Visual Computing

Technology Report

Dear readers,

With 5,900 companies employing some 55,000 people, Vienna ranks among the top five IT metropolises in Europe. These companies generate a total of around EUR 20 billion each year.

These figures illustrate the enormous significance of digital technologies for Vienna as a business location. The industry generates high-quality jobs, which likewise require a highly qualified workforce. Vienna benefits greatly from a first-class education system, excellent infrastructure and a dense network of university-based and other research institutions. According to various studies, the city is particularly strong in innovation, comprehensive support of startups and a strong focus on sustainability.

The VIENNA 2030 economic stimulus and innovation strategy identified six key topics for the Austrian capital. The strategy defines the specific thematic areas in which Vienna will strive to become a world leader within the next ten years through the development of powerful innovations ("Viennese solutions"). One of these key topics is Vienna's road to digitalisation. High-quality digital solutions from the city will be internationally recognised for their fairness, transparency, security and autonomy. Vienna will become "the" city in which digital solutions expressing a new concept in digital humanism are developed and implemented to sustainably and inclusively benefit people.

Inspired by the large range of educational and research options on offer, a significant number of companies and institutions implementing ideas and projects in the visual computing sector have been established in Vienna. From established universities to application-oriented competence centres, start-ups to long-established companies, the Viennese technological scene could hardly be more diverse, and it has major international significance.

This Technology Report provides an overview of a wide range of trends and developments around the topic of visual computing in Vienna, highlighting prominent experts, actors and activities in the city.

We hope you enjoy reading it!
Your Vienna Business Agency team

vienna
business
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Contents

Image processing technologies have achieved new significance in the economy and society of today. Over the past year, new developments in digital cameras have seen the quantity of data produced and communicated in the area of visual communication increase enormously. For example, an average of 995 photos are uploaded onto social media platform Instagram every second, and it's no longer solely private content. Around 25 million companies are currently represented on Instagram, and projections indicate that approx. 200 million users visit at least one company profile per day.[1] 76% of all internet users who disclose personal information online either post or share private photos or videos. YouTube records more than 1.9 billion registered users each month, and it is estimated that even more unregistered users visit the platform. Every day, users play a total running time of one billion hours of YouTube videos, and many billions of hits are generated.[2]

Ever higher resolutions and faster apertures mean that sensors are already capturing objects in three-dimensional space. Scanners are creating entirely virtual spaces with minimal delay. Digital eyes now see with such precision that they are at least as capable as actual humans at tasks such as quality control and recording groups of people, if not even better, more reliable and immune to fatigue. This image data can be used to simulate scenarios in virtual spaces, a concept that has applications in many different areas. In planning processes, projects such as roads can be calculated for optimum capacity utilisation while many features (hotspots, access roads, lane numbers, etc.) can be simulated months before construction begins.

The underlying technology can be utilised in a diverse range of sectors.

○ Production

In the production field, sensors and cameras enable faster quality control and lead to reduced error rates and fewer discrepancies. Data can also be categorised, analysed and reentered into the production chain to support the planning process and remedy causes of defects.

○ Medicine

In medicine, the recording of higher-dimensional data enables tiny objects to be depicted, as well as making body parts and even chemical connections visible and open to manipulation.

○ Big data

As sensors and scanners become better able to resolve fine details in their environment and specific objects, ever greater quantities of data have to be stored. Graphic, multi-coloured and multi-dimensional depictions are helpful in the analysis of enormous volumes of data, having the advantage over tabular representations in making it possible to both see and simulate scenarios.

○ Optical sensors

Optical sensors provide extra information, and are therefore important in depicting an environment on a computer. This additional information can be used to make a virtual reality (VR) experience more immersive. During the space planning stage before implementation, modelled 3D objects can be added to a live camera image (augmented reality – AR), making it possible to visualise potential planning scenarios. Parameters can be changed quickly and decision making becomes easier.

○ Pattern or image recognition

Anonymous personal detection and perimeter monitoring increase security at airports and in public areas. Cat or burglar: location and environmental data can be analysed and movements recognised and correctly classified. Congestion and queues at passport control can be detected early and additional counters opened to avoid further delays.

1
www.omnicoreagency.com/instagram-statistics

2
www.youtube.com/intl/de/about/press

○ Virtual reality (VR)

Virtual and augmented realities have become important factors in the entertainment industry. Virtual environments, as well as people and objects, are becoming steadily more realistic. Simulations of weather, light, and textures are becoming more plausible, affording the user a more intense, immersive experience in a virtual scenario.

○ Geometric modelling and 3D printing

3D printing is used to create quick, cost-effective models of complex architectural projects, manufacturing prototypes and even dental models for the medical sector. Patients receive a computer-generated, 3D-printed test model, which can be used for trials and adapted prior to a medical procedure.

The expression "a picture is worth a thousand words" takes on a whole new dimension in visual computing. Related technologies have long since become prevalent in our daily lives, even if we don't always recognise them.

These "seeing" systems are currently used in many sectors, including security technology, industrial manufacturing processes, quality assurance and automation technologies for the transport industry, as well as for the evaluation and automatic recognition of dangerous situations and in access systems. These concepts are essential for autonomous systems relying on visual information, enabling the systems to comprehend the situation and then react appropriately by applying other technologies.

2.2 Virtual & augmented reality

Virtual reality (VR) refers to three-dimensional simulations of entire rooms and environments. In augmented reality (AR) scenarios, by contrast, a live image is enhanced with 3D-rendered elements. There are also various other terms and abbreviations that are not always consistently defined, including extended reality (XR), mixed reality (MR), cross reality and several more.

Generally speaking, XR is both an umbrella term and a simple abbreviation, used to refer to various technologies such as VR, AR and MR.[5] The virtual reality sector is the province of special VR glasses, 360-degree camera recording and depiction using simple smartphone VR glasses, as well as a range of camera techniques. VR glasses replace the "live" image while allowing the wearer to interact with and move through actual space. Simulations are becoming ever more realistic and believable as optical sensors become more precise, research and development activities in the field continue, and progress is made in more than just the hardware field.

