Activity Report

2013/ 2014

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Activity Report

Dear Rectorate,
Dear Colleagues,

the Department of Mathematics and Science is a very active Department at the German University of Technology in Oman (GUtech). It was found in 2010 and forms together with the Department of Applied GeoSciences the Faculty of Science. It has three pillars: Chemistry, Mathematics and Physics. It is running the GUtech Chemistry and Physics laboratories and supports the Foundations program towards staffing and curriculum.

It has excellent collaborations with the Sultan Qaboos University, Sultanate of Oman, the German Elite-Universities RWTH Aachen and TU München, the TU Wien, Austria, the University of Giessen, Germany, Durham University, Great Britain, the Centre for Theoretical and Computational Chemistry in Tromsø, Norway, as well as with the Kyoto Sangyo University, Japan.

The academic year 2013/ 2014 provided several significant changes for the Department of Mathematics and Science: Prof. Dr. Volker Enss retired, Judith Kreuzer became PhD, and our four new colleagues Ms. Shafiqa Al Foora, Ms. Fatma Al-Hatmi, Dr. Sausan Al-Riyami and Prof. Dr. Florian Rupp joined. Thus, these endeavors in hiring extremely well educated Omani nationals as well contribute to a high extend to the continuous capacity building for the Sultanate of Oman. We hope that Shafiqa, Fatma, Tahiya (who was hired 2012 already) and Dr. Sausan serve as role models for the future generations of Oman and help to carry out Sultan Qaboos ibn Said's vision of a well educated Omani society.

In 2013, for the first time at GUtech the number of students starting in the BSc program reached the mark of 100 leading to major challenges in administration and education as well as the necessity to invent a new student centered teaching paradigm, now known as Kaizen learning. Moreover, we conducted several events for GUtech students, the scientific community and the broader public: the construction of the largest tetrahedron sponge, the co-organization of the "Third International Conference on Numerical Analysis and Optimization: Theory, Algorithms, Application, and Technology", as well as an exhibition with several talks on crystallography together with Prof. Dr. Michaela Bernecker and the special session "Applied Analysis and Dynamics in Engineering and Sciences" at the 10th international conference of the American Institute of the Mathematical Sciences.

Many of these activities were documented and given to the press thanks to the excellent support and advice of Manuela Gutberlet. Her press releases form the basis of the "special events" section of this activity report.

Of course, these events and the smooth daily running of our research and teaching activities could not be done without the overwhelming support of Student Affairs and Administration, whom we cordially thank.

Finally, it is worth to mention, that together with the Department of Computer Science, Mathematics & Science plays a leading role in the DAAD-founded blended learning project between GUtech and the RWTH Aachen.

Please, allow me to give a short outlook on some upcoming events in the academic year 2014/ 2015: several research and conference proposals have and will be submitted to The Research Council of Oman, and we hope to get positive feedback for some of them soon. A joint student-workshop with the European Association of Geoscientists and Engineers will be held under the theme "The Art of Science". A presentation of Best Practice/ Kaizen Teaching is to be conducted at the Academic GUtech staff workshop in October 2014. We will introduce at Gutech the RWTH Aachen App and test it in large scale teaching environments. Further a series of blended learning workshops is planned.

On behalf of everyone at Mathematics & Science, I thank you for your continued support as we continuously improve our teaching to the benefits of our students and findings in research to the wealth of the people in the Sultanate of Oman.

Sincerely,

Prof. Dr. Bernhard Heim
Dean of the Faculty of Science
HoD Department Mathematics & Science

أعضاء إدارة الجامعة الكرام....
الزملاء والزميلات الأعزاء ...

يعتبر قسم الرياضيات والعلوم أحد أهم الأقسام الفعالة في الجامعة الألمانية للتكنولوجيا في عمان (جيوتيك). لقد تأسس هذا القسم كركيزة أولية لكلية العلوم في الجامعة عام 2010 م جنبا لجنب مع قسم علوم الأرض التطبيقية. ينقسم قسم الرياضيات والعلوم إلى ثلاثة أقسام: الكيمياء، والرياضيات، و الفيزياء. ويعمل القسم على دعم مختلف البرامج الدراسية لاسيما البرنامج التأسيسي (مرحلة ما قبل الجامعة).

