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ABSTRACT

The aim of this thesis project was to create something that has never been there before in motorcycle design. A new, deep collaboration between the future generation of riders and their bikes. It should create a whole new riding experience. And this experience should be inspirational and new to several fields of transportation design besides motorcycling.

The process started with the research and inspiration finding. It continued with form exploration through sketching, ergonomic tests and photoshop sketches. The whole process was based on an interdisciplinary working method. Being in touch with modelers, engineers, generative designers, color and trim designers was an essential part of the project. The interdisciplinary work continued digitally, with many different types of software. Creating the 3D visualisation of the project required the use of Alias, Cinema 4D, Rhino, Grasshopper, Fuse, Speedform, Maya and VRED. Frequently reviews on the current project status and taking part in technical meetings, along with responsible designers at BMW, in combination with weekly reviews with the university, structured the time plan throughout the whole project. As well as flying to the university for check-ups and presentations.

BMW Spirit provides a revolutionary experience for future motorcycle riders. Focusing on the interaction between the rider and the bike, it creates the opportunity to build a deep relationship. Since AI becomes more and more important in our daily lives developing ways of human-machine interactions will be crucial for our future. The concept is focused on the opportunities it could bring to combine an Artificial Intelligence with motorcycling. BMW Spirit creates a human-machine symbiosis and is controlled like an extension of the human body, with intuitive movements. The built in Artificial Intelligence is the rider’s companion and develops its own character and consciousness over time. It learns and grows together with the rider and adapted to the rider. Growing trust enables more possibilities to push the limits and enjoying the power of this unique riding experience.
INTRODUCTION

Since I have been a child I accompanied my father on his motorcycle trips. That’s the decisive reason for my passion for motorcycling and bike design. So early on I knew there is no way around making my driver’s license when I am 18. Meanwhile I have a Honda Fireblade and I love riding my bike along beautiful roads of the Alps. I have been riding on the race track a few times as well. The feeling of total control over speed and physics is what motivates me to develop a performance bike concept. When you really feel the boundaries of physics and the way you guide a motorcycle riding along the track with over 250 km/h it changes your mind. You feel every tiny change to your bike and your body and exactly that inspired me to look deeper into this topic. The deep relation to the machine involves a lot of trust to it as well. The control over your body movements always has direct impact on the performance of the bike.

I see great potential in the above mentioned human-machine relationship. Exploring the possible levels of human-machine interaction based on the riding of a motorcycle, can uncover great potential for the whole industry, which basically didn’t change much for the last 60 years.
PROCESS
ARTIFICIAL INTELLIGENCE

The research is a major part of this complex project. It can be split into three main topics with Artificial Intelligence being the first category that has been investigated. It includes future developments, the character of autonomous machines, which principles they would follow and how a machine could express itself besides audible or visual signals.

The next logical step was to find out in which way the machine and the human could work together efficiently. This includes areas like communication, response time, sitting positions as well as haptics and material. Making machines feel alive will be important in the near future with more and more intelligent systems being implemented into our daily routine. The final big challenge during the research phase was to explore how all the collected knowledge can lead to a holistic riding experience that is fundamentally different to the riding of a motorcycle from today. The whole system needs to be thought through in every detail to lead to a credible result.

WHAT IS AI?

From SIRI to self-driving cars, artificial intelligence (AI) is progressing rapidly. While science fiction often portrays AI as robots with human-like characteristics, AI can involve anything from Google’s search algorithms to DeepQA projects to autonomous weapons.

Important to mention is the difference between AI and AGI. “Artificial general intelligence” (AGI) is the intelligence of a machine that could successfully perform any intellectual task of a human being. It is a primary goal of some artificial intelligence researchers and a common topic in science fiction and future studies. Artificial general intelligence is also referred to as „strong AI“, „full AI“ or as the ability of a machine to perform „general intelligent action“. Academic sources reserve „strong AI“ to refer to machines capable of experiencing consciousness.

Some references emphasize a distinction between strong AI and „applied AI“ (also called „narrow AI“ or „weak AI“): the use of software to study or accomplish specific problem solving or reasoning tasks (e.g. only facial recognition or only internet searches or only driving a car). Weak AI, in contrast to strong AI, does not attempt to perform the full range of human cognitive abilities.“ (https://en.wikipedia.org/wiki/Artificial_general_intelligence)

Stephen Hawking, Elon Musk, Steve Wozniak, Bill Gates, and many other big names in science and technology have expressed major concern in the media and via open letters about the risks evoked by AI, joined by many leading AI researchers.

The reason for the recent relevance of this topic is the AI’s potential to become more intelligent than any human. We have no reliable way of predicting how it will behave. We can’t use past technological developments as a basis because we’ve never created anything that has the ability to outsmart us. The best example of what we could face may be human evolution itself. People now control the planet, not because we’re the fastest, biggest or strongest, but because we are the smartest. If we’re no longer the smartest, would we remain in control?

The AGI is programmed like the human brain. It learns and improves by practicing. But in comparison to a human brain, electronic circuits perform 1 million times faster than bio chemical ones. That essentially means that machines think 1 million times faster than humans. Running for 1 week, an AI system could perform 20,000 years of human level intellectual work.

To mention one example of what is already happening today, Facebook’s chat bots have already developed their own language to communicate. They were no longer understandable for humans and had to be shut down. AI’s could potentially create their own programming language and rewrite their code, resulting in the worst case in an escape from human control.

