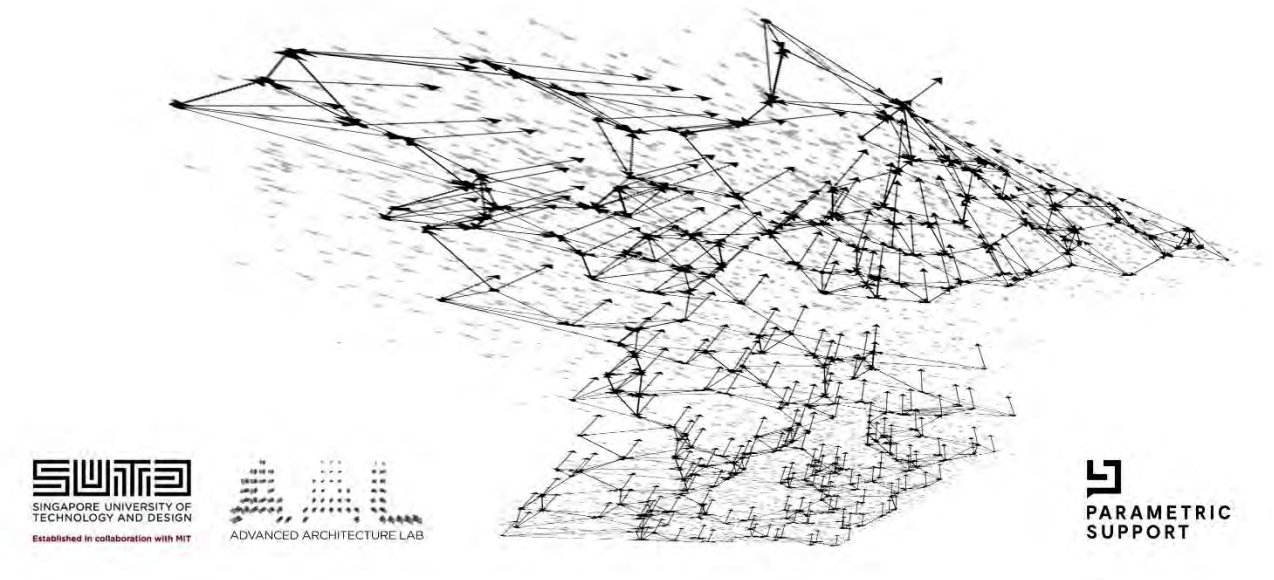


Figure 1. **The main graphic.**

Workflows for Conceptual Architectural Design Optimization (ADO)

The workshop will explore applications of mathematical optimization to architectural design. Participants will learn about major classes of black-box optimization algorithms—Metaheuristics (including Swarm Intelligence), Direct Search and Surrogate Model-based Optimization—and experiment with algorithms from each category: Genetic Algorithms, Particle Swarm Optimization, DIRECT, and optimization with Radial Basis Functions.

Participants will use state-of-the-art optimization tools in Grasshopper and test them on benchmark problems. In a second step, they will develop customized optimization objectives and workflows and apply them to a predefined parametric geometry. Participants also are encouraged to bring optimization problems from their own practices and research to the workshop.

The objective of this workshop is to provide participants with both the conceptual background and technical skills required to integrate optimization into their architectural practice and research. The workshop will yield benchmark results for the test problems and provide examples of how different formulations of optimization objectives can inform conceptual architectural design process.

Technical requirements

Participants should be familiar with Rhinoceros, and have a basic knowledge of Grasshopper.
Participants should bring their own laptops, with the required software preinstalled.

List of necessary facilities

Minimal requirements:
Comfortable space for the workshop participants with power points, projector, screen.

Preferred:
Access to a computer lab with powerful computers and the required software (preinstalled or with the ability to install it), black or white board.

Required Software (free unless indicated otherwise):

- Rhinoceros 5 (30-day free evaluation)
- Grasshopper3d 0.90076
- Optimization solvers: Galapagos, Silvereye, Goat, Opossum, Octopus
- Analysis: DIVA (free educational license), Ladybug, Karamba (free version with limited functionality, full licenses subject to availability)

Results to be exhibited at CAADRIA

Posters and short videos.