للقسم علاقات تعاونية مثمرة مع كل من جامعة السلطان قابوس في عمان، وبعض الجامعات الدولية النخبة كجامعة آخن، وجامعة ميونيخ للتكنولوجيا ،وجامعة جيسن بألمانيا، وجامعة فينا للتكنولوجيا في النمسا، وجامعة دورهام في بريطانيا العظمى، ومركز النظرية والحاسوبية للكيمياء في ترومسو في النرويج ،وكذلك مع جامعة كيوتو سانغيو في اليابان.

لقد طرأت عدة تغيرات جوهرية في قسم الرياضيات والعلوم للعام الدراسي 2014/2013 متمثلة بالآتي: تقاعد الأستاذ الدكتورفولكر، وحصول جوديث كروزير على درجة الدكتوراة في الرياضيات البحتة، كما أن القسم إستقبل أربع أعضاء جدد: شفيقة الفورية، وفاطمة الحاتمية، والدكتورة سوسن الريامية، والأستاذ الدكتور فلوريان. يسعى القسم لتبني سياسة التعمين والسعي لتوظيف أعلى الكفاءات من سلطنة عمان. ويأمل القسم بأن تكون كلا من تحية (المنظمة للقسم منذ عام 2012)، وشفيقة، وفاطمة، والدكتورة سوسن بمثابة قدوة للأجيال القادمة في عمان ونأمل أن يكون ذلك تنفيذا لرؤية حضرة صاحب الجلالة السلطان قابوس بن سعيد - حفظه الله ورعاه- للتعليم للمجتمع العماني.

لقد بلغ عدد الطلاب المنتسبين لبرنامج البكالوريوس 100 طالب وطالبة للمرة الأولى في جيوتيك في عام 2013م والذي شكل تحديا كبيرا من الناحية الإدارية والناحية التعليمية، فضلا عن ضرورة إبتكار نموذج تدريس محوره الطالب، والتي تعرف الان بإسم "Kaizen learning" وعلاوة على ذلك لقد قام القسم بتنظيم عدة فعاليات لطلاب جيوتيك متمثلة في بناء أكبر هرم رباعي الوجوه، والمساهمة في تنظيم " المؤتمر الدولي الثالث للتحليل العددي والتطويرلكل من : للنظريات، والخوارزميات، والتطبيقات والتكنولوجيا"، فضلا على إقامة معرض متمثلا بعدة محاضرات عن البلورات بالتعاون مع الأستاذة الدكتورة ميكائيلا. وكذلك المساهمة في الدورة المميزة تحت شعار " التحليل التطبيقي والديناميكي في الهندسة والعلوم" في المؤتمر الدولي العاشر للمعهد الأمريكي للعلوم الرياضية.

أخيرا من الجدير بالذكر بأن قسم الرياضيات والعلوم يلعب دورا قياديا جنب إلى جنب مع قسم علوم الحاسوب في تأسيس مشروع DAAD للتبادل العلمي المشترك بين جيوتيك وآخن.

أود أن أحيطكم علما على أن بعض الأحداث المستقبلية للعام الدراسي 2015/2014 متمثلة بالآتي: هنالك عدة أطروحات وخطط للبحث العلمي والمؤتمرات قد تم وسيتم تسليمها إلى مجلس البحث العلمي، ونأمل في الحصول على ردود إجابية قريبا. كما أنه سيتم تنفيذ ورشة عمل طلابية مشتركة مع الجمعية الأوربية لعلماء الجيولوجيا والمهندسين تحت شعار " فن العلوم". كذلك عرض الأمثلة التعلمية أوكايزن كورشة عمل للأكاديميين في أكتوبر 2014م. وسيتم تقديم تطبيق RWTH Aachen App وإختباره في بيئات تعليمية واسعة النطاق. وإضافة إلى ذلك سيتم تقديم تطبيق سلسلة من الخطط لتنظيم ورش عمل مختلفة .