STONG AI OR ARTIFICIAL GENERAL INTELLIGENCE

Open AI and Deep Mind AI are the most ambitious present projects focusing on Artificial General Intelligence systems also discovering and enacting the path to safe artificial intelligence. The most recent achievements of these projects are the victories over experienced players in the games Dota 2 and GO (GO: „more board configurations than atoms in the universe, no way to solve the game by calculation, too complex“ (deep mind CEO: Demis Hassabis)).

New tech spawns new anxieties, says scientist and philosopher Grady Booch, but we don’t need to be afraid of an all-powerful, unfeeling AI. Booch allays our worst (sci-fi induced) fears about superintelligent computers by explaining how we’ll teach, not program, them to share our values. Rather than worry about an unlikely existential threat, he urges us to consider how artificial intelligence will enhance human life.

„Superintelligence: Paths, Dangers, Strategies“ a book by the Swedish philosopher Nick Bostrom from the University of Oxford lays the foundation for understanding the future of humanity and intelligent life. What happens
when machines surpass humans in general intelligence? Will artificial agents save or destroy us?

It argues that if machine brains surpass human brains in general intelligence, then this new superintelligence could replace humans as the dominant lifeform on Earth. Sufficiently intelligent machines could improve their own capabilities faster than human computer scientists, and the outcome could be an existential catastrophe for humans.

It is unknown whether human-level artificial intelligence will arrive in a matter of years, later this century, or not until future centuries. Regardless of the initial timescale, once human-level machine intelligence is developed, a „superintelligent“ system that „greatly exceeds the cognitive performance of humans in virtually all domains of interest“ would follow surprisingly quickly, possibly even instantaneously. Such a superintelligence would be difficult to control or restrain.

While the ultimate goals of superintelligences can vary greatly, a functional superintelligence will spontaneously generate, as natural subgoals, „instrumental goals“ such as self-preservation and goal-content integrity, cognitive enhancement, and resource acquisition. For example, an agent whose sole final goal is to solve the Riemann hypothesis (a famous unsolved, mathematical conjecture) could create, and act upon, a subgoal of transforming the entire Earth into some form of computronium (hypothetical „programmable matter“) to assist in the calculation. The superintelligence would proactively resist any outside attempts to turn the superintelligence off or otherwise prevent its subgoal completion. In order to prevent such an existential catastrophe, it might be necessary to successfully solve the „AI control problem“ for the first superintelligence. The solution might involve instilling the superintelligence with goals that are compatible with human survival and well-being. Solving the control problem is surprisingly difficult because most goals, when translated into machine-implementable code, lead to unforeseen and undesirable consequences.

The human brain has some capabilities that the brains of other animals lack. It is to these distinctive capabilities that our species owes its dominant position. If machine brains surpassed human brains in general intelligence, then this new superintelligence could become extremely powerful - possibly beyond our control. As the fate of the gorillas now depends more on humans than on the species itself, so would the fate of humankind depend on the actions of the machine superintelligence.

But we have one advantage: we get to make the first move. Will it be possible to construct a seed Artificial Intelligence, to engineer initial conditions so as to make an intelligence explosion survivable? How could one achieve a controlled detonation?

NISSAN BRAIN TO VEHICLE TECHNOLOGY (CES 2018)

With the Nissan Brain to Vehicle Technology, real time brain activity is captured to control a car. In fact it can use the signals from the brain even before the body could react to it.

The system is encoding motor cortex activities (The motor cortex is the region of the cerebral cortex involved in the planning, control, and execution of voluntary movements) to know that the driver will be steering in the next 300 milliseconds. This enhances the execution of upcoming events and synchronizes the support with the driver’s action.

With this system, if you are still touching a steering wheel, it feels like you are in control of the car by your hands, even if the steering wheel isn’t even connected to the car’s steering mechanics.
Researchers at the John’s Hopkins University in Baltimore, Maryland developed a bionic arm that responds to human thoughts. It represents a new generation of robotics that can seamlessly integrate with our body. A sensorial innovation that remaps human nerves responsible for touch, enabling the patient to feel through robotic prosthetics just like they would through their real skin.

The University is working on neuro prosthetics that cannot just be controlled with your mind, but that can also give active feedback to your mind, basically making you feel/think something. This is completely revolutionizing how humans interacting with machines.

The modular prosthetic limb (MPL) interprets and converts signals from the human body’s nervous system to motion. When the MPL interacts with objects 100 sensors send information back to the brain (force sensor, contact sensor, temperature sensor), creating a real sense of touch.

The information exchange works on a level that wasn’t achievable before. If the patient wants to open his hands, he just thinks about the movement. The process used to achieve this is called targeted muscle reinnervation. The nerves responsible for the feelings in your hands are reconnected with other muscular systems in different body parts. The brain is tricked into thinking that p.e. your fingers are at this newly located position. Sensors can then read muscle activity from the newly connected body parts and send this information to the robotic arm.

The robotic arm learns how to understand what the patient wants to do so he doesn’t have to control the arm consciously which is a fundamental difference to present-day artificial limbs.

So would people start replacing their arms with robotic ones, if it even feels just normal? Is it an interesting question that could lead to a seamless fade from needed interventions to intentional biohacking.