Schedule

DAY 1 2/04/2017

RESEARCH BACKGROUND, INTRODUCTION, BENCHMARK PROBLEMS

- Theoretical introduction to optimization in architectural engineering (methods and applications)
- Theoretical introduction to structural and environmental simulation with Karamba, Ladybug, Diva
- Solving benchmark problems
    - Structural
    - Solar
    - Geometric

DAY 2 3/04/2017

DEVELOPMENT OF OPTIMIZATION STRATEGIES – work in groups

- Preparation of the parametrized model of the generic pavilion / Preparation of individual problems
- Formulating fitness function for each strategy
- Preparation of the posters and videos for CAADRIA exhibition

External supporting company

Parametric Support is a spin-off company from Technical University Berlin. The company is developing their own optimization technologies based on Swarm Intelligence and offer optimization consultancy for architects worldwide. Parametric Support helps architects to discover inexpensive and high-performing design solutions that balance environmental, structural and financial aspects such as daylight availability, structural optimization, geometry rationalization, adaptation of projects to building code, and cost-effectiveness. The mission of Parametric Support is to simplify and accelerate the exhaustive and time consuming design phase where multiple competing objectives must be satisfied.

Bollinger-Grohmann-Schneider ZT GmbH Vienna – Karamba support

Karamba is being developed by Clemens Preisinger in cooperation with Bollinger-Grohmann-Schneider ZT GmbH Vienna. Its dissemination is a team effort. Karamba team an interdisciplinary team of architects and structural engineers who use Karamba in our daily office work at Bollinger-Grohmann-Schneider.

Images

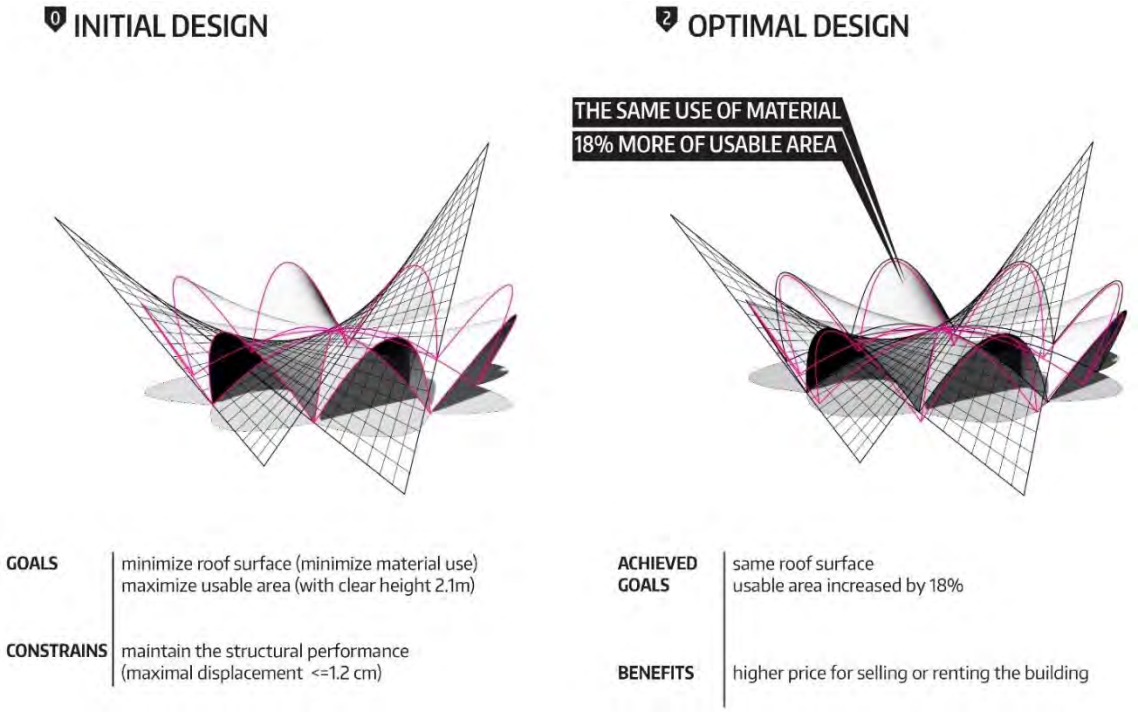
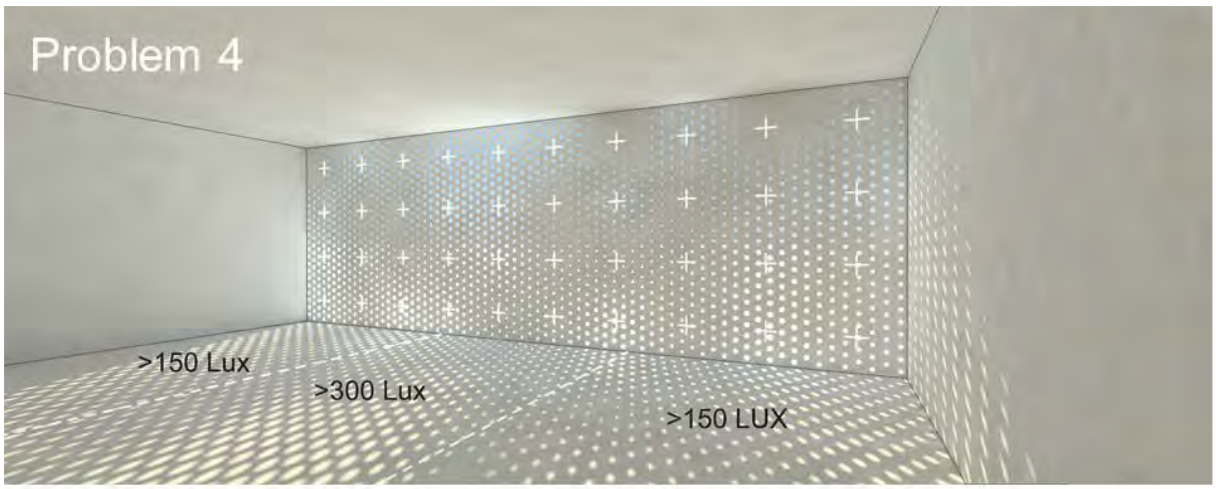


