Mixed Reality Workflows

Applications of virtual reality in the design process by Filip Maukš

Doctoral research:	Applications of virtual reality in the design process
Realization:	2017 — 2022
Researcher:	Mgr. art. Filip Maukš, ArtD
Research supervisor:	Assoc. Prof. Peter Olah, ArtD.
Text:	Michala Lipková

Modular construction of variable motorcycle geometry simulator

The dissertation project explored the use of virtual and mixed reality in transport design within the activities of FAD STU's MX lab, a workplace focused on research in the field of digital design tools and the impact of emerging technologies on the design process.

Through a series of industrial design case studies, the project introduced different mixed reality workflows, including aspects of software development (beta testing features of the then-emerging VR modeling tool Gravity Sketch) and modular hardware infrastructure for physical, ergonomic simulation.

As a part of the exhibition at BASE Milano, Filip Maukš is presenting the final case study of his dissertation project - the hybrid e-bike/dirt bike concept. The project was developed during Filip's internship at Škoda's research department and successfully demonstrated a design workflow with maximum use of VR tools.

The design research at MX lab (Multidisciplinary research and experience design laboratory) oscillates at the intersection of several disciplines, ranging from artificial intelligence, software development, and mechatronics to ergonomics, additive manufacturing, or human-computer interaction.

Filip Maukš's research, carried out from 2017 to 2022, was focused on exploring emerging software and hardware solutions for virtual reality modeling. The thesis provides an interesting snapshot of specific stages within the development of this rapidly accelerating field.

As a part of the initial analysis of the digital tools, Maukš lists the following advantages of the use of virtual reality in transportation design (Maukš, 2022):

- The opportunity to visualize new designs of big objects (e.g., cars or motorbikes) on a real scale can save significant amounts of resources and work hours otherwise used to build a physical model.
- Virtual reality provides a wide range of options for data configuration - e.g., 3D data of a new car exterior can be visualized through VR software in various colors and materials.
- Models can be placed and viewed in a studio's interior and any simulated outdoor environment - an option previously available only for design studios with significantly advanced infrastructure.
- Individual parts of the simulated model can be changed in real-time (e.g., lights or bumpers), allowing faster and more effective review and evaluation of design possibilities (similar to configurators already common on car manufacturers' websites).

Further in the text, Maukš describes the status quo of automotive simulators in the following words:

“The primary feature of the simulator is its synchronization with virtual data. The person sitting inside the simulator is shown the new design visuals in virtual reality, and they can interact with them through the physical simulator. In this mixed reality scenario, the virtual steering wheel lines up with its physical counterpart to provide haptic feedback.”

The field of motorcycle design was chosen as the main subject of the dissertation project. The decision was made firstly because of the author's personal experience with the subject (previously realized projects as well as personal race driving experience) and secondly because of the easier technical feasibility with regard to the scale of the object (in comparison to car design).

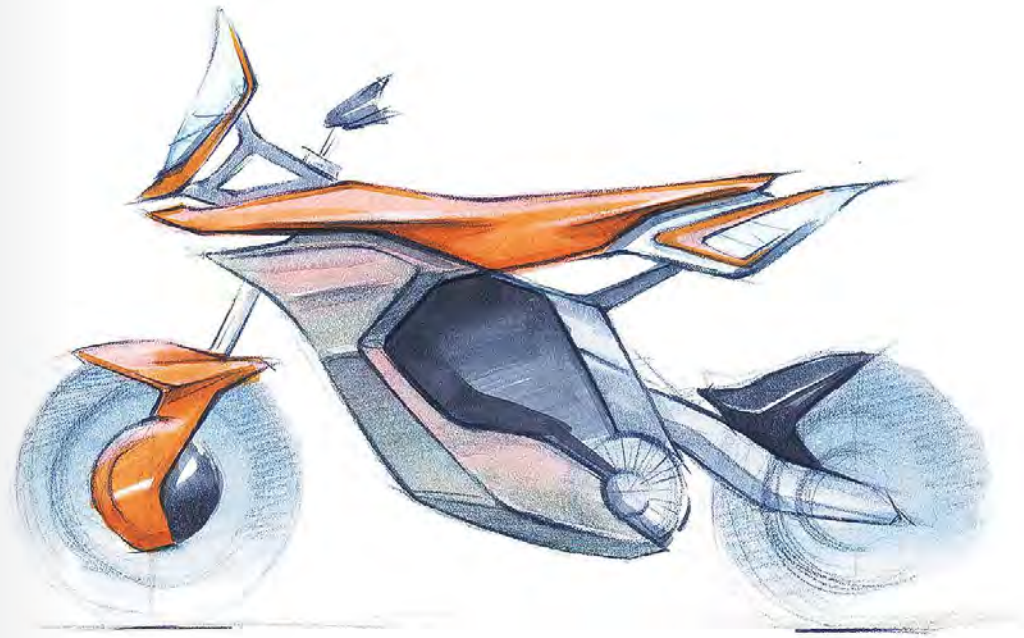
The introductory part of the thesis contains an overview about virtual reality technology. It classifies virtual and mixed reality (MR) in the reality-virtuality continuum (Milgram et al., 1999) and provides examples of different interactions between the real world and virtual data in the design industry. Maukš views MR as the most modern and rapidly developing way of interacting between the real and digital realms. Thanks to the characteristic feature of mixed reality — the ability to synchronize digital and real data — in MR, virtual and real objects can react and influence each other in real-time, which he further explores in all of the case studies featured in the thesis.