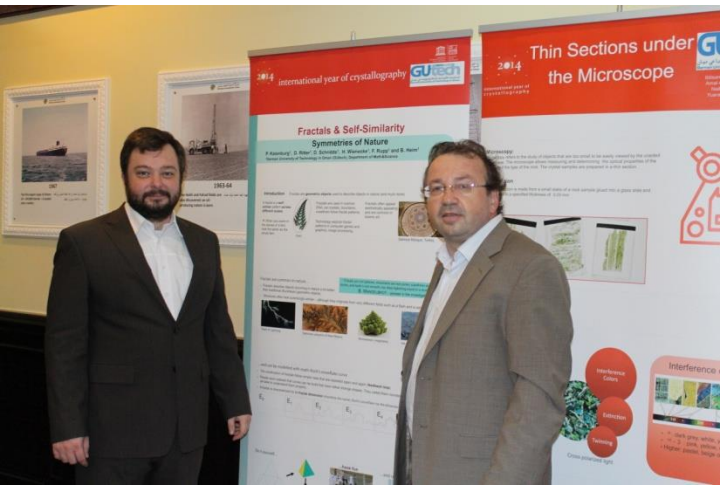
ونيابة عن الجميع في قسم الرياضيات والعلوم، أتقدم لكم بالشكر الجزيل على دعمكم المتواصل ومن جانبنا فنحن نواصل تطوير طرق التعليم لدينا ونعمل على تكريس جهودنا في البحث العلمي لما فيه مصلحة لشعب سلطنة عمان.

مع خالص التقدير

أ.د. برنهارد هايم
عميد كلية العلوم
رئيس قسم الرياضيات والعلوم
الجامعة الألمانية للتكنولوجيا في عمان

Activity Report

Setting-up the tetrahedron fractal for the exhibition at the Geological Society of Oman (left-hand side), and (right-hand side) presentation of certificates to two students who helped translating important Arabic documents of The Research Council into English in order to be accessible by all members of the university.



Prof. Dr. Florian Rupp (left) and Prof. Dr. Bernhard Heim (right) in front of posters for the exhibition at the Geological Society of Oman at the occasion of the UNESO year of crystallography (left-hand side), and (right-hand side) Mrs. Tahiya Al-Shuaili carefully checking a delivered order for the Chemistry laboratory – typically we are hard working and don't have time to pose for fancy photos.

The cover picture displays the positively invariant manifold of the famous Lorenz attractor. In 1963 Edward Lorenz designed a simple 3-dimensional model for convections and weather formation in the atmosphere. To his great astonishment the solutions of this system turned out to capture a great sensitivity on the chosen initial data, two trajectories starting nearby ended at certain simulation times at completely different spots. This behavior together with the strange shape of the attractor coined the term "butterfly effect" which means that a change as light as the flap of a butterfly of the initial data may have drastic results in the longer run. The peculiar nature of the long time dynamics, their swirling into the attractor gave rise to the study of chaotic systems. In particular, the geometry exhibited by the Lorenz attractor itself is that of a fractal object with a Hausdorff dimension of about 2.06.

Persons: Who we are

Shafiqa Al Foora is studying in Al Zahra for Girls College since 2005. Her specialties are Science in Finance and Banking as well as Accounting. Since the 15th of June 2013 she is working at the German University of Technology in Oman. She started with a trainee program involving training at the reception of the university Copy Centre, Financial and HR for 4 month. After that she joined the Department of Mathematics and Science as a secretary. She organizes the time table and supports the department and the complete Faculty of Science in administration matters. In particular, Shafiqa helps the students of our department as well as those of the Faculty of Science and organizes the department's events.