3D-BIOPRINTING TECHNOLOGY

3D-Bioprinting technology is developing rapidly as well. Nowadays small tissues and blood vessels can be already printed functionally. If you can design them on the computer, you are basically able to print them out. Human stem cells and bio ink/gel are the mainly used materials for the printing processes. When printed, the cells are able to merge to bigger structures and even exchange information between each other. Sugar is used to form vanes. When the sugar dissolves, the vanes are used to supply the cells with blood and therefore keep them alive.
Their Mission: To catalyze and support research and initiatives for safeguarding life and developing optimistic visions of the future, including positive ways for humanity to steer its own course considering new technologies and challenges.

Research Goal: The goal of AI research should be to create not undirected intelligence, but beneficial intelligence.

THE 23 ASILOMAR AI PRINCIPLES
Artificial intelligence has already provided beneficial tools that are used every day by people around the world. Its continued development, guided by the following principles, will offer amazing opportunities to help and empower people in the decades and centuries ahead.

Research Issues
1) Research Goal: The goal of AI research should be to create not undirected intelligence, but beneficial intelligence.
2) Research Funding: Investments in AI should be accompanied by funding for research on ensuring its beneficial use, including thorny questions in computer science, economics, law, ethics, and social studies, such as:
   - How can we make future AI systems highly robust, so that they do not malfunction or get hacked?
   - How can we grow our prosperity through automation while maintaining people's resources and purpose?
   - How can we update our legal systems to be more fair and efficient, to keep pace with AI, and to manage the risks associated with AI?
   - What set of values should AI be aligned with, and what legal and ethical status should it have?
3) Science-Policy Link: There should be constructive and healthy exchange between AI researchers and policy-makers.
4) Research Culture: A culture of cooperation, trust, and transparency should be fostered among researchers and developers of AI.
5) Race Avoidance: Teams developing AI systems should actively cooperate to avoid corner-cutting on safety standards.

Ethics and Values
6) Safety: AI systems should be safe and secure throughout their operational lifetime, and verifiably so where applicable and feasible.
7) Failure Transparency: If an AI system causes harm, it should be possible to ascertain why.
8) Judicial Transparency: Any involvement by an autonomous system in judicial decision-making should provide a satisfactory explanation auditable by a competent human authority.
9) Responsibility: Designers and builders of advanced AI systems are stakeholders in the moral implications of their use, misuse, and actions, with a responsibility and opportunity to shape those implications.
10) Value Alignment: Highly autonomous AI systems should be designed so that their goals and behaviors can be assured to align with human values throughout their operation.
11) Human Values: AI systems should be designed and operated so as to be compatible with ideals of human dignity, rights, freedoms, and cultural diversity.
12) Personal Privacy: People should have the right to access, manage, and control the data they generate, given AI systems' power to analyze and utilize that data.
13) Liberty and Privacy: The application of AI to personal data must not unreasonably curtail people's real or perceived liberty.
14) Shared Benefit: AI technologies should benefit and empower as many people as possible.
15) Shared Prosperity: The economic prosperity created by AI should be shared broadly, to benefit all of humanity.
16) Human Control: Humans should choose how and whether to delegate decisions to AI systems, to accomplish human-chosen objectives.
17) Non-subversion: The power conferred by control of highly advanced AI systems should respect and improve, rather than subvert, the social and civic processes on which the health of society depends.
18) AI Arms Race: An arms race in lethal autonomous weapons should be avoided.

Longer-term Issues
19) Capability Caution: There being no consensus, we should avoid strong assumptions regarding upper limits on future AI capabilities.
20) Importance: Advanced AI could represent a profound change in the history of life on Earth, and should be planned for and managed with commensurate care and resources.
21) Risks: Risks posed by AI systems, especially catastrophic or existential risks, must be subject to planning and mitigation efforts commensurate with their expected impact.
22) Recursive Self-Improvement: AI systems designed to recursively self-improve or self-replicate in a manner that could lead to rapidly increasing quality or quantity must be subject to strict safety and control measures.
23) Common Good: Superintelligence should only be developed in the service of widely shared ethical ideals, and for the benefit of all humanity rather than one state or organization.
THE OVERVIEW OF THE RESEARCH AND CONCEPT

This is the overview of the research and how it is translated into the leading aspects of the concept. With the essential question: „What if motorcycles could feel alive?“.
This overview is visualized with a guiding structure to be able to follow the main points easily.
"WHAT IF MOTORCYCLES COULD FEEL ALIVE?"

The aim of this thesis project is to create a new deep collaboration between the future generation of riders and their bikes. The collaboration will be dealt with on many different levels. Reaching from logical factors like the sitting position, to the mental connection between the intelligence of the vehicle and the human. The fusion between the rider and the bike will be guided by an AGI (Artificial General Intelligence) that is learning from the rider and the bike’s behavior. The aim is that it results in a more efficient and intuitive riding style that incorporates not just the visual sense of the human body.

The concept focuses on the human machine interaction to build a long lasting relationship between the customer and the product in this case the motorcycle. The relationship ensures an emotionally durable and thus sustainable product. Coming along with further advantages such as greater safety, enhanced rider abilities as well as increased efficiency.

A quote by the famous Austrian skier Günther Mader pretty much covers, what the concept is aiming to achieve accordingly the riding experience of the user. "The greatest point in skiing is the feeling you get when you are guiding." (Günther Mader)

The feeling of freedom you get when you are "flying" along the street or track, combined with the sensation of the perfect turn, should create a new level of experience.

