ARCADES

Final Open Workshop and Career Fair

November 27-29, 2019

TU Wien, Vienna

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 675789

The electronic version of this booklet can be found at:
http://arcades-network.eu/index.php/publications/

The open-source LaTeX template, AMCOS_booklet, used to generate this booklet is available at `https://github.com/maximelucas/AMCOS_booklet`

Contents

About

ARCADES Final Open Workshop and Career Fair

The ARCADES Final Open Workshop and Career Fair is the last of a a series of network events in the framework of the ARCADES Project: a European funded ITN under the H2020 Marie Skłodowska-Curie grant agreement No 675789. ARCADES aims at disrupting the traditional paradigm in Computer-Aided Design (CAD) by exploiting cutting-edge research in mathematics and algorithm design. The challenge taken up by ARCADES is to invert the trend of CAD industry lagging behind mathematical breakthroughs and to build the next generation of CAD software based on strong foundations from algebraic geometry, differential geometry, scientific computing, and algorithm design. ARCADES trains 13 ESR fellows who will present at the Final Workshop their research results during the 36 months of the project.

The event is organized by the University of Linz with the help of TU Wien and the ARCADES coordination team. Attending the events will be free of charge.

The last day of the event, November 29th , is dedicated to the Symposium on Geometry and Computational Design (GCD 6), an international annual event organised by the Center for Geometry and Computational Design of TU Wien. GCD 6 consists of a series of lectures by leading researchers presenting recent developments in geometry, computer graphics, computational design and architectural engineering.

In parallel to the Final Workshop, TU Wien holds their KARRIEREZEIT event which will take place on Nov 26-28 at TU Vienna and offers a variety of workshops where around 20 companies will take part. The companies present technical topics/ challenges from their daily business and will work/ discuss with students and graduates about them in 1,5 hrs workshops. KARRIEREZEIT aims to offer students a possibility to get insights from different companies and to get in direct touch with them for their individual questions regarding career and job plans. Note that KARRIEREZEIT starts a day earlier than the ARCADES Final Workshop so ESRs may want to schedule their travel accordingly. We have made an effort to adjust our program to the KARRIEREZEIT program.

Organisers

Josef Schicho Christos Konaxis Ioannis Emiris
Jan Legersky Doris Hotz

Timetable

CT: Contributed Talk, IS: Invited Speaker, KL: Keynote Lecture, IT: Invited Talk.

Wednesday, 27 of November

14:00–14:30	**Registration - Welcome remarks**		
14:30–14:50	CT	**Clément Laroche** Athena RC, Greece	Swept volumes
14:50–15:10	CT	**Evangelos Bartzos** Athena RC, Greece	On the multihomogeneous Bézout bound for the number of embeddings of minimally rigid graphs
15:10–15:30	CT	**Yairon Cid Ruiz** U. Barcelona, Spain	An overview of the ESR3 project
15:30–16:00	**Coffee break**		
16:00–16:20	CT	**Fatmanur Yildirim** Inria Sophia Antipolis, France	Implicit matrix representations
16:20–16:40	CT	**Ahmed Blidia** Inria Sophia Antipolis, France	New geometric models for the design and computation of complex shapes
16:40–17:00	CT	**Jan Legersky** Johannes Kepler Univ. Linz, Austria	Edge Colorings and Paradoxical Graph Motions
17:30–18:00	**Educational Committee meeting**		
19:00	**Welcome Reception**		