Fatma Al Hatmi graduated from Sultan Qaboos University (SQU) on January 2009 with a Bachelor of Science in Physics and a minor in Mathematics. She did her undergraduate research at the Ministry of Regional Municipalities and Water Resources, Laboratories Centres of Foods and Water, Radioactive Materials Section. From October 2011 to June 2012 Fatma worked as research assistant in the nuclear radiation research laboratories of the Department of Physics of the Sultan Qaboos University (SQU). Moreover, she held a temporary Laboratory Technician position at SQU from February 2012 to December 2012. At the 1st of April Fatma joined our department, and is now a Physics Lab Technician at the German University of Technology in Oman. She is responsible for the preparation of the laboratory experiments for the Bachelor and foundation programs. In addition, she organizes the lab and takes care of the compliance with safety requirements. She helps the lab manager to design the new physics lab during summer 2014. Together with Dr. Sausan Al-Riyami, she improves the experiments in the physics lab.

Sausan Al-Riyami graduated from Sultan Qaboos University (SQU) with a Bachelor of Science in Physics and with a minor in Earth Science. She obtained her master in Science and Engineering with a first-class honour degree, and got her PhD in Applied Science for Electronics and Materials. Both of her master and PhD studies were done in Kyushu University in Japan. In addition, she received a diploma certificate in Novel Carbon Resources Sciences Global Centers of Excellence (Global-COE). During her study she received several academics awards and research grants such as the Japanese Government Scholarship "Monbukagakusho", the Sasakawa Scientific and the Research Grants for Science Fellows, and Research Grant from Global Centers of Excellence "Global COE" in Novel Carbon Resource. On 2nd of February 2014 she joined the Department of Mathematics and Science of the German University of Technology in Oman as a Physics Lecturer. Her research focuses on the preparation and characterization of n-type ultra-nanocrystalline/ hydrogenated amorphous carbon (UNCD/a-C:H) composite films that were prepared by pulsed laser deposition (PLD) technique for the first time in diamond field. This material is believed to be a candidate for several applications such as photovoltics, coating and biotechnology.

Department coffee with interns and friends.

Tahiya Al-Shuaili finished her Bachelor Degree in General Chemistry from Sultan Qaboos University (2010). She worked as Call Center Employee in the "Project 2010" of the General Census of Population, Housing & Establishment, Oman. During her work at the General Census, she also completed a 2-month training in "Advanced Communication & Call Center" from Infoline Company, Oman. In January 2012, she started a new job in the German University of Technology in Oman (GUtech) as Chemistry Laboratory Technician. While in GUtech, she also completed a training program, "Project Management". Some of her activities as Chemistry technician are the support of teaching chemistry. This includes for example assisting in the implementation of good health, safety and cleanliness in the laboratory, keeping an inventory and good supply of laboratory material as well as the preparation of laboratory needs and issuance of these goods to all sorts of laboratory users.

Elena Berdysheva obtained her BSc and MSc in Mathematics and Applied Mathematics at the Ural State University, Ekaterinburg, Russia. In 2000, she obtained her PhD in Mathematics there. She conducted her post-doctoral studies at the Mathematical Institute of the University of Erlangen-Nuremberg in Germany, in particular, as an Alexander-von-Humboldt Fellow. From 2002 to 2011 she worked at the University of Hohenheim, Stuttgart, Germany, where she obtained her Habilitation in 2010. She also served as an Adjunct Professor at the FernUniversität in Hagen and as a Visiting Professor of Numerical Mathematics at the University of Giessen, Germany.

Shafiqa Al Foora (left-hand side)

Fatma Al Hatmi in the physics lab

Elena joined GUtech in 2011 as Professor of Mathematics. Her list of research visits include institutions as The Ohio State University, Columbus, Ohio, US, King Abdulaziz University, Jeddah, Saudi Arabia, and Alfred Renyi Institute of Mathematics, Budapest, Hungary, among others. She is also a member of the Editorial Board of Results in Mathematics (Birkhaeuser). Her research interests are in the field of Applied Analysis and include Approximation Theory, Harmonic Analysis, Special Functions and Orthogonal Polynomials as well as Numerical Analysis.