Future technologies are essential to translate the concept to reality. It starts millimeters away from the human body with future intelligent clothing which helps not just to sense but also to physically support the human. Like mentioned above an AGI with deep learning capabilities brings the motorcycle to life. This means it will be an intellectual being with a framed consciousness. Since the motorcycle will develop its own consciousness it is important to think about the character of autonomy. How will it behave? How can it express itself/communicate? Where are the boundaries? How will it decide? Will it develop a personality?

Due to the relation between the rider and the bike, both will build trust and thus a safety feeling has to be implemented. It will be about negotiating their intentions and finding the perfect balance. It can almost be compared to the collaboration between rally drivers and their co drivers. They also have to trust blindly, which sometimes takes years to be developed. But when achieved results in a very successful team.

"Imagine surfaces start to communicate with you. Your mobile gets goose skin when your lover texts you. Your WiFi controller changes the look and feeling of its surface according to different game situations. Your sofa gives you a short massage as a warm welcome when you return home from a hard day of work. Your laptop feels dried out when battery status is getting low.

`.fluid.` is a concept study of an interacting, changing surface. While getting input from the hands of its spectators, its surface changes from liquid to solid, from plain to three-dimensional symmetric patterns. It provokes you to get in touch with it, to play with its open interface and to collaborate with other people to find out how far you can push it." (Hannes Jung »Talk to me – Form follows mood« at KISD (Köln International School of Design))

This quote and project description inspires to think of new ways of communication using not just audible and visual input but the surface of the human body as a way of receiving information. It can be in very subtle movements, vibration, temperature change, pressure or in many more ways. These are used to give information to the rider about the asphalt, upcoming corners and the condition of the bike in a way where it becomes subconscious. But also the bike will learn from its rider about his/her intention through these sensorial interactions and adapt in future actions.

The goal of this concept is to inspire future street motorcycles by learning from the achieved greater safety, increased riding efficiency and the enhanced human abilities. This human-machine symbiosis will also create a scenario, how motorcycles would move together with the autonomous traffic of the nearby future maintaining the pleasurable experience motorcycling is all about.
WHAT IF MOTORCYCLES COULD FEEL ALIVE?

HUMAN - MACHINE RELATIONSHIP
SUSTAINABLE PRODUCT

BIONIC HUMAN ENHANCEMENT
NEUROLOGY
BIONIC
SYNBIOSIS
HUMAN BODY AND MACHINES
INTELLIGENT CLOTHS

DEVELOPMENT
EXPRESSION
CONTROL BALANCE
PERSONALITY

CHARACTER OF AUTONOMY

WHAT IF SURFACES COULD COMMUNICATE WITH YOU?
INTENTION & NEGOCIATION
PRESSURE
VIBRATION
STRUCTURE
TEMPERATURE
FLEXIBILITY
STIFFNESS

A WAY OF MOVING TOGETHER

BETWEEN RIDER AND BIKE
NEGOCIATE. THE INTENTION

GENERAL INTELLIGENCE

OVERVIEW
PERSONALITY OF THE AI

- Framed Development

The development of the integrated AGI has to be kept inside of certain boundaries. These boundaries could p.v. be the values/principles by the future of life institute (see page 15) but have to be tailored to motorcycling specifically.

WEAK AI
- If there are just dedicated tasks fields for the AI to improve in, the range of improvements is highly restricted and directed by the manufacturer/software. Individual adaption by the user is less effective.
  - Low risk/low reward

OR

STRONG AI
- AGI is needed if the MC is just a part of a bigger system (e.g. smart home) and the AGI must take “multidisciplinary decisions”. It could judge on its own which information about the user/surrounding is important for more efficient development.
  - High risk/high reward

Anxieties and Solutions

The implementation of artificial intelligence comes with several anxieties, which have to be addressed.

How can the AI take over control without surprising the rider?
- A solution to this would be asking for approval.
  - While riding a motorcycle, there would be hardly time for that. The AI has to judge in each situation if the human control or automation is more efficient or necessary.

How can a rider trust the AI’s decision-making?
- The average future human will have more natural trust in computer systems by the rise of AI in everyday life.
  - By experiencing the bike, a rider will grow the trust level over time. On top of that, the AI could demonstrate its skills without the rider being on the bike.

Which ethical values and principles does the AI follow?
- This topic cannot be answered in any clear way, but there are several directions it could go in the future.
  - Values could be manually programmed by either the user or the manufacturer from stock. The values could adapt to the “average human’s” values or to the specific users’ values.

This question also brings up a lot of follow-up questions like:
- How is it treated if the AI adapts to the users’ ethical values/principals and these cause any damage?
**DEVELOPMENT OF AGI**

An AGI system has to learn over time how to react to certain situations. This happens on multiple levels. The first input to the software would happen manually by the rider’s basic information. The software then needs to learn how to interpret these basic inputs to later transfer them into physical actions. Another level of learning will be the rider’s reaction to the AI’s behavior in certain situations. The AI can blend in more and more over time by adapting to the rider’s skills/attitude/decision-making. It can also be used to train or challenge the rider to enhance certain skills. Since the AI is part of a whole system, that is implemented in your daily life, it will have many more input values that can be taken into consideration.