In AR, on the other hand, the live image remains visible but digital content is added. The live image may be viewed through transparent AR glasses or displays or be depicted by (smartphone) cameras. Video games and smartphone apps use the live camera image in conjunction with other data: most
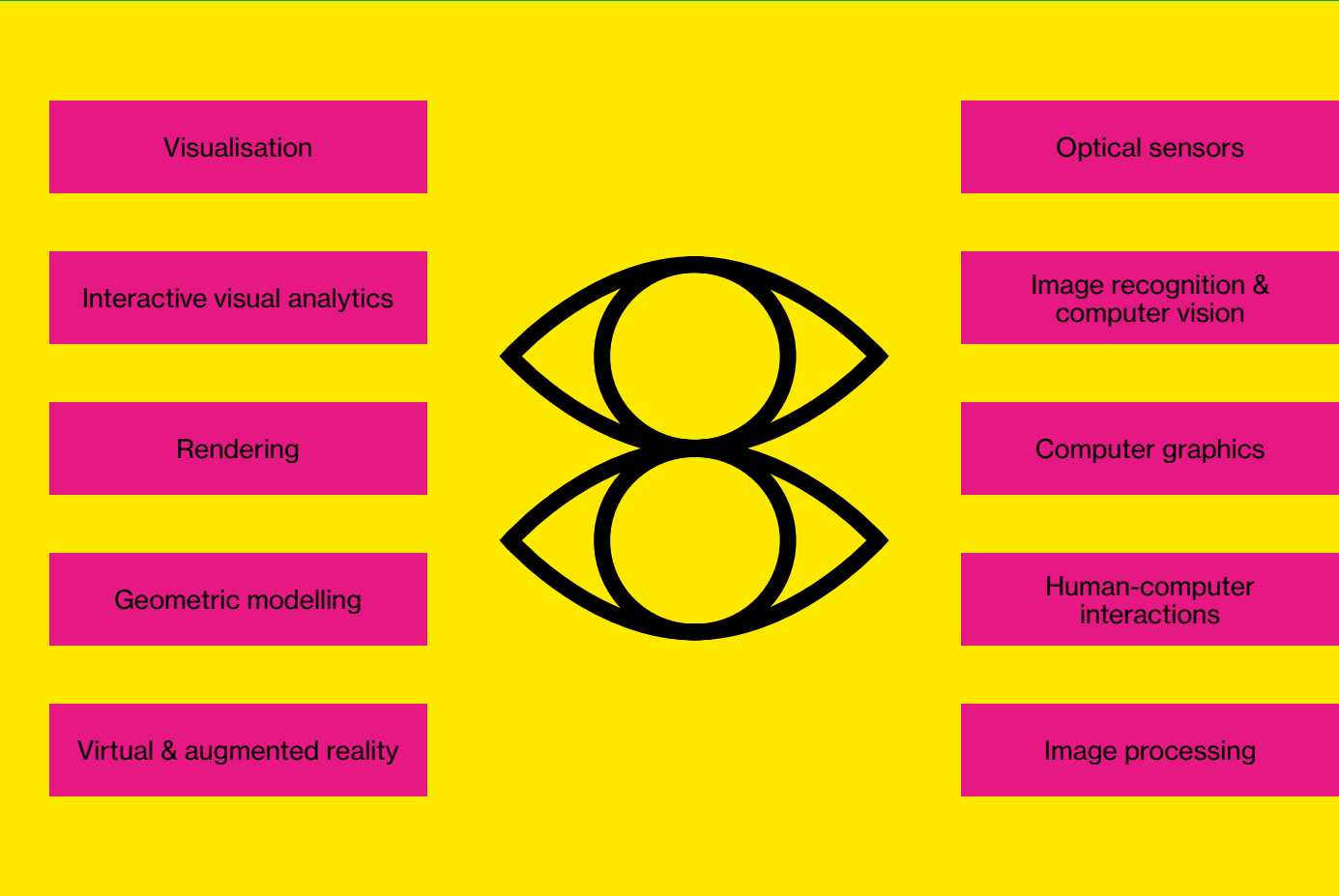
The umbrella term "visual computing" covers a wide range of different sectors. Various disciplines established in 2005, including computer graphics, image processing, computer vision and other sectors featuring similar methods and applications, were grouped under this heading at the first International Symposium for Visual Computing, ISVC 2005.[3] Many of the methods used in these disciplines (including image formats, filter methods, colour models and programming methods) are very similar, and the need to process huge volumes of data and the use of graphics hardware are common features. Increasingly, these applications are requiring techniques from several disciplines at once. "The term encompasses almost all computing disciplines involving images. Visual computing is a cross-sectional discipline that will, in many applications, become part of everyday work and life"[4], says Werner Purgathofer from the Institute of Computer Graphics at TU Wien.

The overview of visual computing on page 9 describes a range of areas of application for visual computing. These sectors are all at different stages in the acquisition process and have different potential for commercial applications.

2.1 Image recognition and computer vision

Pattern or image recognition encompasses technologies that enable content-related information to be extracted from existing images, while computer vision refers to the computer's capacity to recognise an environment and correctly interpret it. It is a simulation of human sight and has the ability to interpret what it sees.

3
www.isvc.net

4
www.derstandard.at/2000011821540/Mit-Visual-Computing-in-neue-Bilderwelten

5
www.unity3d.com/de/what-is-xr-glossary

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see Werner Purgathofer, Institute of Computer Graphics at TU Wien

- Visualisation
- Interactive visual analytics
- Rendering
- Geometric modelling
- Virtual & augmented reality
- Optical sensors
- Image recognition & computer vision
- Computer graphics
- Human-computer interactions
- Image processing

use existing sensors such as GPS to superimpose additional information. Historical data associated with buildings or memorials can be presented in this way, as can navigation aids at airports or current offers from shops in the user's immediate area.

2.3 Computer graphics & computer animation

Computer graphics refers to the generation of graphics whose components can be depicted two-dimensionally on the plane. Other sub-sectors focus on the question of how complex forms might be geometrically modelled and how images or animations can be calculated (rendered) from virtual environments created in this way. Image processing is a related concept, but nonetheless can be distinguished from computer graphics. It involves the processing of existing images in order to automatically evaluate their content – essentially the inverse of the computer graphics generation process.

These days, computer graphics play a central role in our lives. The range of applications is diverse, extending from the entertainment industry (films, computer games, visual effects, etc.) through architectural and spatial planning to various segments of the creative industries.[6]

2.4 Visualisation and interactive visual analysis

Visualisation incorporates the visual representation of (abstract) data. The larger the volume of data, the greater the importance of optical presentation and simulation. Visualisations can be generated using computer graphics or on the basis of sensor data.

The visual analysis of multi-dimensional abstract data processed by visualisation methods is important for the big data sector, among others. Depending on the viewing angle, this technique can make it possible to make reliable statements and achieve an initial understanding of complex data.[7] By changing the parameters, chronological sequences and changes can be seen in real time. This is especially important for the accurate interpretation of large volumes of data such as bank details, user data or weather information, and changes over a specified period of time. Werner Purgathofer: "The real challenge is to process data without geometric components. It's like taking a glass cube containing 100 black peppercorns. You

6
www.tugraz.at/institutes/cgv/research/research-general-information

7
visplore.com/use-case/data-exploration

can turn it around and look at it from all angles until you find a pattern in the arrangement of the seeds".[8]

2.5 Geometric modelling & 3D printing

The term "geometric modelling" refers to the special methods and data structures used to generate realistic models based on raw data from optical sensors. For example, distances to and from specified objects can be calculated and spaces reproduced in CAD systems (or similar) on the basis of multiple photographs taken from different positions.

Geometric models can be expanded from two-dimensional curves to three-dimensional surfaces. The various representation schemes used in different sectors are quite distinct. Algorithms for the efficient control of 3D printers also come under this heading.

2.6 Image processing and image editing

Not to be confused with image recognition, image processing involves rendering improved images from existing pictures. Depending on the application, "improved" can mean very different things. Image editing is a different concept again, in which interactive methods are used to manually alter images.

2.7 Graphics components of human-machine interaction

This term encompasses the interactive graphical control of automated systems. One aspect is human-computer interaction (HCI), which refers to the user-friendly design of interactive systems and interfaces. The field requires a knowledge of computer science along with skills in psychology (especially media psychology), occupational science, cognitive science, ergonomics, sociology and design.

Human-machine interaction is relevant to any application in which users are required to use or interact with complex machines or processes. Important considerations in this area include the need to register people for collision control and to examine (safety) parameters with a view to protecting both human and machine.