Figure 2. Sample Problem (Structural): Problem formulation and result

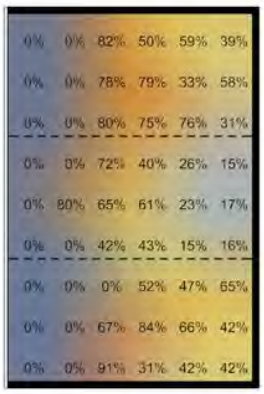


40 continuous variables x
(40 attractor points controlling 1692 individual openings)

$$x_i = \overline{\sum_{i=0}^{39} \frac{w_j}{d_j^3}}$$

Maximize (annual) Daylight Availability (DA)
in "partially daylit" (150-1500 Lux) and "fully daylit" (300-1500 Lux) zones

Figure 3. Sample Problem (Daylighting): Problem formulation



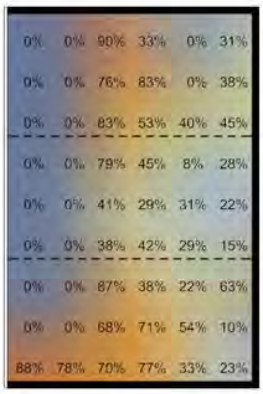
Galapagos (GA)
Average Best Solutions

after 50 evaluations

31.85%

after ~150 evaluations

32.37%



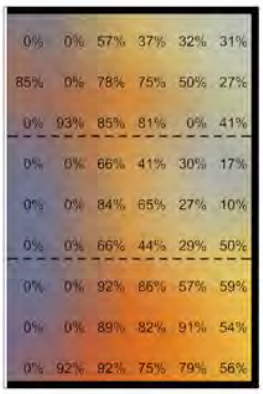
Goat (Direct)
Average Best Solutions

after 50 evaluations

29.26%

after ~100 evaluations

29.35%



RBFOpt(MSRSM)
Average Best Solutions

after 50 evaluations

32.40%

after ~150 evaluations

39.05%

Figure 4. Sample Problem (Daylighting): Results

Workshop Leaders

Judyta Cichocka (Wroclaw University of Technology, founder of Parametric Support)

Judyta is a researcher in the field of architectural design optimization. She is the founder of Code of Space, a PhD candidate at Wroclaw University of Technology, the main partner of Absolute Joint System in Poland and was a parametric design tutor at Victoria University of Wellington and at Advances of Architectural Geometry in London (2014) and Zürich (2016). Judyta also co-authored Silvereye, an optimization tool based on Swarm Intelligence. She published several papers on optimization and parametric design.