Thursday, 28 of November

9:30-10:30	IS	**Stefanie Hahmann** U. grenoble, France	Shape from sensors: Curve networks on surfaces from 3D orientations
10:30-11:00	**Coffee break**		
11:00-12:00	IS	**Rimvydas Krasauskas** U. Vilnius, Lithuania	Kinematic interpretation of Quaternionic-Bézier formulas
12:00-14:00	**Lunch break**		
14:00–14:20	CT	**Francesco Patrizi** SINTEF, Norway	A Quasi-interpolation Method Based on LR B-splines
14:20–14:40	CT	**Andrea Raffo** SINTEF, Norway	Local representations of raw points via collections of tensor product B-splines
14:40–15:00	CT	**Theofanis Katsoulis** U. Strathclyde, UK	TshipPM: A T-splines-based Parametric Modelling Tool for the gen- eration of Container and Tanker ship-hulls
15:00–15:30	**Coffee break**		
15:30–15:50	CT	**Sotirios Chouliaras** U. Strathclyde, UK	An Isogeometrically enhanced CAD-CAE tool for analysing the effects of shape modifications
15:50–16:10	CT	**Michael Jimenez** TU Wien, Austria	An overview of the ESR12 project: Architecture as an Impetus for Geometry
16:10–16:30	CT	**Konstantinos Gavriil** Evolute, Austria	An overview of the ESR13 project: Computational design for architecture
17:30	**Supervisory Board meeting**		
20:00	**Conference Dinner**		

Friday, 29 of November

Symposium on Geometry and Computational Design

9:30	**Opening**		
	MICHAEL WIMMER Director of the Center for Geometry and Computational Design		
	MICHAEL DRMOTA Dean of the Faculty of Mathematics and Geoinformation		
9:45	IT	**MIRELA BEN-CHEN** Israel Institute of Technology, Israel	Chebyshev Nets on Discrete Surfaces
10:30	**Coffee break**		
11:00	IT	**JAN KNIPPERS** U. Stuttgart, Germany	Integrative Computational Design and Construction for Architecture
11:45	IT	**KRISTINA SCHINEGGER** U. Innsbruck, Austria	Vague Geometries
12:30	**Lunch break**		
14:15	IT	**PETER SCHRÖDER** Caltech, USA	Shape from Metric
15:00	IT	**KATHRIN DÖRFLER** TU Munich, Germany	Strategies for Robotic On-site Construction
15:45	**Coffee break**		
16:30	IT	**VITEZSLAV STEMBERA** TU Wien, Austria	How to Predict the Plastic Collapse of Structures Efficiently?
16:30	IT	**GORAN SIBENIK** TU Wien, Austria	Data Exchange between Architectural Design and Structural Analysis Models
16:30	IT	**ARVIN RASOULZADEH** TU Wien, Austria	Variational Path Optimization of Linear Pentapods
16:30	IT	**MICHAEL HENSEL** TU Wien, Austria	Embedded Architectures – En route to Data-driven Modelling for Architecture and Environment Integration
18:30	**Conference Dinner**		

List of Abstracts – Talks

Wednesday 27th

Swept Volumes

C. Laroche[1,2]

[1] Athena Research Center, Athens, Greece
[2] National and Kapodistrian University of Athens, Athens, Greece

We present a new way to describe the volume generated by an object following a rigid transformation in 3D, with an implicitly representation. Both the geometry of the base object and the sweeping movement are combined for building a structure allowing the standard implicit representation queries plus extraneous informations about the time spans of interest for each query. This work has been first developped during the secondment at RISC Software GmbH in the winter of 2019.

On the multihomogeneous Bézout bound for the number of embeddings of minimally rigid graphs

E. Bartzos[1,2]

[1] Athena Research Center, Athens, Greece
[2] National and Kapodistrian University of Athens, Athens, Greece

In this research we focus on multihomogeneous Bézout (m-Bézout) bounds of algebraic systems derived from the embeddings of rigid graphs. We introduce two methods to compute the m-Bézout bounds for the embeddings of minimally rigid graphs in $\mathbb{C}^d$ and S^d. The first relates the number of graph orientations to m-Bézout bound. The second leverages a matrix permanent formulation and yields the first non-trivial asymptotic upper bound in dimension $d \geq 5$, both in the Euclidean and spherical case, thus improving upon the best bound today.