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derstandard.at/2000011821540/Mit-Visual-Computing-in-neue-Bilderwelten

"In a digital world full of images and videos, computer vision is one of the major drivers of economic success and a core technology of the future", declares Markus Kommenda from the AIT. According to industry estimates, visual data is set to dominate overall data transfer figures in the coming years. Transfer via mobile devices (mobile phones, smartphones, tablets, etc.) is expected to grow at three times the rate of the conventional internet.

With rapid increases in the computing power of mobile phones, most of us are carrying around what amounts to a mobile computer vision workstation. The number of smartphone users around the world is expected to reach 3.5 billion in 2021.[9] The latest mobile graphics chips, currently found in any reasonably priced smartphone or tablet, are able to calculate algorithms so complex that, at the beginning of this century, they would still have required a mainframe computer. To better illustrate this enormous increase in computing power, Professor Graham Kendall from the University of Nottingham compared the RAM (working memory) and ROM (read-only memory) of an iPhone with the computer system used for the 1969 moon landing. He came to the conclusion that a modern smartphone has approximately 100,000 times more computing power.[10]

VR/AR glasses have been around for some time, both in industry and in the consumer sector, but these systems are not always apparent at first glance. Classic glasses, the kind that usually come to mind first, are currently used more for specialised applications such as AR/VR prototyping, creating a tangible experience from CAD data, virtual reality presentations and employee training.[11] Augmented reality systems and their underlying technologies are primarily used in smartphones, tablets and other mobile systems. As an example, live images (using built-in cameras) can be enhanced with helpful, informative data to enable users to orient themselves in unfamiliar or complex environments (indoor navigation), manage storage systems or facilitate remote support.

The increasing integration of cameras contributes to the protection of critical infrastructure, but it is no longer feasible to analyse the resultant data without using modern computer vision. Transport systems (cars, trains, autonomous systems, etc.) and the cities of the future are substantially built on the basis of optical sensors. However, efficient, ambitious production processes and ongoing quality control measures today are highly dependent on image processing technologies.

Visualisation and simulation solutions are continually gaining significance in the planning of processes and projects. Above all, it is very difficult to optically depict large volumes of data in a simple and understandable format without the help of these systems. Reliable visualisation systems are indispensable where evaluations need to be completed in real time, such as in infrastructure-critical sectors. The object is "to prepare data for the decision-maker in such a way as to enable the correct decision to be made quickly", says Georg Stonawski, senior advisor at VRVis.

It will be exciting to see how the market develops in this sector as constant advances are made in technologies, sensors and cameras, and research and development into new technologies makes steady progress. The technologies that users ultimately take on board in both the consumer and industrial sectors will determine which trends become part of our everyday lives.

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de.statista.com/statistik/daten/studie/309656/umfrage/prognose-zur-anzahl-der-smartphone-nutzer-weltweit

10
www.futurezone.de/science/article226520435/Nur-per-Handy-koenntest-du-heute-die-komplette-Mondlandung-steuern.html

11
vr-dynamix.com/virtual-reality-industrie-4-0

4.1 Visual computing companies in Vienna

Inspired by the large range of educational and research options on offer, a significant number of companies already implementing ideas and projects in the visual computing sector have been established in the city. Some of these companies originated from university research departments, centres of excellence or non-university research institutions, and now continue their work either in cooperation with these organisations or independently. Others have arisen from other technological sectors or, in some cases, from the creative industries.

The following company profiles describe a selection of exemplary, well-known, established or new visual computing companies in Vienna. This is not an exhaustive list.

○ Anyline
Anyline specialises in optical character recognition (OCR, or text recognition) technologies with the aims of simplifying data capture and increasing reliability in comparison to manual data input by humans.

Customers of the company include major brands such as PepsiCo, Porsche, Toyota and United Nations (UN) organisations, as well as several police organisations (Bavaria, North-Rhine Westphalia, Austria) who use this technology for the rapid recording of vehicle license plates and ID documents.

A promising combination of research efforts and agile technological development has brought Anyline to the attention of investors as well: around 17 million dollars have been invested in the company since its founding in 2013. An exciting feature of the company's activities is its collaboration with smartphone manufacturers and major software providers to integrate OCR technology into the operating systems of mobile phones. "Europe needs a few good, relevant technology companies to stand their ground against the dominance of American and Asian technology corporations. We are determined to rise to this challenge", says Lukas Kinigadner, CEO and co-founder of Anyline.

The current visual computing scene both in Vienna and throughout Austria is very impressive in many respects. Many well-established companies and organisations have already enjoyed many years of international success. Constant growth can be observed in the sector, in terms of research and education and in the number of companies active in the field. However, the number of players is not the only special feature. Almost the entire value added chain is covered, from basic and application-oriented research to hardware, software and development tools.

Even though augmented and virtual reality are just one aspect of the visual computing scene, the image on page 15 (compiled by enliteAI in collaboration with Matthias Grabner) provides an impressive overview of well-known Austrian players in this technological sector.

Viennese research into visual computing has been highly influential on the international scene, where the diverse range of activities in the city has attracted considerable attention. From long-established universities and application-oriented centres of excellence to start-ups with a focus on research, the city has given rise to a research scene that promises significant added value.

Technological developments are, however, not the only aspects of visual computing to be strongly represented in Austria. Over the past year, the increasing establishment of XR technologies on the consumer market means that the creative industries have also begun to explore the visual computing sector. It is especially exciting to see the diverse educational backgrounds and professional experiences of the pioneers in this field. Many of these creative individuals come from the theatre, film or arts industries, while others are musicians, gamers, interaction designers, communication designers or UX and UI designers. Their projects are creating entirely new immersive experiences, forming interdisciplinary teams and implementing a diverse range of projects.[12]

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White Paper "Digital Realities" (2018) by the Vienna Business Agency
viennabusinessagency.at/creative-industries/relevanz

○ Kaleido AI
Kaleido AI's image and video processing tools make it a "hidden champion" in the Austrian start-up landscape. The company's remove.bg product, launched in 2018, enables image backgrounds to be automatically recognised and removed. Kaleido AI has continued to develop this technology, and the company subsequently released the Unscreen tool, which can be used to detach people and objects in videos with a single click, in 2020.

Kaleido user figures increased from three to over 20 million across 180 countries in the past year. The system is used to remove more than 100 million photo and video backgrounds every month. Customers of the company include global brands such as Alibaba, Samsung and the New York Times.

○ CogVis
CogVis applications run on the computing systems of all current platforms, hardware versions and peripheral devices, including cameras and movement sensors. The software is used in vertical markets such as security, trade, industry and medicine to analyse the content of images, videos and 3D data. The company's efforts focus on computer vision algorithms in combination with considerations of design, functionality and usability. The application is controlled via a web browser.

○ contextflow
contextflow supplies an image search machine for radiology applications to generate quicker and more precise diagnostic findings. This technology is based on the concept of AI image analysis. The system works to rapidly locate reference cases and reference diagnoses. This approach originated from an EU research project at the Medical University of Vienna, which focussed on the automatic evaluation of MRT and CT scan images. contextflow is an alumnus of the academic incubator INiTS and is funded by Austria Wirtschaftsservice Gesellschaft (aws) and the Vienna Business Agency.