---

**ARTIFICIAL GENERAL INTELLIGENCE**

The opportunities it could bring to combine AGI with motorcycling:

- New riding experience
- Relationship trust building
- Physical + neural connection
- Enhance rider’s abilities
- Greater safety
- Communication between rider and bike
- More efficient riding
- Emotionally durable product
- Influence the architecture of future motorcycles

---

**CONTROL BALANCE OF MOTORCYCLING (UNCONSCIOUS)**

- Accelerating
- Braking
- Steering input
- Turn/radius
- Weight distribution (gyroscopes)

**INFLUENCES**

- Safety
  - Possible active Hazards
  - Possible passive Hazards
  - Weather
  - Road condition
- Rider
  - Heart rate
  - Stress level
  - Concentration
  - Hormone levels

---

**AGI SAVED**

Plug to motorcycle

NOT BOUND TO IT

Learning from different situations
EXPRESSON OF CHARACTER

1. MOVEMENT
- TURN/ANGLE
- ACCELERATING
- BRAKING

RESPONSE IN DETAIL
- Movement of whole body
- Shape change
- Surface communication

1. Emotional
- Calming
- Soft/Gentle
- Aggressive/Rough
- Anxious
- Excitement
- Stressed
- Loose/Fun
- Controlled/Focused
- Pushing
- Rational
- Accelerating
- Braking
- Scanning/Calculating
- Turn/Angle
- Caution

2. SHAPE CHANGE
- Fun (wriggling)
- Pushing
- Calculating
- Caution/Anxious
- Accelerate/Brake
- Scanning

3. SURFACE COMMUNICATION
- Controlled/Focused
- Color
- Loose/Fun

BASIC NATURE
The AI is programmed based on the principles of the Future of Life Institute. For this reason, the basic characteristics of the AI are guaranteed.

LOYAL
CONFIDENT
ENTHUSIASTIC
The rider will show his intentions with movements of his body. The AI will react on these intentions. Each movement of the reactions can feel different, expressing the character of the AI. The AI will develop adapted to the rider. It will have a calmer character together with a cautious rider and it will be more pushing together with a confident and fast rider.
This artificial limb can be controlled by thoughts and you can feel through it. When the arm grabs something, sensors conduct this movement to the brain and you can feel what the hand is touching.

This was the inspiration for the thought: „What if you could steer the bike like an extension of your body with intuitive movements? What if you don’t need handlebars anymore, what if you could directly hold on to the bike and control it with your whole body?"
BIONIC HUMAN ENHANCEMENT

CAN YOU IMAGINE THE CAPABILITIES OF A HUMAN MACHINE UNION THAT IS NOT JUST WORKING TOGETHER BUT NEUTRALLY CONNECTED AND EVEN ARTIFICIALLY MANUFACTURED TO ACHIEVE A COMPLETELY NEW EXPERIENCE OF INDIVIDUAL TRANSPORT?

FUSION OF THE HUMAN BODY AND MACHINES

LEVEL 1 MUSCLE CONNECTION (MOVE BY MOVEMENT)
LEVEL 2 TARGETED MUSCLE REINNERRATION (MOVE BY THINKING)
LEVEL 3 TARGETED SENSORY REINNERRATION (SENSORIAL FEELING)
On the one hand, there are the Sensorial Interaction Areas, where the communication between the rider and the bike happens and the expression of the character of the AI. On the other hand, there is the Dynamic Fusion. Inspired by the Bionic Human Enhancement aspect. The symbiosis of the rider and the bike and the steering of the bike, like an extension of the human body.

The triangle structure visualizes the communication principle. On the one side there is the Artificial General Intelligence and on the other side there is the rider. They communicate through the motorcycle. So the bike is the medium for communication and the expression of the AI’s character.
**Design Essentials**

The Design Essentials are the results of the research.

The first point is to bring the BMW characteristics into the design and further develop them. Furthermore, the Sensorial Interaction Areas need to be integrated into the design. The expression of the character needs to be implemented and visualized. And a very important aspect is to create a symbiosis of the rider and the bike or even to integrate the rider into the bike. When you want to be able to steer the bike like an extension of your body, the bike needs to be able to follow the movements of the human body.

The year 2048 was chosen as a time horizon. Thinking about the target group, you need to consider that the target group is not born yet or they are children at the moment. That means that they have a completely different relationship toward motorcycles. They are also more familiar with the topic AI and how to interact with it.

The concept bike can be used in the cities, but it is mainly for longer distance trips and performance situations like riding on the racetrack.

**Package Development**

The center frame is similar to the human spine. It holds all the important elements. It also works as the suspension for the front and rear driving unit. The upper frame element houses the sitting structure, the light elements and the flexible battery. The Flex-Battery consists of small cells that are housed in a flexible shell. These cells create an electric circuit that changes if the battery’s shape changes. The flexibility is needed due to the bike’s ability to twist and bend while riding. Each sphere has multiple positive and negative contacts that are automatically activated/deactivated depending on which circuit is used at the time. Inside of the front blade are spheres that transfer the energy to the ground. They are controlled magnetically. Spheres can turn 360°, so a lot of new movements are possible with this architecture.
At the beginning of my project I thought about the question: „How can the riding experience of the future be different than today?“. I tried to find ways how to move and steer the bike intuitively.

Furthermore I tested different sitting positions and their ergonomics. I looked at the negative shape of the human body and how I can integrate it in the design.

I had the opportunity to mill a 1:1 scale model at my university. So I did experiments of how the rider could be even more integrated into the bike. How the fusion between them two could be even more intense.