Our computations indicate that m-Bézout bounds are tight for embeddings of planar graphs in S^2 and $\mathbb{C}^3$. We exploit Bernstein's second theorem on the exactness of Mixed volume, and relate it to the m-Bézout bound by analyzing the associated Newton polytopes. We reduce the number of checks required to verify exactness by an exponential factor, and conjecture further that it suffices to check a linear instead of an exponential number of cases overall.

Relating geometric singularities of parametric curves and surfaces with algebraic moving ideals

Y. C. Ruiz[1,2]

[1] University of Barcelona, Barcelona, Spain
[2] Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

In this talk I will present an overview of the results obtained within the project "Relating geometric singularities of parametric curves and surfaces with algebraic moving ideals". This project is at the crossroad of commutative algebra and geometric modelling. Detection and analysis of singularities of curves and surfaces are at the core of Computer Aided Design of shapes. The aim of this PhD proposal is to approach this geometric problem with tools of Commutative Computational Algebra which are being explored at this moment with very satisfactory results. More concretely, we will study the relation between parameterisations of curves and surfaces and algebraic features of the module of syzygies (or higher syzygies) of the coordinates of the parameterisation. This geometry of syzygies approach is a rich research area in commutative algebra which already provided interesting and promising results in the case of plane curves, and we expect to extend its results to surfaces and spatial curves. The algebraic parallel of these algebraic moving ideals are the blow-up algebras. The ubiquity of these algebras has directed us into the theory of D-modules, where we have found interesting connections between system of differential equations and the equations of the moving ideals. Also, we have applied these algebras on relating combinatorial properties of graphs with algebraic properties of its edge ideals. The final goal of this project is to unravel these results for space curves and surfaces, highlighting those that would provide applications in geometric modelling and visualisation. It is also expected to find more compact formulas for implicitisation of rational parameterisations, which we also expect to achieve.

Implicit matrix representations

F. Yildirim

Inria Sophia Antipolis, France

I will present implicit matrix representations corresponding to two problems that I studied during my PhD studies : implicitization of rational algebraic curves in arbitrary dimension (which is a joint work with L. Busé, C. Laroche) and computation of orthogonal projections of a point on a rational algebraic surface in three dimensional space (which is a joint work with N. Botbol, L. Busé and M. Chardin). In fact, these matrices are called implicit matrices because they have the property that their ranks drop at a given point p on the geometric object we consider.

New geometric models for the design and computation of complex shapes

A. Blidia

Inria Sophia Antipolis, France

The representation of complex shapes is a major bottleneck in geometric modelling. Classical representations are based on bspline surfaces, which are trimmed and assembled to describe shapes. But these models have several drawbacks: weak connection between topology and geometry, inaccuracies along trimmed curves, obstacles in their local refinement. They induce a high computational cost in many geometric operations and in the use and transformation of these models.The objective of the Ph.D. project is to investigate new geometric representations, based on new types of spline functions, which extend the standard bspline representation used in CAD. We will study the space of piecewise polynomial functions of bounded degree on domains with arbitrary topology. We will analyze their dimension and determine bases with good geometric properties. These functional spaces will be used to construct families of models with a prescribed topology, which automatically satisfy regularity constraints along edges or across surfaces. We will also investigate local refinement properties for adaptive methods in geometric representation problems. We aim to demonstrate the impact of the approach in specific modelling problems. Several applications are foreseen: fitting and reconstruction of structured shapes from point clouds, description of computational domains for isogeometric analysis and numerical simulations, deformation of models for shape optimization, shape design from sketchs and curve networks. Some of these applications such as modelling problems for ship hull, bulb, propellers and for architecture will be investigated in collaboration with industrial partners of the network.

Edge Colorings and Paradoxical Graph Motions

J. Legersky[1,2]

[1] Johannes Kepler University, Linz, Austria
[2] Dept. of Applied Mathematics, Faculty of Information Technology, Czech Technical University, Prague, Czech Republic

A motion of a graph is a curve of pairwise non-congruent realizations of the graph in the plane such that distances between adjacent vertices are constant. We discuss the existence of edge lengths allowing a motion using a special edge coloring. We show that these so called NAC-colorings can be used also to obtain motions with injective or symmetric realizations or to classify all possible edge lengths allowing a motion for some graphs. A subclass of NAC- colorings allows to study motions of graphs on the sphere. The main focus in all these questions is on the graphs that have only finitely many non-congruent realizations compatible with generic edge lengths, namely, they can move only for a special choice of edge lengths.