○ Visplore
Visplore GmbH offers a highly dynamic graphic analysis solution for investigating large volumes of data from machines, sensors and simulations. The company's eponymous software uses pre-configured analytical tools to save time in data processing and enables people with limited or no programming experience to quickly obtain new and often unexpected findings from big data. Visplore's particular strengths include interactive data cleansing and selection, the ability to analyse correlations and trends and the software's seamless integration with platforms such as Python, R and Matlab. The company focusses on applications in industry and the energy sector. As one example, Visplore enables process technology engineers and experts to efficiently carry out independent analysis on quality assurance and maintenance procedures, a task that was, in general, previously reserved for trained data scientists. Areas of application include process optimisation, error analysis, model creation and everything in between.

Visplore GmbH is a spin-off of the VRVis research centre, and the company's work is based on internationally acclaimed research results. At the beginning of 2021, btov Partners became a VC investor in the company. Over 20 companies use Visplore solutions, among them Verbund, Mondi, Georg Fischer Casting Solutions and AIT.

○ ViewAR
ViewAR has released more than 30 apps designed to create dynamic AD models for spatial planning, home planning, product and furniture design and more. The apps can also be used as visualisation tools for end customers and sales teams or as supporting tools in industry. ViewAr adapts the app to the customer's wishes and individual requirements.

○ vrisch
vrisch specialises in the use of interactive 360-degree videos and virtual reality applications for marketing purposes. A distinction must be made between the various levels of virtual reality, where technologies range from reasonably priced cardboard VR glasses used with a smartphone to provide easy immersion in different worlds, through to 4D virtual reality setups with professional VR glasses and input devices that may also include fans, headphones and other equipment designed to create a more intensive virtual experience.

○ Wikitude
Since the company's founding in 2008, Wikitude has been developing AR technologies for smartphones, tablets and smart glasses. Companies, agencies and developers from over 180 countries regard Wikitude as their trusted AR technology partner. According to Wikitude, over one billion users benefit from applications based on the company's technologies.

Wikitude is one of Austria's internationally best-known visual computing companies, primarily owing to the company's development and release of the world's first mobile AR app.

AR & VR Landscape Austria v3.1 - February 2020

4.2 Education and research in Austria

National experts are in complete agreement with the Austrian start-up scene: Austria's research institutions and educational centres place the country at the forefront of international excellence in visual computing. "Austria has no need to defer to Silicon Valley", declared Georg Stonawski of VRVis at the Vienna Business Agency's "Visual Computing" business meeting. "Considering the size of our country, Austria has a remarkably large visual computing community", says Werner Purgathofer.[13]

Many internationally recognised visual computing research projects in areas such as transport systems come from Austrian institutions.

"Applied research into visual computing and computer vision is a distinct strength of Austria, and of Vienna in particular", declares Markus Kommenda of the Austrian Institute of Technology (AIT). The Technical University of Vienna is a prominent example, but research into visual computing is also being conducted at VRVis, AIT, University of Vienna and the Medical University of Vienna.

○ VRVis
For the past two decades, VRVis has been working tirelessly to build a bridge between science and economics. As a Vienna-based COMET Centre, VRVis carries out cutting-edge applied research in visual computing. Austrian companies are developing and applying the latest technologies to help people make innovative leaps and improve competitiveness.

"With our expertise in algorithms and complex data structures", says managing director DI Dr Gerd Hesina, "we are supporting our partners most notably in the field of analytics – our expertise lies in handling big, time-dependent and complex data."

VRVis uses interdisciplinary applications and the interconnection between various methods of visualisation, predictive analytics, data science and artificial intelligence to facilitate an informative visual representation of data, while using predictive capabilities to lay the foundation for important decisions in business and industry.

○ Vienna University of Technology
Werner Purgathofer directs research into visual computing and teaches at the purpose-built Institute of Computer Graphics.[14] This course of study explores the methodological convergence of key technologies and technical processes in the fields of computer vision, computer graphics, visualisation and augmented/mixed/virtual reality in combination with the design

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www.derstandard.at/2000011821540/Mit-Visual-Computing-in-neue-Bilderwelte

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www.cg.tuwien.ac.at

of innovative interfaces.[15] Course content includes the technical and methodical competencies of image acquisition, depiction, processing, analysis, synthesis and the use of visual information, namely images and image sequences in a temporal and spatial context.[16]

○ AIT – Austrian Institute of Technology

Research into intelligent vision systems is divided into three main sub-headings at AIT, the Austrian Institute of Technology. The first deals with quality control and industrial inspections. Until recently, human eyes were responsible for recognising errors and wastage. Researchers in the field are working to develop trustworthy and user-friendly solutions in the form of automated visual recognition systems for applications such as identifying printing errors in banknotes.

The second area addresses autonomous driving systems and assistance systems for public transport applications.[17] Developments include recognition systems for heavy construction machinery designed to reduce collisions by increasing oversight capability.

The final topic encompasses monitoring technologies with a focus on security and the recognition of groups of people. The 2D-3D Flow and Scene Analysis project measures patterns of movement in groups of people at places such as the airport in order to calculate the optimum number of counters to open at passport control. The system will also identify how many people pass through each scanner at security checkpoints. This requires that the technology be able to distinguish, for example, between a person holding a piece of luggage and one carrying a small child.

○ University of Vienna

At the University of Vienna's Faculty of Computer Science, researchers are investigating visualisation and data analysis (VDA)[18] in the fields of design studies, parameter space analysis, and sampling and reconstruction, as well as in the research field of cooperative systems (COSY).[19] COSY investigates cooperative systems with a focus on IP-based technologies in core and access networks, network-based information and communication economics, end users and communication ecosystems, subjective grades of service, usable security and culture over IP.

○ Medical University of Vienna

Researchers at the Medical University of Vienna are investigating the research cluster of medical imaging,[20] one of five research priorities at the institution. The university's procedures provide insight into the genetic, biochemical and cellular processes of living organisms and enable the precise depiction of morphological conditions and the representation and quantification of organ-specific functions.

Moreover, visual computing techniques and technologies are also coming to be relied upon in other disciplines and research institutions. At the University Clinic of Dentistry in Vienna, for example, research is being conducted into the possible applications of digital impressions in dentistry. Digital support in creating simulations of anticipated treatment procedures increases expected success rates for both patients and medical staff.

Many institutions throughout Austria are also conducting a significant number of visual computing projects.