Since even during the short duration of the doctoral thesis, MR and VR technologies moved forward rapidly, the possibilities and limits of the specific hardware and software were not the prime focus of the research. The author rather focused on the impact of specific, brand-independent features and principles in relation to the actual steps of the design process - the design process: the process of ideation, concept development, design execution, and final design presentation.

Thanks to the rapid improvements in the field, VR tools are becoming increasingly suited for early creative work, e.g., capturing a first thought or creating multiple variations of an early design idea - extending the possibilities beyond hand sketching using paper and pen or 2D digital sketching using a graphic tablet.

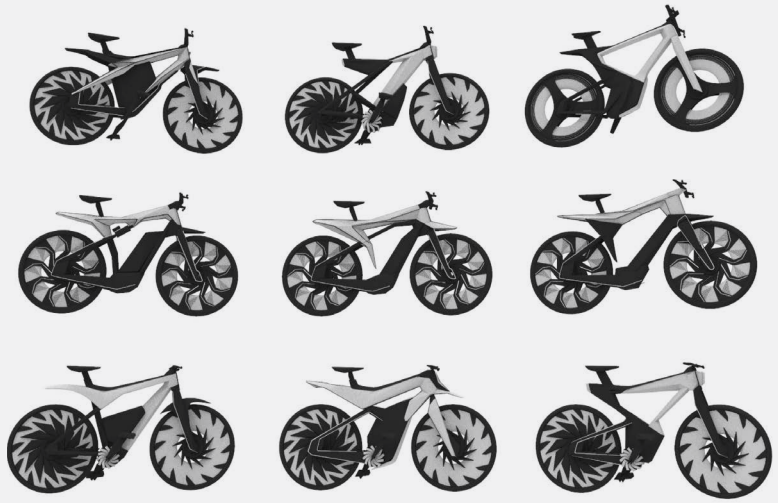
From the hardware and software perspective, Maukš highlights the following points in the MR/VR trends in terms of technology that were relevant to the thesis' case studies:

- At the time of project realization (2017 - 2022), HTC and Oculus were the key players driving the adoption of VR headsets in the mass consumer market. Therefore, the HTC Vive headset, in combination with the HTC Tracker and later Oculus Quest 1 and 2, was first used in the realized case studies.
- Gravity Sketch was used as the main VR modeling software (using Oculus Quest) since it proved to be a promising tool that allows sketching in virtual reality. Using Gravity Sketch, the designer can capture an idea of a design directly in 3D space and share the virtual design directly with others in real time through the so-called “co-creation mode.” At the same time, the company was open to closely cooperating and participating in the research by exclusively disclosing beta features that were not publicly available (Gravity Sketch, 2020).
- An interesting shift has also occurred in the design presentation field: Gaming engines like Unreal Engine and Unity, orig-



Top: Rally motorcycle concept - sketches from the second case study

Next page: Fast doodles from the VR ideation process (Gravity Sketch) and Gravity Sketch output model



"The primary feature of the simulator is its synchronization with virtual data. The person sitting inside the simulator is shown the new design visuals in virtual reality and they are able to interact with it through the physical simulator. In this mixed reality scenario, the virtual steering wheel lines up with its physical counterpart to provide haptic feedback."

inally developed for creating computer games, are now used in industrial design and the automotive industry. Gaming engines combine quality visualizations with the ability to program a wide range of interactive features, e.g., material configurators, door animations, interior mood light changes, or other featured simulations.