Thursday 28th

Shape from sensors: Curve networks on surfaces from 3D orientations

S. Hahmann IS

Stefanie Hahmann, Univ. Grenoble Alpes, France

We present a novel framework for 3D shape reconstruction using inertial and magnetic sensors. When placed onto a shape, these sensors provide local surface orientations along a curve network on the shape, but their absolute position in the world space is unknown. The challenges with this type of 3D acquisition are threefold. First, sensor measurements are noisy and inconsistent. Second, since positions are unknown, the acquired curve network has to be reconstructed from orientations. Finally, the smooth surface needs to be inferred from a collection of curves with normals. To compute the shape from measured data, our main insight is to formulate the reconstruction as a set of optimization problems. Using discrete representations, these optimization problems are resolved effciently and at interactive time rates.

Kinematic interpretation of Quaternionic-Bézier formulas

R. Krasauskas IS

Vilnius University, Institute of Computer Science, Vilnius, Lithuania

The orbits of 3d flat sections of the Study quadrics under the kinematic map are characterized as Darboux cyclides having one connected component with possible isolated singular point. In particular, this allows us to find simple kinematic interpretation of several low-degree rational parametrizations of this class of Darboux cyclides, including earlier unknown ones.

A Quasi-interpolation Method Based on LR B-splines

F. Patrizi

SINTEF AS, Olso, Norway

In order to break down the tensor structure of standard B-splines, Locally Refinable (LR) B-splines have been introduced by extending the concept of knot insertion of the 1D B-splines to local insertion of (d-1)-dimensional boxes for the dD case. Like standard tensor-product B-splines, LR B-splines have local supports, are nonnegative and, using weights in (0,1), they form a partition of unity. However, a full description of their linear independence is still an open problem. LR B-splines are defined over mesh instances, called LR-meshes. These are built as a sequence of local insertions starting from a coarse tensor mesh. In the literature is provided a way of generating LR-meshes over which the corresponding LR B-splines are locally linearly independent. These meshes have a hierarchical structure, and the procedure requires an a priori knowledge of the subregions of the domain where the mesh should be finer. On the other hand, a quick and light construction of quasi-interpolation schemes based on Truncated Hierarchical (TH) B-splines has been developed in the literature. It is actually also applicable in the general setting where the basis functions have local supports, are nonnegative, form a partition of unity and are locally linearly independent. Moreover, it is proved that such a quasi-interpolant is actually a projector on the space spanned by the basis functions under some not-so-restrictive hypotheses on the given data set.

Local representations of raw points via collections of tensor product B-splines

A. Raffo

SINTEF AS, Oslo, Norway

Continuous representations are fundamental for modeling sampled data so that computations and numerical simulations can be performed directly on the model or its elements. To effectively and efficiently address the approximation of perturbed point clouds we propose the Weighted Quasi Interpolant Spline Approximation method (wQISA). We provide global and local bounds of the method and discuss how it still preserves the shape properties of the classical quasi-interpolation scheme. This approach is particularly useful when data noise can be represented as a probabilistic distribution: from the point of view of nonparametric regression, the wQISA estimator is robust to random data perturbation such as noise and outliers. Finally, we show the effectiveness of the method with several numerical simulations on real data, including curve fitting on images, surface approximation and simulation of rainfall precipitations.