○ IST – Institute of Science and Technology

At the Institute of Science and Technology in Klosterneuburg, a team under Bernd Bickel is researching the development of new modelling and simulation methods and working on efficient representation and processing algorithms for materials and functional objects.[21]

○ St. Pölten University of Applied Sciences

The media computing research group at FH St. Pölten is exploring the conception, design and implementation of interactive systems. Efforts focus on the areas of human-computer interaction, game design, information visualisation, visual analytics, multimedia signal processing, computer vision and multimedia retrieval.[22]

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informatics.tuwien.ac.at/bachelor/media-informatics-and-visual-computing

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informatics.tuwien.ac.at/master/visual-computing

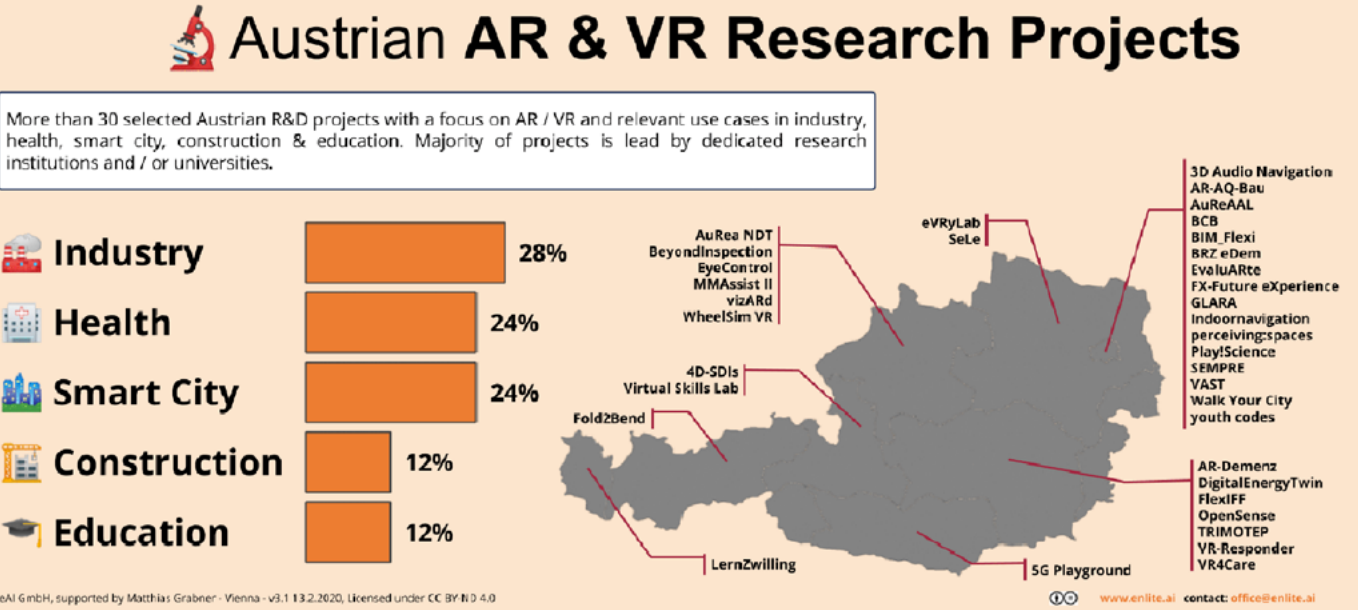**17**
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informatik.univie.ac.at/vda

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informatik.univie.ac.at/forschung/forschungsgruppen/cooperative-systems

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cluster.meduniwien.ac.at/mic

21
ist.ac.at/en/research/bickel-group

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mc.fhstp.ac.at/en

Austrian **AR & VR Research Projects**

More than 30 selected Austrian R&D projects with a focus on AR / VR and relevant use cases in industry, health, smart city, construction & education. Majority of projects is lead by dedicated research institutions and / or universities.

Industry — 28%
Health — 24%
Smart City — 24%
Construction — 12%
Education — 12%

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www.enlite.ai contact: office@enlite.ai

○ Kepler University Linz

At Kepler University in Linz, the Institute of Computer Graphics focusses on computer graphics and computer vision with an emphasis on light field technology and visual analytics.[23]

○ University of Applied Sciences Upper Austria, Hagenberg

Staff at the University of Applied Sciences Upper Austria in Hagenberg are both conducting research and teaching courses in visual computing.[24]

○ Fraunhofer Institute

The "Visual Computing" business unit of the Fraunhofer Institute is now based in Graz. Key research areas at the Institute include visual decision-making aids for planning production facilities, virtual engineering (e.g. for optimising indoor power and navigation systems) and the digital society.[25]
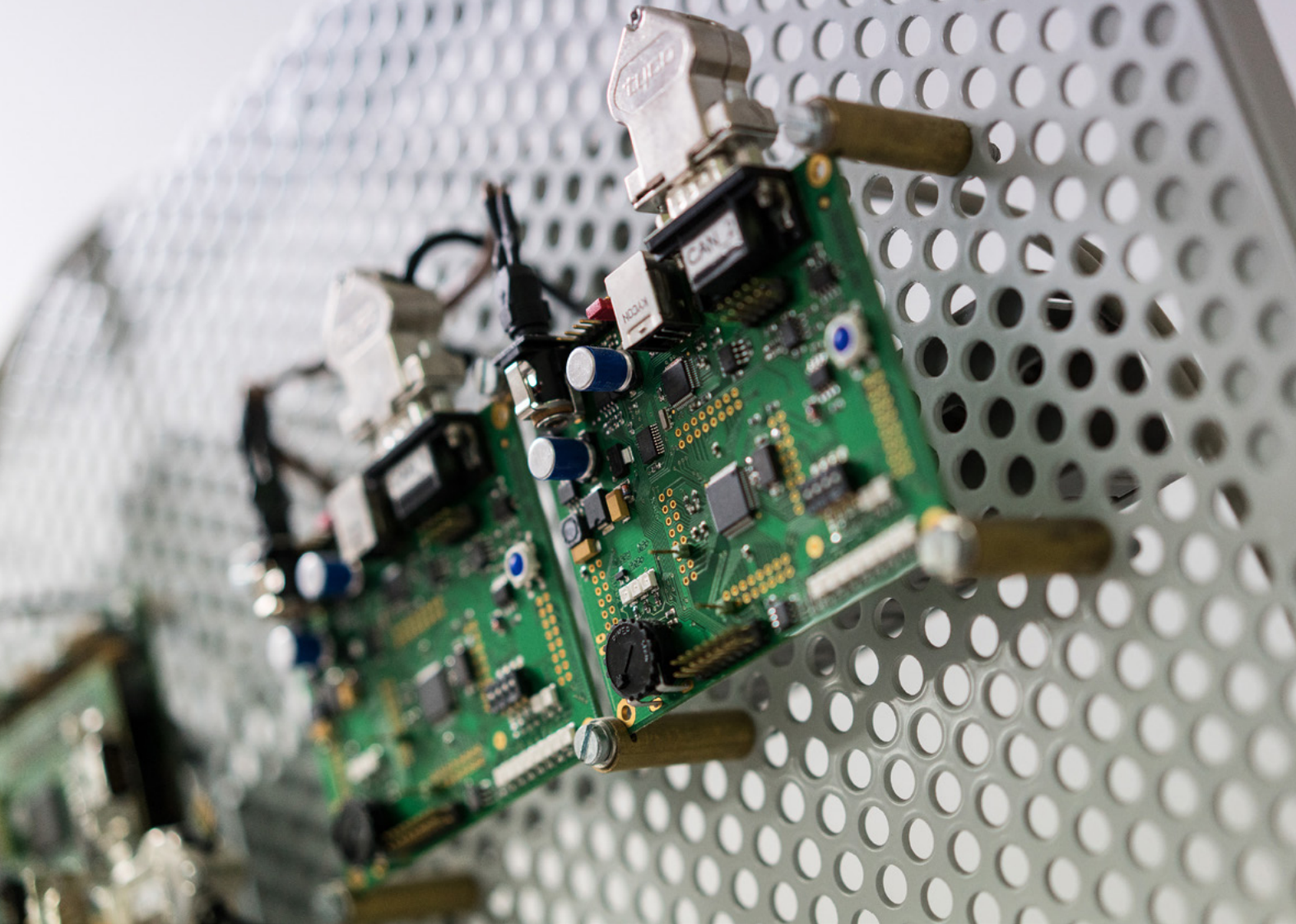
4.3 Organisations and initiatives

○ XRVienna

XRVienna is Austria's largest XR (AR/VR) community and has set itself the task of connecting Austrian developers with XR users and other interested parties to facilitate access to the topic. In contrast to numerous other meet-up groups, however, this networking role is not the central focus of the organisation. XRVienna seeks to enable direct and interactive collaboration between the different actors in the field. The collaborative development of projects by all participants and interested parties is also a key focus.[26]

○ City of Vienna – Vienna provides space

The "Wien gibt Raum" (Vienna provides space) programme uses precise photographic recording and measurement of the city to facilitate the use of public spaces by citizens and companies.