Bernhard Heim studied Mathematics, Physics and Information Technology at the University of Freiburg, Germany. After his diploma in Mathematics with minor subject Physics, he continued his studies at the of University of Mannheim, Germany, and received a PhD in Mathematics (1997). Until 2000 he was a post doc at the Max-Planck Institute for Mathematics in Bonn (MPIM), Germany. After working 4 years for the German Railway company in several management positions he went back to the MPIM in Bonn and received his Habilitation in 2008. Since 2009 he is a professor at the German University of Technology in Oman (GUtech), serving as a Head of the Department of Mathematics and Science and as a Dean of Science since 2010 and 2012, respectively. His research field is the topic of automorphic forms, a discipline unifying algebra, number and function theory, with applications in string theory, statistics and engineering. He frequently is invited to conferences as a speaker or for research collaboration to Germany (RWTH Aachen, Mannheim, Bonn), Japan (Kyoto, Tokyo) and other countries. He recently organized a Conference in Oman in 2012 at GUtech and as a co-organizer in 2014. He has Master and PhD students, is an author of several research papers, and editor of two scientific journals. Moreover, he recently developed together with Prof. Florian Rupp a new concept on teaching Mathematics for Engineering programs in the Middle East, called Kaizen learning.

Concepcion S. Mendoza holds a MS Chemistry degree (1993) from the University of San Carlos, Philippines, a PhD degree in Applied Chemistry/Environmental-Analytical Chemistry from Kagoshima University, Japan (1997) and in 2001-2002, did post-graduate studies in Water Chemistry at Karlsruhe University (presently, Karlsruhe Institute of Technology), Germany. She has been involved in teaching, research and consulting at the Chemistry Department of the University of San Carlos, Philippines, Research Center for the Pacific Islands and Department of Applied Chemistry and Chemical Engineering, both at Kagoshima University, Japan, at Engler-Bunte Institute, Karlsruhe University in Germany, and at the Department of Applied Sciences of the Higher College of Technology in Muscat, Oman. Her experience in the industry was as Quality Control Chemist of Coca-Cola Bottler's Inc., Philippines. Since April 2012, Concepcion is employed as Professor in Chemistry at the Department of Mathematics and Science of the German University of Technology in Oman. Her research focus is on the analytical chemistry of water, soil, air, biota, industrial products and other environment-related topics like water quality assessment and monitoring, wastewater treatment and characterization, air pollution studies, soil-sediment evaluation studies, solid waste audit, basic research on metal chelation.

Florian Rupp studied Mathematics at the Technische Universität München, Germany, and holds both a Diploma in Mathematics (2003) as well as a PhD in Mathematics from the TU München (2005). In 2008 Florian returned from a position as Management Consultant to the TU München. During his time in consulting he had a major management part in a due diligence, procurement organization diagnosis & restructuring project for a leading pan-European vending company (private equity investment), as well as a benchmarking & procurement diagnosis/ strategy project for a leading global automation technology company to name just two activities. Several research and teaching stays led him to the Center for Theoretical and Computational Chemistry (CTCC) in Tromsø, Norway, the King Abdullah University of Science and Technology (KAUST) near Jeddah, Saudi-Arabia, and the African Institute for the Mathematical Science (AIMS) in Cape Town, South Africa. Since the end of 2013 Florian is Professor at the Department of Mathematics and Science at the German University of Technology in Oman. His research interests comprise stochastic dynamical systems and their stability/ bifurcations, Hamiltonian systems and (classical) molecular dynamics, applications and mathematical modeling in Chemistry, Biology, Engineering, and in particular the Social Sciences, as well as the simulation of Partial Differential Equations with stochastic/ random forcing or controls.

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Prof. Dr. Bernhard Heim and delegates from the RWTH Aachen, India and Japan on the way to Halban Campus.