One approach was to connect the rider and the bike with a stretched fabric which could also support the communication between them.
TESTING + EVALUATING

CONNECTION ELEMENTS
STRECHED AND ELASTIC
ONE POSSIBLE WAY OF SURFACE COMMUNICATION
For this Degree Project the possibility to remap human senses and combine them with electromagnetic circuits opens a ton of new possibilities to achieve the most intense rider-bike relationship-experience. The bike could become as familiar to the rider as the own body, controlling it almost subconsciously, seeing it more as a process of growing together rather than expanding human capabilities. Learning to ride this vehicle will than feel more like learning to walk. This would also change the role of the AGI system in this collaborative experience. Its role would be more shifted towards the process of learning and understanding rather than controlling and driving on its own.

It’s also comparable to a rally driver and its co-driver. It’s a very long team-training process in which trust is one of the main factors. Cutting edge drivers can
almost blindly navigate through the stages in high speed on the physical limits. That’s not just because they are the most talented drivers, but because the calls and descriptions of their co-drivers are so accurate, they can immediately transfer them into tiny steering movements or throttle/braking actions. Also when analyzing drivers you can clearly determine who is driving with full trust and who is driving on sight.

There are similar insights when observing dancers by their harmonious interplay. Small indications to the partner lead to aesthetic movements together as a couple. It’s also after long training a subconscious process that lives from the emotion and feeling during the execution.
HAPTICS

Defined as interactions that involve the sense of touch, it’s a major topic to ensure functionality of the concept. Haptic communication is very important to achieve a level of subconscious communication between a human and a machine. The ability to recognize an object, a meaning, or a feeling by touching something is important to explore. The Haptic perception of humans is defined by our evolution, which led to a certain distribution of touch sensors spread around our body.

Now it’s about haptic technology to use our body as a tool of perception. An interface that communicates with the user through the sense of touch has to be optimized to fit the human abilities, since the touch sense for humans is comparatively rough. Human’s ability to learn by training although shows great potential to achieve a subconscious way to communicate haptically.

Muscle memory helps drastically to sensitize human perceptions over time to get more precise results. (p.e. Riding a bicycle is impossible to unlearn, riding a bicycle that steers reversely is impossible to ride without month long intense training.)

In case of the motorcycle, the linking element that plays a big role in the communication is in fact the suit the rider wears. As the first layer above the skin of the rider, it can establish direct contact to the skin and underlying muscles to exchange information with the body. Features like air pockets or artificial supportive muscles integrated into the suit will provide a much more holistic riding experience.
**USER GROUP**

Defining a new kind of user group within motorcyclists is quite challenging due to the fact that there is such a vast amount of heritage and history linked to motorcycles in general.

Generally, riders can be put into four groups. The Cruisers, The Sport Riders, The Adventure Riders and Stunt/Off-road enthusiasts. But within those groups there are tons of subcommunities such as people that love not just motorcycles but also repairing and modifying them. People that do it for the social factor or the performance driven person, etc. Since there is no real functional justification for a motorcycle as a medium of transportation, the user group is fully defined by the provided experience. The feeling of a deep relationship to the bike and a connection to the human body, is something yet to be discovered. The more intense riding experience will attract people who love to focus fully on the riding itself. Also, a platform for technology is provided with this concept. It’s a way to challenge the tradition of motorcycling by autonomous technologies, but maintaining the pure focus on the riding experience.
Batteries of the Future

Since electric driving technologies become more and more efficient and battery sizes shrink, the concept of electric motorcycles becomes a real option for the public. Apart from scooters, actual electric motorcycles are mainly built by smaller manufacturers that focus on Electric drive only like Zero, Energica or Evoke to name just a few.

The battery capacity is in fact the major drawback on electric driving technology nowadays. Batteries are simply too big and heavy for what they deliver in effective driving range. The most modern systems today are able to charge a motorcycle to 85% in about 20 minutes with a DC Charger providing a guaranteed range of 120 Km. It sound okay at first, but is considering an average of 70 km/h still means that 20% of your time during a trip will be waiting for recharge. Luckily, the future predicts brighter times for Li-Ion battery technology. Predictions for the solid state Li-Ion Battery say that the capacity of such batteries should double in around 5-15 years. Some producers also consider the reusability of battery packs for stationary home energy storage until they reach their terminal age, and get recycled carefully.

Another promising power saving solution for electric vehicles is the Redox Flow Battery. Usually intended to be stationary energy saving solutions, the recent reduction in size opens very new opportunities.

The Flow-Cell mainly consists of two tanks of electrolytes flowing past a membrane, exchanging ions through the membrane in one or the other direction while charging or discharging. One major advantage of this Battery solution are the two recharging possibilities. It can be recharged like every other battery, but the liquids can also be swapped, providing a fully recharged vehicle in just a few minutes. The process of swapping the liquids could even use the currently existing gas station network, which in combination with charging station, would provide a perfectly stable grid for EVs.
ADDITONAL RESEARCH

BMW MOTORRAD HISTORY

BMW initially started as an aircraft engine company during first World War. After deciding to enter a new terrain and produce motorcycles from 1921, BMW became technology leader in the market. Max Friz is known as the forefather of the famous Boxer-Engine, which he designed during the uncertain period after the war for BMW. The next milestone in BMWs design history is defiantly the BMW R5 which was for its time, one of the most sporty motorcycles due to its high power to weight ratio. Many innovations in motorcycle design such as the nowadays common hydraulically damped forks (R12, 1936), or the first ABS system on a motorcycle (K100, 1987) originate from BMWs drawing boards. Even the first Concept bike (Futuro, 1980), or the first production motorcycle with a full fairing (R100RS, 1977) were developed in the hands of BMW.