TshipPM: A T-splines-based Parametric Modelling Tool for the generation of Container and Tanker ship-hulls

T. Katsoulis

University of Strathclyde, Glasqow, UK

A time-efficient T-splines-based parametric modeller (PM) with low complexity (number of control points), with a very rich design space containing diverse design possibilities, as well as increased robustness regarding to the geometric validity of the produced ship-hulls. TshipPM generates smooth instances (at least G1-continuous for bicubic T-splines), with increased fairness (non-oscillatory distribution of curvatures). It is compared with a commercial PM (CAESES), with both PMs' outputs compared against a parent containership hull (Moeri KCS) used in the literature for CAD and CFD benchmarking purposes. The employed comparison criteria include moments up to 2nd order, the sectional area curve, the Gaussian curvature for assessing surface fairness, and the Hausdorff distance for measuring the geometric distance between two hulls.

An Isogeometrically enhanced CAD-CAE tool for analysing the effects of shape modifications

S. Chouliaras

University of Strathclyde, Glasqow, UK

Design of engineering systems is becoming increasingly complex and demanding due to a plethora of requirements regarding efficiency, economy, safety, comfort and lower-carbon footprint. Realistic simulation of the associated physical phenomena, processes and subsystems places a premium on tightly integrated Design-Through-Analysis (DTA) tools. According to a study undertaken by T. Blacker, Manager of Simulation Sciences at SNL (Sandia National Labs), almost 80

An overview of the ESR12 project: Architecture as an Impetus for Geometry

M. Jimenez

Technische Universität Wien, Vienna, Austria

In this talk, I will give an overview of the work done during the course of my time as ESR12 within the ARCADES Network. The starting-off point was the idea from previous work of my adviser, to use geometric properties to help in the architectural design modern glass façades, and their support structures. To that end, the main focus of my work was on surfaces that have a constant ratio of principal curvatures, whose geometry provides a natural way of obtaining support structures, while keeping a uniform aesthetic to the resulting façade. The first part of my work, focusing mostly on the discretization/optimization of these surfaces, resulted in one paper, which was published with two other colleagues from the TU Wien. At the end of my talk, I will go over my current work, which is about the smooth theory behind these surfaces within a large class of surfaces, with the intention of helping generate more interesting examples.

An overview of the ESR13 project: Computational design for architecture

K. Gavriil[1,2]

[1] Evolute GmbH
[2] Technische Universität Wien, Vienna, Austria

In this talk I will present an overview of the results obtained within the project "Computational design for architecture". The main initial direction of this PhD is to study geometric modeling under the presence of material constraints. Materials like wood, glass and metal introduce constraints to the abstract geometric modeling of surfaces. The developability of these materials is an example of such a constraint which has been well studied. Additional constraints unique to each material, such as cold bending of glass, the double bending and stretching of metal sheets, and the preferred direction of timber panels can be taken into account. The incorporation of these constraints, induced by the unique properties of each material, to the design process will find immediate applications in areas such as architecture and engineering. At first, different constraint formulations for both material stretching and bending will be studied for both NURBS surfaces, which are the industry standard for geometric modeling, and triangle meshes for the discrete case. Algebraic and nonlinear analysis of these constraints will be carried out, as well as analysis of the error behavior. These constraint formulations will be linked to the existing mechanical property measurements of various materials. We intend to develop an interactive design tool which allows the user to deform given surfaces from their initial configurations, such that material constraints are maintained within thresholds dictated by the material used. The interactive design tool will be implemented as a plugin to the widespread 3d modeling system Rhinoceros3D. The implementation will make use of an extensive C++ SDK for geometric optimization applications developed at Evolute GmbH. We, also, intend to present this work and any additional progress that will be made to top venues of geometric modeling and geometric computing.