Visitors & Interns

- Visitors: Dr. Fazal Abbas (University of Buraimi), Dr. Tobias Neckel (TU Munich)
- Interns (full time at the department): Jonas Gallenkämper, Pascal Kaienburg, Judith Kreuzer, Dennis Ritter, Dennis Schridde, Paul von Stockhausen and Nils Viet
- Interns (shared for dedicated tasks for students of engineering): Lukas Bechheim, Jonas Weigand and Hannah Wienecke

What the interns say …

- "Teaching in Oman is a great and honor-full task, which costs a lot of effort but returns even more. In such an international environment as at Department of Mathematics and Science (MAS) you learn much about cultural differences and opportunities. MAS interacts with almost all study programs, so you get into contact with people of different communities. Combined with the great team at MAS, it is a real pleasure to come to work every morning." (J. Gallenkämper)
- "Our work in the Math department was first of all just an awesome experience. To teach highly motivated students motivates us as well to improve our way of teaching so that even less talented students might archive good results in the exams. A perfect win, win situation. Being surrounded by friendly but demanding professors at the same time makes the job as an intern a very interesting opportunity if a little break during studies is needed." (P. v. Stockhausen)

Services for the University

Although, usual at leading universities the time and amount of work spent on diversified administrative matters that affect the smooth running of the university should not stay unmentioned:

The members of the Department of Mathematics and Science served as chairs and active members in several hiring committees, chaired the strategy committee of the Department of Applied GeoSciences and held active roles in the Operational Finance, Human Resources and Infrastructure committees.

We served in the recruitment of Interns, are continuously updating the webpages and GUtech MyPortal sites for the Departments of Applied GeoSciences and Mathematics and Science.

We had and have leading roles in the blended learning activities at GUtech and provide the Chemistry and Physics Laboratory for the foundation program, including the budget planning and resource allocation.

We continuously organize student events and mentor students for several programs not only during their BSc thesis phases. In particular, we served in the Faculty Mentored Undergraduate Research Award Program (FURAP) committee to select and encourage autonomous research projects of our students.

Reports for the accreditation of several programs were as well provided as invigilation duties and presentations at the orientation days of the programs for Computer Science, Engineering and Applied GeoSciences.

Finally, we have the leading role in compiling a research survey based on inputs of GUtech as a whole for The Research Council of Oman.

Prof. Dr. Bernhard Heim together with students and interns after a student team event

Achievements in Teaching

During the academic year 2013/ 14 the members of the department gave 15 lectures for 623 students altogether across three lines of study programs:

Winter Term 2013/ 14:

- Mathematics I for Engineering & Computer Science (lectures, consultation hours, corrected homework assignments, exams, quizzes, e-learning with MUMIE, and exercises for 102 students)
- Chemistry I for Engineering (lectures, consultation hours, corrected homework assignments, exams, quizzes, lab experiments, and exercises for 93 students)
- Mathematics III for Engineering (lectures, consultation hours, corrected homework assignments, exams, quizzes, and exercises for 34 students)
- Mathematics for Earth Scientists I (lectures, consultation hours, corrected homework assignments, exams, quizzes, and exercises for 21 students)
- Mathematics for Earth Scientists II (lectures, consultation hours, corrected homework assignments, exams, quizzes, and exercises for 14 students)
- Numerical Computation for Computer Science (lectures, consultation hours, corrected homework assignments, exams, quizzes, computer labs with MATLAB, exercises and research projects for 12 students)

Spring Term 2014:

- Mathematics II for Engineering & Computer Science (lectures, consultation hours, corrected homework assignments, exams, quizzes, e-learning with MUMIE, and exercises for 99 students)
- Chemistry II for Engineering (lectures, consultation hours, corrected homework assignments, exams, quizzes, lab experiments, and exercises for 86 students)
- Physics II for Engineering (lectures, consultation hours, corrected homework assignments, exams, quizzes, lab experiments, and exercises for 87 students)
- Mathematics IV for Engineering (lectures, consultation hours, corrected homework assignments, exams, quizzes, computer labs with MATLAB, and exercises for 32students)
- Simulation Techniques for Engineering (lectures, consultation hours, corrected homework assignments, exams, quizzes, computer labs with MATLAB & Simulink, and exercises for 17 students)
- Logic & Discrete Structures for Computer Science (lectures, consultation hours, corrected homework assignments, exams, quizzes, and exercises for 8 students)

Posters of the team work projects realized by the students of "Simulation Techniques for Engineering". Picture taken in front of the Engineering Department with a showcase on typical metallic objects.