In recent years BMW held its position as the motorcycle market leader in Europe, with the GS models being the best-selling product of BMW Motorrad worldwide.

The design language followed by BMW in modern times is defined by two main attributes. Precision and Emotion. These are two very contrasting attributes, which represent the aim to seamlessly integrate the technical parts on a motorcycle into the sensual fairing surfaces, maintaining both characteristics.

898 CCM, 67 PS  980 CCM, 70 PS  98 PS
AFTER-RIDING EXPERIENCE

A motorcycle, compared to a car, delivers a unique riding experience. Leaning into corners is something you usually do not get on the road. The experience could even make your daily commute, or shopping trip a special routine.

Paired with modern Capturing and VR technology, a motorcycle could provide the perfect platform to share the riding experience online on social media or other future platforms. The technology can also be used to compare riding styles, and learn from each other by viewing another rider’s footage via VR.
GOALS AND WISHES

The focus of the project should be set on the new ways of interaction and information exchange between the rider and the bike. It should feel like a new level of human-machine collaboration.

I want to create a concept that shows the potential of future technologies in the motorcycle industry. It should retain a riding experience that is fundamentally different from the known motorcycling, which didn’t change much for almost 100 years.

The outcome should not just satisfy the purists of motorcycle riders, but also bring a new user groups to the field.

The visual appearance will be influenced by the new use of technologies as well as BMWs future visions. The actual functionality of technical components will be justified by meaningful assumptions, since these cannot be tested during the project. Focus on visualizing and detailing of the HMI & major touch points.
CREATIVE DEVELOPMENT
1. STRUCTURE
The whole motorcycle is structured in a way that allows the rider to slip through certain parts of the outer shell. Different sitting positions use different parts of the vehicle. Cutting the whole volume into stripes enables the motorcycle to follow the movements of the human body.

2. VOLUME STUDIES
Organic + Performance
3 SITTING POSITIONS

While analyzing the sitting position of the rider in every possible situation, the body contact areas were determined. These are used as a medium for human-machine-interaction in different ways while riding.

4 STRUCTURE DEVELOPMENT

The final arrangement of the stripe structure is an important stage. All three functions: beaming, communicating and comfortable riding can be considered wisely here.
DEVELOPMENT

Picture was the next

ending,

had to
5 DESIGN DEFINITION

BMW Character:  Main appearance = Perception
Structure = Emotion

The main appearance show the performance of the bike and the stripe structure brings emotion. It makes the bike feel alive!
THE RIDER
Bionic Human Enhancement Bike = Extension of the human body.

Light Performance Helmet
Flex Suit
Body Sensing Area
Sensorial Interaction Areas
Performance Boots
These screenshots show snapshots of animations that show how the bike is controlled and how it behaves. Like mentioned above, the character of the AI will develop differently, according to the rider.

The screenshot 1 shows one example of a confident rider, who loves speed. He has a fast and pushing riding style. The response of the AI feels pushing and edgy. Showing that the AI also wants to go fast and telling the rider, when he could go even faster.

The second example shows a cautious rider with an enjoying and relaxed riding style. Adapted to that the AI shows its approval with calming and soft movements.

The battery concept, developed during this project, combines the advantages of a petrol driven and electrically driven vehicle. You can charge the battery pack or you empty the cells and refill charged ones, as quickly as refueling a car today. This could bring e-mobility one step closer to a practical daily use.

Braking and accelerating are two major actions that...
define this unique motorcycling experience. The screenshot shows the intuitive and simple movements for accelerating and braking. During accelerating the bike get slimmer and sleeker to reduce the air resistance. During braking the volume of the bike increases to support the movement of the rider.

4 The front blade can shift separately to dodge obstacles.
5 Each sphere in the front is suspended separately.
3D DIGITAL MODELLING

The main volume was built in Autodesk Alias. To create the stripe structure the Rhino plug-in Grasshopper was used. The technical elements were built in Autodesk Speedform.
RESULTS
THE FLEX-BATTERY

The Flex battery consists of small sphere cells that are housed in a flexible shell. An elastic battery is needed because of the motorcycles ability to bend and twist. The battery concept, developed during this project, combines the advantages of a petrol driven and electrically driven vehicle. You can charge the battery pack or you empty the cells and refill charged ones, as quickly as refueling a car today. This could bring e-mobility one step closer to a practical daily use.
**THE PACKAGE**

The central element of the vehicle is a spine-like construction which controls the movements of the bike. It also works as a suspension for the front and rear driving unit. The front steering unit houses 3 contact spheres, which transmit the steering input to the road. They are based on the same principle as a stepper motor.

**THE STRUCTURE**

The rider steers the bike with his whole body, so the motorcycle needs to follow the movements of the human body. The structure ensures the agility of the bike and the communication between the human and the motorcycle, through the sensorial interaction areas. It also supports the different sitting positions and the transitions between them.
Because of the emotional relationship between the rider and the bike, the design is more organic compared to today’s motorcycles. The symbiosis of the rider and the bike is an essential element of the concept.

An important part was the layout of the stripe structure. In the middle of the bike the distance between the stripes is the biggest, because there the bike needs to be the most flexible. The distance is getting smaller towards the rear and the front of the bike.

The matt connection elements between the stripes are only located where the rider touches the bike in the central area. They are fading out towards the front and the rear of the bike and are preventing the rider from getting trapped between the moving stripes.

