hexadecimal values were more ideal. By default, the total amount of characters per pixel is 7 (000000,), which makes it more predictable. Secondly, the maximum length is reduced to 420 bytes.

However that this is great, it is still too much for Arduino to handle at once. That is why the data was split up in chunks of maximally 128 bytes. Through serial communication, each chunk would be sent until the final chunk. After that final chunk, the Arduino could update the LED matrix. It worked pretty well, and it turned out to show each image accurately.

Finally, the animation was a bit slow. The Arduino and Processing were both waiting on each other. The interval for sending data might be too big. Reducing this interval lends for more flexibility in timing. So the baud rate was increased. This instantly sped up the animation "frame rate", however, it showed glitches. The computer can perfectly handle fast baud rates, but the Arduino needed some more time. The buffer would not be entirely cleaned before the next amount of data arrived. This meant that there were visible "shifts" in the images. A small delay in transmitting the data from the computer solved this.

[D] *Co-reflection setup*

The co-reflection took place at the government office of the state Limburg. It was held with mobility experts. I divided the setup of the co-reflection as follows: exploration, ideation and confrontation. This is the co-reflection setup proposed by *Tomico (2009)*. The goal was to find out which expression was most effective, and what aspects from the expressions are the most effective.

"Co-reflection: User involvement aimed at societal transformation" (Tomico, 2009)

Methods

Exploration	**Storytelling.** the context is that you are approaching a crossroads. From all the sides, traffic is coming. There is no obvious right-of-way, which causes confusion. What was the last time you were in such a situation?
Ideation	**Eliminating the Obvious.** After the context has been discussed, it was used for imagining a situation. In this situation, no obvious right of way on a crossroads, the participants are asked to signal giving right of way with the current means (claxon, lights, gestures), but perhaps also more creative means. After each suggestion, it would be eliminated, stimulating the participants to come up with new signals until exhaustion of ideas. If you were in this situation, and you wanted to give right-of-way, how would you communicate this?
Confrontation	**Discussing the Designs**. After the ideation is exhausted (no more new means of communication can be found), the participants have been stimulated to engage with the design context, as well as the current constraints. This gets them to understand my design vision better. During the confrontation I show them the expressions that I have designed. From these designs, I ask their opinion about the extent they find it effective, what they would do based on seeing this expression and their overall impression on this expression.

[D] *Co-reflection setup*

Activities	
Storytelling:	⋟ Sketching situation on paper ⋟ "When was the last time"
Eliminating the obvious:	⋟ Discussion: "how would you signal right-of-way"? ⋟ "What if that were not possible"-questions
Discussion of designs:	⋟ Full-screen animation of expressions projected on a car (on-screen). ⋟ Discussion: what do you think of this expression? ⋟ Discussion: what makes you think this way?

Goals	
Exploration:	⋟ Getting in the mood ⋟ Empathizing with a confusing traffic situation.
Ideation:	⋟ Opening up process: what is the underlying problem? ⋟ "Activating the brain"
Confrontation:	⋟ Discussing the designs ⋟ Gaining insight into what are the most effective signals.

[E] *Co-reflection results*

Ideation

Visualization	Results	Quotes
	Struggling to find signals, apart from the standard ones. If there is no way to signal giving right-of-way, possibly taking right-of-way is the best option.	"If it is too hard to give a signal, I'd take my own right-of-way to reduce time waste."

Confrontation

Visualization	Results	Quotes
General results / general discussion	⩾ Very important in the transitional phase, but less in the final phase. Fully autonomous is will only need computer communication ⩾ Only applying a signal to the front of the car may not work well enough (communication towards different directions).	
	⩾ Calm expression ⩾ This car gives right-of-way ⩾ It is not entirely clear in actual traffic.	"If I would see this, I would take my right-of-way"
	⩾ Expresses danger ⩾ Takes right-of-way ⩾ The intensity and the speed give it an aggressive look.	"First thought that pops to mind, is danger" "Expresses like an ambulance" "I think this is very distractive"
	⩾ This expression is regarded vague. ⩾ This expression has no signaling function whatsoever. ⩾ The vague, slow, non-uniform movements cause confusion.	"I don't have a clue what this car tries to say" "This one seems focused on self-expression and advertising".
	⩾ Clearly signals that this car needs room to pass. ⩾ This expression comes across as more understandable and believable.	"Out of my way, I'm approaching!" "The movement is aggressive, but the color and the intensity are less prominent, and make it less aggressive on overall"

[E] *Co-reflection results*

Visualization	Results	Quotes
	⩾ The alternating movement is a bit confusing. ⩾ Could potentially be a strong signal due to the movement, if more in one direction. ⩾ A limited visibility due to the local appearance.	"Looks like a heart-rate from hospital equipment" "If it is more prominent, I would know it gives me right-of-way" "The right-left movement is a bit confusing"
	⩾ Bad visibility due to low position ⩾ Evokes a more functional feeling Like emergency vehicles alarms.	"I am in a hurry" "The low position of the signal makes it badly visible".
 *Second time by request.*	⩾ It is clearer than the horizontal orange signal. ⩾ This signal (taking right-of-way), along with the others is unwanted and aggressive.	

Visualization	Results	Quotes
 *Second time by request.*	⩾ A better example of signaling, green, means "you have right-of-way". ⩾ In a different color, it might be suitable for taking right-of-way; it is more polite.	
General results / discussion	⩾ In a transitional phase, autonomous cars need to gain trust, before they are fully accepted. This might be better easier by making the car focus on giving right-of-way in these situations. ⩾ Prioritizing: who do you give right-of-way? Traffic from the right! ⩾ Waving the crossing traffic in given directions is probably the most effective.	
 *During discussion, third time.*	⩾ However signals like this might be too aggressive, it could be made less aggressive and more acceptable when it is slower, and less frequent. Color might be key here. ⩾ The transition might be interesting as well.	

APPS ON WHEELS

FINAL BACHELOR PROJECT BY JEROEN ROOD

TU/e 2013-2014