List of Participants

Ioannis Emiris	ATHENA RC, Athens, Greece
Christos Konaxis	ATHENA RC, Athens, Greece
Clément Laroche	ATHENA RC, Athens, Greece
Evangelos Bartzos	ATHENA RC, Athens, Greece
Carlos D'Andrea	U. Barcelona, Barcelona, Spain
Yairon Cid Ruiz	U. Barcelona, Barcelona, Spain
Laurent Busé	Inria Sophia Antipolis, Sophia Antipolis, France
Bernard Mourrain	Inria Sophia Antipolis, Sophia Antipolis, France
Fatmanur Yildirim	Inria Sophia Antipolis, Sophia Antipolis, France
Ahmed Blidia	Inria Sophia Antipolis, Sophia Antipolis, France
Josef Schicho	Johannes Kepler University,Linz, Austria
Jan Legersky	Johannes Kepler University,Linz, Austria
Georg Muntingh	SINTEF AS, Oslo, Norway
Francesco Patrizi	SINTEF AS, Oslo, Norway
Andrea Raffo	SINTEF AS, Oslo, Norway
Panagiotis Kaklis	University of Strathclyde, Glasgow, UK
Theofanis katsoulis	University of Strathclyde, Glasgow, UK
Sotirios Chouliaras	University of Strathclyde, Glasgow, UK
Helmut Pottmann	Technische Universität Wien, Vienna, Austria
Michael Jimenez	Technische Universität Wien, Vienna, Austria
Heinz Pottmann	Evolute GmbH, Vienna, Austria
Konstantinos Gavriil	Evolute GmbH, Vienna, Austria
Alexander Leutgeb	RISC Software GmbH, Hagenberg, Austria
Christian Arber	Topsolid, France
Robin Fairey	ITI, Cambridge, UK
Christian Müller	Technische Universität Wien, Vienna, Austria
Steafanie Hahmann	Grenoble Institute of Engineering - Ensimag, Grenoble, France
Rimvydas Krasauskas	Vilnius University, Inst. of Computer Science, Vilnius, Lithuania
Shahroz Khan	University of Strathclyde, Glasgow, UK

Useful Information

Talks of the Final Workshop will be held in the **Contact room**, Gusshausstrase 27-29, stair 1, floor 6, 1040 Wien.

Talks of the Symposium on Geometry and Computational Design (GCD6) which will take place on Nov 29, 2019 at TU Wien's **Kuppelsaal**, Karlsplatz 13.

Coffee breaks will be offered on site and **lunch** will be offered on Thursday at TU Wien's **MENSA**.

Wi-Fi will be available during the conference. TU Wien also provides access to an eduroam network.

The **conference dinner** will be held at the restaurant **Griechenbeisl**, Griechengasse 9 Fleischmarkt 11, the oldest restaurant in Vienna.

How to get to the Vienna University of Technology?