The core practical part of the dissertation project included 3 case studies:

- **Presentation in VR -**
  Sports motorcycle concept
  The first case study followed up on Maukš's diploma project - by taking 3D data (and previously prototype in only 1:4 scale) created using traditional desktop CAD modeling technique and simulating them in real size on a physical motorcycle simulator. The simulator was set to match the ergonomics of an electric motorcycle, and the 3D model of the motorcycle was mapped onto the simulator construction, including the handlebars, whose physical motion corresponded with the motion of the handlebars in VR. The second part of the simulation was a VR configurator programmed to change the color of fairings and wheel discs. The six color swatches in the background represent the color palette. The top colors are for wheel rims, and the bottom is for fairings. The colors can be switched by pointing the controller at one of the samples and pressing the button on the controller. The simulation exposed several ergonomic design issues and attracted attention to the potential of real-size ergonomy testing in MR/VR during the early stages of the design process.

- **Creativity in VR -**
  Rally motorcycle concept
  The second case study focused on experimenting with VR tools during the early stages of the design process. In the modeling environment of Gravity Sketch, a 3D model of the simulator was introduced to reference the ergonomics of a sports rally motorcycle and a 2D scan of a hand drawing as a basis for future design. Modeling in virtual reality combines elements of classic modeling with 2D sketching. In 3D space, it is possible to create lines or volumes using spatial gestures. The case study was focused on capturing the initial idea and proportions of the future design, which acquired a sculptural touch thanks to gestural modeling. Since the design was modeled in real size and can be presented through virtual reality, it proved to serve as a more effective communication tool during expert critiques. The simulator used to visualize the sports bike was transformed into the ergonomics of the rally bike and synchronized with 3D data to test the seat's ergonomics and the

seat's shapes and fairings. During the project, it was possible to establish direct cooperation with the company Gravity Sketch. A trial beta version of the Gravity Sketch software was created to synchronize the 3D data of the rally motorcycle and simulator.

- **Maximizing the use of VR tools - Hybrid e-bike/dirt bike concept**
  The third case study, developed during an internship at the Škoda Auto design studio in Mladá Boleslav, explores the problem of last-mile micro-mobility and its intersection with the possibilities of making the most of the eclectic drive in the cities of the near future. The electric bike project started with an empty scene in the VR modeling program Gravity Sketch. It ended with a presentation of the final design in 1:1 scale VR with a programmed configurator; the case study intended to use every available possibility of working with virtual reality in all stages of the design process (ideation - refinement - presentation).

The motorcycle simulator developed during the research project fulfilled the task of the very first prototype. However, when using it, the real-life experience of interacting with the motorcycle and with the user's own weight is still missing. The motorcycle lowers on the shock absorbers under the rider's weight, which affects the position and reach to the ground. With a motorcycle, the rider moves his body, whether leaning into corners or maneuvering at low speeds.

The perpendicular static frame of the simulator prototype did not yet allow these aspects to be tested. The vision of the next research activities in the MX lab is to continue developing simulation environments for industrial design that provide a more realistic user experience and allow the designer to appropriately replace physical prototyping with technological aids.

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Filip Maukš is an industrial designer passionate about motorbike and bicycle design. He is currently actively participating in FAD STU's research group, MX lab. During his doctoral research, he formed a partnership with Gravity Sketch and interned at ŠKODA DESIGN. Filip has experience designing for hardware startups as a lead designer at Trainshot Ltd.

Hybrid e-bike/dirt bike concept - final presentation sketches from the third case study

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Publication

Michala Lipková: DESIGN × SCIENCE
Doctoral design research projects
at FAD STU in Bratislava

Publisher:
Faculty of Architecture and Design,
Slovak University of Technology
SPEKTRUM STU Publishing, 2024
ISBN 978-80-227-5397-5

Text author:
Michala Lipková

1st edition, Bratislava 2024

Proofreading:
Katarína Kasalová

Edition:
250 pieces

Graphic design:
Chmela studio

Typeface:
Styrene by Commercial type

Print:
DIW print

Paper:
Mirror Silver Gloss 300 g/m² (cover),
Munken Polar 120 g/m² (core)
distributed by Europapier Slovensko

Exhibition project

DESIGN × SCIENCE
Doctoral design research projects
at FAD STU in Bratislava

Location:
BASE - We Will Design
Via Bergognone 34
20144, Milano, Italy
16. — 21. 4. 2024

Featured authors:
Vladimír Boroň, Petra Hurai, Vlasta
Kubušová, Filip Maukš, Martin Mjartan,
Martin Sombathy, Lucia Suchá

Exhibition curator:
Michala Lipková

Co-production:
Institute of Design FAD STU in Bratislava,
The Shamrock Green s.r.o.

Installation design:
Filip Maukš, Petra Hurai, Michala Lipková

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This project was supported by public
funds provided by the Slovak Arts Council.
The publication exclusively represents the
opinion of the author and the Slovak Arts
Council is not responsible for the content
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