Adrian Krężlik (School of Form, founder of Parametric Support)

Adrian is a practicing architect with six years of postgraduate experience. The founder and the owner of Architektura Parametryczna – the biggest Polish consultancy company in parametric de-sign. He worked on large scale projects in China, USA and Saudi Arabia for the most innovative companies: Zaha Hadid Architects in London, FR-EE Fernando Romero and Rojkind Arquitectos in Mexico. In his work, he focuses on applying digital strategies in design and construction processes. He is an active player across the parametric scene.

Aloysius Lian, (Advanced Architecture Laboratory, Singapore University of Technology and Design)

Aloysius Lian is the principal of Lian Architects and a Research Scientist at SUTD's Advanced Architectural Laboratory. He has practiced and taught architecture in the United States and Singapore, after graduating from Pratt Institute with a Master of Architecture. In his seven years of working in Singapore, he has completed a wide range of buildings from small residential to large scale institutional projects. Aloysius has worked extensively with various types of computational tools, including parametric design, simulation, and optimization.

Thomas Wortmann (Advanced Architecture Laboratory, Singapore University of Technology and Design)

Thomas is a PhD candidate and studio instructor in SUTD's Architecture and Sustainable Design pillar. In 2013, he graduated from MIT with a Master of Science in Design and Computation, after having worked for several years as a project architect for the Dutch architectural practice of NOX, known for its pioneering use of digital design tools. As a member of the Advanced Architecture Laboratory, he has been responsible for the computational design and programming of projects such as the lighting installations for iLight Marina Bay and nZwarm in Wellington, and the generative, digitally fabricated wall screens for the Venice Biennale and the National Design Center Singapore. His research interest is the integration of computers into the architectural design process, with a focus on model-based optimization tools.

Most recently, Thomas and Aloysius have completed the "Future of Us" grid shell in Singapore, automatically generating cut sheets and assembly instructions for over 10.000 individual panels. Since 2014, they have taught design studios and parametric design courses at Singapore University of Technology and Design, Singapore Polytechnic, the Singapore Institute of Architects, the Building Construction Authority Academy, and Archifest. In 2016, they lead an architectural optimization workshop during the Advances in Architectural Geometry Conference at ETH Zurich, entitled "Optimize this!".

References

Costa, A., Nannicini, G., Schroepfer, T., & Wortmann, T. (2015). Black-Box Optimization of Lighting Simulation in Architectural Design. In Complex Systems Design & Management Asia (Cardin, M.-A., Krob, D., Lui, P. C., Tan, Y. H., & Wood, K., Eds.), pp. 27–39. Cham, CH: Springer.

Wortmann, T., Costa, A., Nannicini, G., & Schroepfer, T. (2015). Advantages of Surrogate Models for Architectural Design Optimization. AIEDAM, 30(4), 471–481.

Wortmann, T., & Nannicini G. (2016). Black-Box Optimization Methods for Architectural Design. In Proceedings of the 21st International Conference of the Association for Computer-Aided Architectural Design Research in Asia (Chien, S., Choo, S., Schnabel, M. A., Nakapan, W., Kim, M. J., Roudavski, S., Eds.). Hong Kong: CAADRIA.

Cichocka, J., 2016. Particle Swarm Optimization for Architectural Design 1st ed., Vienna: Code of Space.

Cichocka, J.M., Browne, W.N. & Rodriguez, E., 2015. Evolutionary Optimization Processes As Design Tools : In Proceedings of 31th International PLEA Conference ARCHITECTURE IN (R)EVOLUTION, Bologna 9-11 September 2015.