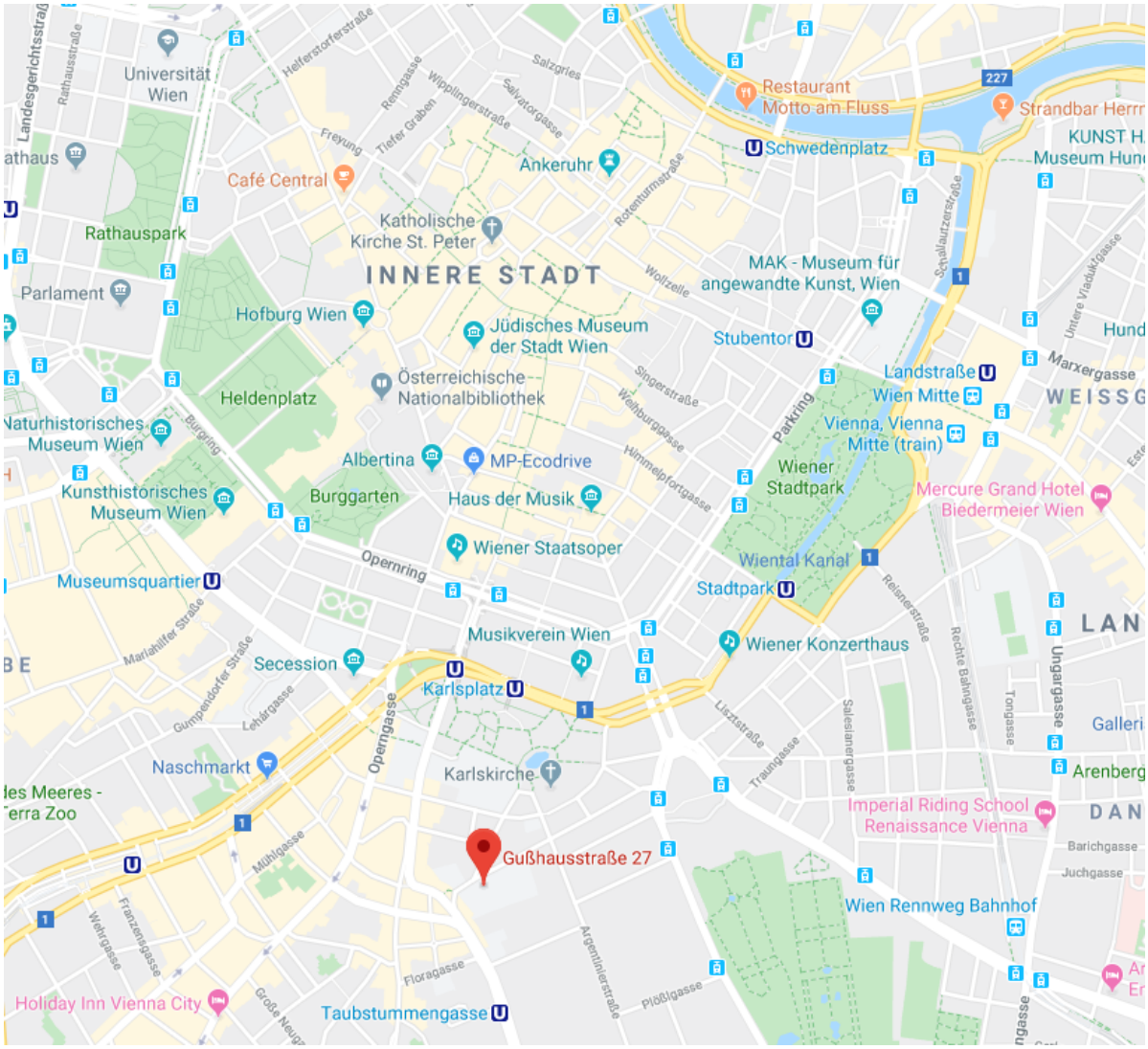
Depending on where you are coming from, you may travel to Vienna by plane, train, bus or car. Once you are in Vienna, follow the directions below to go to Vienna University of Technology.

- **By Plane**
  The Vienna International Airport (VIA) in Schwechat is about 20 km south-east of Vienna. There are many different ways to get into the city:
  - From/to station Wien-Mitte by City Airport Train (CAT) non-stop: approx. 16 min.
  - From/to station Wien-Mitte and Station Wien-Nord (Praterstern): S7 (ÖBB Suburban Train Network): approx. 25 min.
  - From/to the centre of Vienna (Schwedenplatz/ Morzinplatz) and other destinations in Vienna by Vienna Airport Lines: approx. 25 – 35 min.
  - Taxi: approx. 35 min.

- **By Train/Bus**
  If you prefer travelling by train you will find detailed information at the website of the

ÖBB (Austrian Federal Railways).

- **By Car**
  - from the south and east: Südautobahn (A2) – Südosttangente – Exit Gürtel – Südbahnhof – Prinz Eugenstraße – Schwarzenbergplatz – Karlsplatz
  - from the west: Westautobahn (A1) – Hietzinger Kai – Schönbrunner Straße – Rechte Wienzeile – Karlsplatz
  - from the north: Donauuferautobahn (A22) – Südosttangente – Exit Gürtel – Südbahnhof – Prinz Eugenstraße – Schwarzenbergplatz – Karlsplatz If you travel by car, please do not forget to purchase the official highway toll sticker if you plan to use Austrian highways.



Acknowledgements

The ARCADES Final Open Workshop and Career Fair is organised in the framework of the ARCADES project, funded by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 675789.