The front blades represent the solid part of the bike, with a closed form language. The middle and rear part of the bike have an open and fractal form language showing the bike’s agility.
The topview shows the flow of the volume, adapted to the human body, while the front blade and the tire split are aligning, to form a strong stroke. Visually cutting through the centerline of the vehicle.
A simple rear light design, aligning with the rear tyre. And a view in the technical area of the bike.
This view shows in detail how the distances between the stripes get smaller towards the front of the bike. The connection elements between them are fading out towards the front. The two first stripes merge with the head of the motorcycles.
The footrest and the guiding panel for the legs are aligned to each other to create a visual connection of these two elements.
I maintained the same design language for the upper and lower blade in the front, to create a visual connection between them two. Regarding the color concept: The warm main color of the bike represents the human factor in the concept and the blue color stands for the machine part, to also emphasize the fusion of the human and the machine.
A HUMAN–MACHINE SYMBIOSIS.
The AI is the rider's companion and develops its own character and consciousness over time. It learns and grows together with the rider and adapted to the rider. The human steers the motorcycle like an extension of his/her body, with intuitive movements.
A NEW AND UNIQUE RIDING EXPERIENCE.
UN S.D. GOALS

SUSTAINABLE DEVELOPMENT GOALS

Industry innovation and infrastructure
The project pushes heavily into a very new field of technology. Since AI becomes more important in our lives daily, developing ways of human-machine interactions that are not just screen based will be crucial for our future. The project is focused on a very intuitive and seamless communication that could influence our future lives in many fields besides riding a motorcycle.

Affordable and clean energy
The battery concept, developed during this project combines the advantages of petrol operated and electrically driven vehicles. Since you can change the filling of the battery pack, and charge it individually, the “charging time” can be reduced to a point where it’s quicker than refilling a car. This technology would bring e-mobility one step closer to a practical daily use.

Gender equality
The AI based driving concept enables everybody to enter the field of motorcycling. The individually adapted character of the bike provides a valuable learning curve for each individual rider. The arbitrary sitting positions as well as the bikes ability to self balance remove any physical restrictions from the driver, since it can support where it is needed.
Before the degree project started, I set myself three big goals.
I wanted to create something, that has never been there before in motorcycle design. It should create a whole new riding experience. And this experience should be inspirational and new to several fields of transportation design besides motorcycling. With the question: “What if motorcycles would feel alive?” I created a challenge that was rather complicated to solve. But looking back on these initial wishes I can say that I’m pretty satisfied with the result.

When bringing the rider and the bike even closer together on several levels than today, the sensitive human-machine collaboration became the number one feature that differs this motorcycle from any other out there. This combined with the flexible structure created a whole new story in my mind. A seamless smooth and individual experience, getting rid of all the restrictions current motorcycles bring with them.

Working with the human body on such a detailed level was a big challenge at the beginning. It required a lot of testing, and experiments physically, as well as virtually. Especially analyzing all the touch points to find out how feelings can be transmitted from a machine to a human body is very interesting and taught me a lot about ergonomics and body movements.

A very contrasting part to the human on the other hand was the package development. The aim here was to go for credible assumptions, since testing things was not possible.

During the process I talked to engineers at BMW about certain parts and details to discover more and more how things could come together as one unit. It was a constantly progressing process due to the complexity of factors that influenced the design. There is the human body, technical credibility, the human-machine communication and if that wasn’t enough, the whole thing has to bend and twist, in fact feel alive. So clearly not every smallest detail turned out to be completely thought through in the end. But I was able to push the limits of what was possible to achieve for me in the given timeframe. In my opinion the outcome convinces to be a very new experience when sitting on this bike and inspires me to dream about the future!

These technologies and the idea of a pure and more immersive experience can be transferred to other mediums of transportation as well, standing in great contrast to the clear trend of fully autonomous vehicles.

Another point worth mentioning is the interdisciplinary work I did when I was at BMW. Being in touch with modelers, engineers, generative designers, color and trim designers was a good taste of how it would feel, working as a designer. A really great experience.

The interdisciplinary work continued digitally for me since I worked with so many different types of software. Creating the project required the use of Alias, Cinema 4D, Rhino, Grasshopper, Fuse and Speedform.

Personally, I improved a lot in planning and handling complex projects. I learned to always have an overview of everything, to be able to check at every point in time what needs to be done next, to achieve my goals. Sometimes I felt that I got slowed down by a lack of self-confidence and trust in my own skills.

The many feedback sessions with BMW and my university helped a lot to collect experience in using feedback efficiently to lift my project to the next level.
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APPENDIX

The project pushes heavily into a new field of technology. Since AI becomes more and more important in our daily lives, developing ways of human-machine interactions will be crucial for our future. The project is focused on intuitive and seamless communication that could influence our future in many fields beside motorcycling.
TIME SCHEDULE

KICK-OFF
MEETING
RESEARCH / CONCEPT

CONCEPT FREEZE
MEETING
CONCEPT + IDEATION

ADVANCED IDEATION
MEETING

MID-REVIEW DESIGN FREEZE

3D MODELLING (ALIAS, SPEEDFORM)

DEGREE REPORT

JANUARY
FEBRUARY
MARCH
- **April**: Meeting, Grasshopper
- **May**: Submit Degree Report, Animation+Visu (Maya+VRED), Visualisation (+Rider, +Storyboard)
- **June**: Degree Show, VR Mock-up