The system uses a combination of sensor data (GPS, angle sensors, etc.), geometric recording (LiDAR) and photographic reproductions of the surrounding area generated by special camera systems, all recorded by a surveying vehicle, to create a digital image of the city of Vienna. The vehicle collects all the necessary data during a drive through normal

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23
www.jku.at/en/institute-of-computer-graphics

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www.fh-ooe.at/en/hagenberg-campus

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www.fraunhofer.at

26
www.meetup.com/de-DE/XRVienna

city traffic. The image data includes information such as traffic and road signs with sufficient clarity to ensure that even the smallest text is readable.

Specialised software is then used to collate the geospatial information, image data representing the current situation at the time of the inspection, and data on existing permits and applications. This improves networking among the relevant municipal authorities. The advantage for both citizens and companies is that this one-stop shop provides a central contact point for all enquiries and permit applications.[27]

○ Austrian Computer Society (OCG)

The Visual Computing working group[28] at the Austrian Computer Society (OCG) focusses on providing funding and increasing the visibility of various ICT topics in research and industry, for many areas of application. These include quality control, medical image data processing and visualisation, measurement, robotics, multimedia systems, virtual heritage and visual and special effects for film, television and computer games.

○ Computer Vision Meetup

The Vienna Computer Vision Meetup group focusses on pre-processing, OCR and other aspects of computer vision technologies. The group runs regular community meetings, hack-a-thons and short, relaxed presentations with a view to improving networking and assisting the development of various projects in the field.[29]

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digitales.wien.gv.at/projekt/wiengibtraum

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www.ocg.at/de/visual-computing

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www.meetup.com/de-DE/Vienna-Computer-Vision-Meetup

The objective of the Vienna Business Agency is the continuous development of international competitiveness by supporting both Vienna-based companies and their innovative strengths, and the sustainable modernization of the city as a business location. To achieve this, the Agency provides free consultations to all entrepreneurs in Vienna on the topics of business creation, business location or expansion, business support and financing. Furthermore, networking contacts in the Viennese economy are also made available.
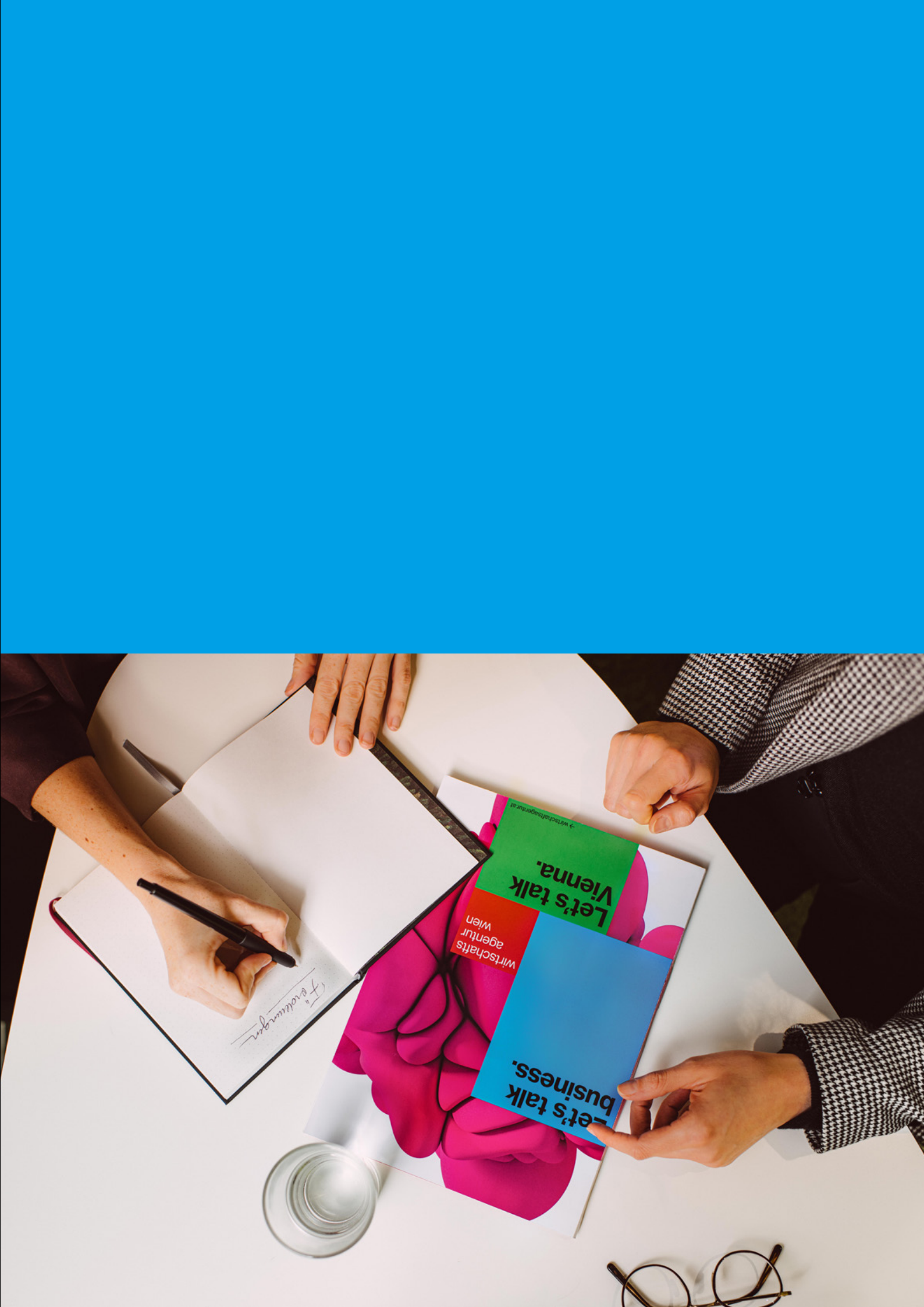
The Vienna Business Agency supports and helps businesses complete their research and development projects with both individual consulting and monetary funding. Depending on requirements, they will receive information about sponsorships, financing opportunities, possible development partners, research service providers, or research infrastructure, according to their needs.

The Vienna Business Agency sees itself as a network of the Viennese Green Tech & Social Tech industry and supports businesses with consultations, as well with distribution and networking among themselves. Events and workshops on topics from the sustainability sector are held regularly.