Students during a Midterm exam of Mathematics I taking place in the research hall.

- Special Topics or Mathematics II for Computer Science (lectures, consultation hours, corrected homework assignments, exams, quizzes, and exercises for 8 students)
- Interpretation of Data and Critical Thinking for Applied Geosciences (lectures, consultation hours, corrected homework assignments, exams, quizzes, and exercises for 20 students)
- Physics for Applied Geosciences (lectures, consultation hours, corrected homework assignments, exams, quizzes, lab experiments, and exercises for 22 students)

Remarks:

- The lecture "Logic and Discrete Structure for Computer Science" (winter term 2013/ 14) was shared with the Department of Computer Science (Prof. Dr. Rudolf Fleischer)
- The lecture "Physics I for Engineering" (winter term 2013/ 14) was provided by external support (Dipl.-Ing. Paul Bandi supervised by Prof. Dr. Michael Modigell)

State-of-the-Art Technology for Chemistry Students at GUtech

Concepcion S. Mendoza & Tahiya Al-Shuaili

The Chemistry Section of the Department of Mathematics and Science provides undergraduate students the opportunity to become scientifically literate and have substantial knowledge of the fundamental chemistry concepts, conceptual networks and process skills that can equip the student to continue to learn and think logically.

Besides conducting independent research, the Chemistry Section sees itself as a vital support unit for chemistry-related needs of the different Bachelor Programs (like Engineering and Applied GeoSciences). Our courses are held by academic advisors and skilled staffs through interactive and student-centred classroom instructions, laboratory investigations, small group projects, and utilization of technology, including computers. A robust state-of-the art Chemistry teaching laboratory located at 514S, appropriately supports safe and effective instruction and collaborative laboratory learning. Since the last academic year, the Laboratory became fully operational and is equipped with heat and acid resistant counter spaces and storage, running water, sinks, good lighting, gas hook-ups, and plenty of electrical outlets. Safety equipment are in place, like exhaust and cooling system, fume hoods, safety showers, eye wash counters, movable exhaust arms, fire extinguishers, fire blankets, first aid kits, emergency alarm, goggles sanitizer, lab gowns, gloves and CCTV camera. It has a good selection of basic and supplemental chemicals in adequate quantities required to complete variable laboratory sessions in the general chemistry course. In addition to different types of glassware, are a variety of laboratory equipment and supplies – like balance, heat sources, support stands and rings, pipettors, pH measuring tools, thermometers, electrodes, corks, filter papers, colorimeters, calorimeters, deionizer, furnace, and others. Other learning provisions like a dry-eraser marker board, projector machine, overhead screen, machine and wireless internet connections, are also available. Safety and efficiency was ensured in its design of the Chemistry Laboratory. Lab fixtures and furniture, lab wares, chemicals and instrumentation; all met the international code and standards. This well-designed Chemistry laboratory can enhance both the teacher's ability to teach and the success of the student's learning experience. The Chemistry Laboratory certainly is one of the major show-case rooms for GUtech. Since its operation to the present, many visitors of the university were interested to take a look into the Laboratory.

Conception S. Mendoza

The Chemistry lab has a variety of chemicals, glass wares and instruments (top).

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A bright, clean and equipped Chemistry Laboratory that is ready for use for 24 students per session. The Chemistry Laboratory at 514S is a state-of-the-art technology setting enabling innovative teaching and mini-projects in the Department of Mathematics and Science at GUtech (top left). Chemical storage cabinets with operating exhaust system and necessary safety signs (top right).