Additionally, the Vienna Business Agency helps with company relocations or internationalization services. Assistance is provided to business founders and young entrepreneurs in the start-up area. Free workshops and training sessions on topics of everyday business are offered as well as small, affordable office spaces.

Founders Labs[30] support aspiring entrepreneurs and founders with a two-month, part-time program to help them get started.

All funding programs of the Vienna Business Agency can be found here: viennabusinessagency.at/funding/programs

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viennabusinessagency.at/startup-and-grow/founders-lab-future-technologies

The following pages provide an alphabetic listing[31] and brief overview of selected Viennese companies providing services in the field of visual computing.

Visual computing companies

COMPANY	DESCRIPTION	CONTACT/WEBSITE
AARDWORX	Aardworx combines many years of research experience with product development. The company provides high-performance visual computing solutions for desktop computers as well as cloud solutions for the visualisation, collaborative editing and analysis of extremely large data volumes. PointShare is an example of a cloud-based service designed for collaborative work on laser scans.	Hormayrgasse 7 1170 Vienna office@aardworx.at www.aardworx.com
AMLOGY / AREEKA	The Amlogy start-up aims to bring products, school books, posters and logos to life using augmented reality. The company implements comprehensive solutions for WebAR in sales and online shopping for customers such as Wien Energie and Coca Cola. In addition, the company's Areeka brand offers a new concept in visualisation for school books and learning materials with AR components.	Sterngasse 3/6/2 1010 Vienna office@amlogy.at www.amlogy.at
ANYLINE GMBH	Anyline provides uncomplicated scanning solutions designed to save time and money. Users can scan text in digital files with Anyline, a fast, easy-to-use market leader in text recognition software.	Zirkusgasse 13/2b 1020 Vienna hello@anyline.com www.anyline.com
ARIOT	ARIOT's central focus is the use of augmented reality for inspection and quality assurance procedures on construction sites. The company aims to develop an augmented reality system for construction sites to improve construction quality, building safety and energy efficiency and increase the efficiency of construction monitoring.	Erdbergstrasse 46/29 1030 Vienna contact@ariot.io www.ariot.io

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This list makes no claim to completeness

COMPANY	DESCRIPTION	CONTACT/WEBSITE
ARTIVIVE GMBH	Artivive was founded by Sergiu Ardelean and Codin Popescu in 2017 in Vienna. The platform is an easy-to-use AR tool that allows artists to create new dimensions of art by linking classical with digital art. Over 90,000 users across 92 countries are using this solution to create works of art. Artivive offers a new and innovative way for audiences at museums, exhibitions, galleries and other cultural institutions to interact with exhibitions.	Reindorfgasse 38, Lokal 1 1150 Vienna hello@artivive.com www.artivive.com
ARX ANIMA ANIMATION STUDIO GMBH	arx anima, founded in 2011, is an award-winning animation studio specialising in high-end character animation and development. The studio boasts a highly-skilled international roster of animators, concept artists, TD's, modelers and shading, rendering, and compositing artists. arx anima's work has been showcased in cinemas, on television and at festivals around the world, and has featured in international digital venues such as the Walt Disney Interactive Channel, Netflix, Cartoon Network and the London Royal Opera House.	Wehrgasse 9 1050 Vienna mail@arxanima.com www.arxanima.com
BPNXT	BPNXT is a multi-disciplinary design studio with a focus on experience design. Efforts focus on the interfaces between design, art, media and technology. Having been an early adopter of cutting edge technologies, the studio's considerable knowledge and experience now bring it to the bleeding edge stage. Current topics of interest include generative design, rapid prototyping, mixed realities and machine learning.	Schiffamtsgasse 11 1020 Vienna contact@beautyparlour.at www.bpnxt.com
BYTEWOOD E.U.	Bytewood is a software developer specialising in virtual and augmented reality and games.	Sachsenplatz 4–6/5 1200 Vienna office@bytewood.com bytewood.com
COGVIS	cogvis specialises in the use of state-of-the-art AI technology for the intelligent analysis and use of 3D data and images. Founded over ten years ago as a spin-off from TU Wien, cogvis currently develops and distributes highly innovative AAL (active and assisted living) solutions that make life for the elderly both easier and safer. The company's number one product is the "fearless" intelligent fall sensor.	Wiedner Hauptstrasse 17/1/3a 1040 Vienna office@cogvis.at www.cogvis.at
CONTEXTFLOW GMBH	contextflow develops software tools that use deep learning to assist radiology workflows. The company's 3D image search machine features an AI function that identifies and orders relevant, visually similar medical images to simplify the diagnostic process and increase confidence – all in seconds.	Floragasse 7/7 1040 Vienna office@contextflow.com www.contextflow.com

COMPANY	DESCRIPTION	CONTACT/WEBSITE
CYBERITH	Cyberith is a market leader in professional locomotion devices for virtual reality, enabling users to explore large virtual environments without actually moving through real space. This innovative product adds movement to VR worlds, with areas of application including research institutions, emergency services and the entertainment industry.	Seegasse 3/1 1090 Vienna info@cyberith.com www.cyberith.com
CYBERSHOES	Cybershoes is a VR walking system designed to enable walking, running and jumping in virtual reality. Users are able to move freely in virtual spaces, without encountering any obstacles. Cybershoes makes it possible for users to experience large spaces, even if the physical space available is limited. Instead of hand-held controls, the system uses legs to solve the problem of locomotion in VR. This significantly increases the degree of immersion in the virtual experience.	Haizingergasse 47/4 1180 Vienna mail@cybershoes.io www.cybershoes.io
EMOTION3D	emotion3D specialises in the development of tailored, real-time solutions for 3D environment analysis, for use with mobile applications in the automobile sector and general industry. This AI/ML software solution enables intelligent products to accurately recognize and interact with a 3D environment and the people within it.	Rainergasse 1/8 1040 Vienna office@emotion3d.ai emotion3d.ai
GEOCONSULT ZT GMBH	Geoconsult is a private and independent engineering consultant providing a range of engineering and research services around the world. Founded in 1973, the company employs approximately 350 people and maintains offices in Argentina, Chile, Germany, India, Singapore, Slovakia, Turkey and, of course, Austria.	Hütteldorfer Strasse 85 1150 Vienna office@vienna.geoconsult.at www.geoconsult.eu/index.php/ kontakt-standorte.html
INNOVATION.ROCKS CONSULTING GMBH	innovation.rocks offers a holistic creative package with a focus on state-of-the-art technologies. The range includes user-friendly online and mobile apps, corporate design solutions, direct marketing and augmented reality.	Ungargasse 64–66, Top 50 1030 Vienna vienna@innovation.rocks innovation.rocks
INS INSIDER NAVIGATION SYSTEMS GMBH	Insider Navigation (INS) is the first company to offer hardware-free augmented reality indoor positioning and navigation solutions for mobile devices. INS uses augmented reality and efficient navigation technologies to offer a unique global solution that enables customers to make buildings (factory halls, warehouses, etc.) easily recognisable by mobile devices and to implement significant added value using AR. The entire interactive AR platform can be set up in any kind of building (factories/production plants, warehouses, tunnels, etc.) to optimise navigation, inspection, inventory, maintenance and many other processes.	Stubenbastei 10/6a 1010 Vienna offfice@insidernavigation.com insidernavigation.com

COMPANY	DESCRIPTION	CONTACT/WEBSITE
INTERACTIVE MEDIA SOLUTIONS	Interactive Media Solutions specialises in the development of innovative interactive products and applications with a focus on information, entertainment and advertising. The company offers a range of products including imFUN, imTABLE, imWALL Multitouch and imWALL Vertical Vision to create interactive floor projections, multi-touch tables, interactive walls and vertical ballet performances.	Liebhartstalstrasse 22/B2/8 1160 Vienna office@im-solutions.com www.im-solutions.com
JUNGE RÖMER – CREATIVE PRODUCTION STUDIO	Junge Römer is a creative production studio based in Vienna, Austria. The studio creates beautiful digital solutions: VR and AR applications for a range of purposes and interactive web and film/video projects. Junge Römer operates in the fields of advertisement, entertainment, sales and education. The studio's team of artists, developers and designers are constantly pushing the boundaries of technology and storytelling to create interactive virtual realities that capture the hearts and minds of audiences.	Loquaiplatz 11/1c 1060 Vienna welcome@jungeroemer.net www.jungeroemer.net
KALEIDO AI GMBH	Kaleido enables millions of individuals and businesses from all over the world to accelerate workflows and unleash their creativity with future-proof visual AI tools. The company built remove.bg to simplify and accelerate workflows, foster creativity, rethink photography and design and enable others to create AI century products.	Ungargasse 37/BT1/3.3 1030 Vienna hello@kaleido.ai www.kaleido.ai
NETAVIS SOFTWARE GMBH	Netavis Software is a pioneer in server-based IP video monitoring and video analytics. The system is used in around 10,000 installations with over 100,000 licenses sold, and project sizes range from 1 to 15,000 cameras across a range of sectors including trade, public administration, banking, transport and industry.	Handelskai 388/Top 221 1020 Vienna info@netavis.net www.netavis.net
RECHENRAUM GMBH	Rechenraum develops efficient and robust 3D software applications designed to process, analyse and model 3D data. The company develops tailor-made stand-alone software solutions and sophisticated ready-for-use software modules for integration into existing applications. Individual solutions are created using geometry and mathematics.	Gartengasse 21/3 1050 Vienna office@rechenraum.com www.rechenraum.com
REPEATO	Test automation for Android apps is a complex undertaking, requiring highly qualified personnel. At least, that has previously been the case. Repeato enables users without any programming knowledge to create app tests via record & play. Machine learning and computer vision make this possible.	Rechte Wienzeile 51/6 1050 Vienna office@repeato.app www.repeato.app

COMPANY	DESCRIPTION	CONTACT/WEBSITE
ROBIMO	Robimo GmbH is a service provider offering multicopter solutions in AI/machine learning, image analysis and 3D reconstruction. The company creates machine control and medical data analysis solutions along with symbol and object recognition for mobile devices.	Rossauer Lände 28/25 1090 Vienna office@robimo.at www.robimo.at
SOMA REALITY GMBH	SOMAREALITY specialises in the implementation of medical augmented and virtual reality applications. The company works collaboratively with the Medical University of Vienna on R&D projects in the areas of training and the analysis of medical processes. Research activities are supported by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and medical partners.	Ullmannstrasse 16 1150 Vienna hello@somareality.com www.somareality.com
SQUAREBYTES INTERACTIVE MEDIA	SQUAREBYTES is a new digital agency in Vienna producing all kinds of 3D visualisations, chiefly for the real estate sector. The company uses virtual and augmented reality to create extraordinarily high-quality 3D visualisations and uniquely realistic virtual worlds.	Walfischgasse 14/8 1010 Vienna info@squarebytes.at www.squarebytes.at
SWAP ARCHITEKTEN ZT GMBH	SWAP Architekten ZT is a medium-sized architectural firm. From the very beginning, research and development have been central elements of the SWAP corporate concept, and the R&D department is one of the firm's most important innovations and special features.	Schottenfeldgasse 65/10 1070 Vienna office@swap-zt.com www.swap-zt.com
MOONVISION GMBH	Moonvision is an award-winning company based in Vienna. The company's international team includes data scientists and developers working together to understand an ever-changing world.	Ballgasse 6 1010 Vienna office@moonvision.io www.moonvision.io
VIEWPOINTSYSTEM GMBH	Viewpointsystem is redefining mixed reality. Using disruptive technologies such as Digital Iris® and Eye Hyper-Tracking®, the company is working to establish completely new approaches to interactions between people and between humans and machines. Technologies such as gaze-based MR and eye gesture recognition make communication intuitive and even subconscious.	Franz-Josefs-Kai 47/3 1010 Vienna office@viewpointsystem.com www.viewpointsystem.com
VIEWAR	ViewAR specialises in the creation of augmented and virtual reality applications. Applications range from creating apps in the furniture sector and visualising construction and architectural projects to optimising distribution in cases such as air freight planning for Lufthansa Cargo. ViewAR applications can also be used with 3D glasses such as HoloLens products.	Porzellangasse 43/29 1090 Vienna office@viewar.com www.viewar.com

COMPANY	DESCRIPTION	CONTACT/WEBSITE
VISPLORE	Visplore GmbH offers a highly dynamic graphic analysis solution for investigating large volumes of data from machines, sensors and simulations. The company's eponymous software uses pre-configured analysis tools to save time in data processing and enables people with limited or no programming experience to quickly obtain new and often unexpected findings from big data. Visplore's particular strengths include interactive data cleansing and selection, the ability to analyse correlations and trends and the software's seamless integration with platforms such as Python, R and Matlab. The company's focus encompasses applications in industry and the energy sector.	Donau-City-Strasse 11 1220 Vienna office@visplore.com www.visplore.com
VRISCH	vrisch is an award-winning VR, AR, and 360 video production company from Vienna, Austria, which specialises in specific extended reality (XR) software developments and experiences. The company provides solutions used in multiple industries including defense, entertainment, HR and advertising.	Hainburger Strasse 17 1030 Vienna hello@vrisch.com www.vrisch.com
VRVIS	VRVis is Austria's leading research centre for visual computing and employs more than 70 staff to conduct innovative research and development projects in cooperation with industry and universities. VRVis is also an important supplier of innovative know-how to small and medium-sized enterprises lacking their own R&D departments. VRVis cooperates closely with the technical universities in Vienna and Graz, the University of Vienna and a range of international research institutions including Virginia Tech and Otto-Guuericke University in Magdeburg, Germany.	Donau-City-Strasse 11 1220 Vienna office@vrvis.at www.vrvis.at
WIKITUDE	Wikitude is a pioneer in the field of mobile augmented reality technologies, and the company is behind a series of award-winning AR solutions for smartphones, tablets and smart glasses. Wikitude AR SDK and the company's numerous free products are used by thousands of apps, brands, agencies, developers and AR enthusiasts for various projects. Wikitude is the world's leading AR technology provider, employing around 100,000 developers.	Bisambergerstrasse 15 2100 Korneuburg info@wikitude.com www.wikitude.com
ZACTRACK GMBH	zactrack® is an automated follow system. People and objects in motion are tracked with high accuracy in a 3D model and followed precisely by means of various effect devices.	Rotensterngasse 21/1 1020 Vienna z.office@zactrack.com www.zactrack.com

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