Who says that chemistry is all about explosions and poisonous and stinking gases? Though, a bit crude but really creatively realized are the products of the Chemistry 2 soap making experience (right and bottom right).

Mastering lab skills in Chemistry 1: The batch of Mustafa Al Ajmi, Mohamad Al Alawi and Zahra Al Ajmi (top to right) were the first group of engineering students to have the first-hand chemistry experience in this laboratory. When you look at their concentrated and focused faces at these photographs you understand that chemistry is more than some facts.

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Life is chemistry! Most people do not believe this sentence but it is true. Our food, water and air are all chemicals and they are useful for us. Chemicals in the chemistry lab are not just for experiments and explosion inside the lab but also they can be used in our ordinary life also. In the same way, setting up experiments and assisting students to carry out laboratory experiments is not just for chemistry classes but it can be outside the laboratory for staff as well. The above two pictures of Mrs. Tahiya Al-Shuaili (left) and Prof. Dr. Conception Mendoza (right, and far right) were shot in the office of Prof. Dr. Bernhard Heim. For demonstration purposes he asked for some ethanol from the chemistry lab to run the coffee machine to make his lovely coffee for a department meeting.

Supervised Theses

Part of the academic job is the supervision of theses. Though not having a own program of studies, we supported students in that respect as following in the academic year 2013/ 2014 :

- Professor Dr. Elena Berdysheva supervised
  - Haitham Al-Mawali (2014): *Wireless Sensor Network Scheduling Algorithms*, Bachelor Thesis, GUtech
  - Katharina Baumann (since 2014): *Operators of Bernstein-Durrmeyer Type with Weights*, PhD Thesis, University of Wuppertal/ GUtech
- Professor Dr. Bernhard Heim supervised
  - Hisham Shaban (2014): *Improved Linear World Super Resolution*, Bachelor Thesis, GUtech
  - Judith Kreuzer (2011-2014): *Borcherds Lifts and Maass Lifts on the Paramodular Group of Level 3*, PhD Thesis, RWTH Aachen/ GUtech
  - Jonas Gallenkämper (since 2013): *Hecke Theory for the Orthogonal Group*, PhD Thesis, RWTH Aachen/ GUtech

Prof. Dr. Elena Berdysheva and Prof. Dr. Bernhard Heim at a conference break at the Sultan Qaboos University

The Philosophy of Kaizen Learning

Bernhard Heim and Florian Rupp

The art of teaching freshmen students is undergoing a rapid paradigm change. Classical forms of teaching are not applicable any more and an unmanageable offer of new multi-media tools and concepts is glutting the market. Moreover, compared to previous courses, the class size triplet. In view of these challenges, we implemented a new teaching concept best described as Kaizen learning. By Kaizen learning, we define a teaching philosophy that is based on a concise mix of short learning units (with feedback loops and tests) and of carefully chosen repetitions (also with feedback loops and tests) to calibrate a course for the students. Here, this intensive blended, student-centered learning paradigm is briefly described together with its direct impact on the students' performance. This case study leads to easy to implement key drivers for successfully teaching science in Oman, such as 1) human-human interaction, 2) clearly communicated expectations, 3) avoidance of a short-term learning attitude, 4) a no calculators policy, 5) continuous Kaizen learning, and 6) balanced combination of traditional teaching and e-learning.

Let us start with some information about the course and its students: The syllabus of “Mathematics I for Engineering” (Math I) at GUtech consists of a) mathematical notations, numbers and elementary logic, b) function basics and trigonometric functions, c) solution methods for linear systems of equations, d) vector spaces, vectors, linear mappings and matrices and e) determinants and diagonalization of matrices. The 102 students who took this course came from 12 different countries (84 from Oman, 6 from India to mention just the two largest nationality groups), 76 of them already attended our pre-university program, and the ratio between female and male students was 63% to 37%. Moreover an introductory mathematics test at the start of Math I showed a wide variety of basic mathematical understanding and skills of the students.

Structurally, the lecture is supported with additional small tutorial groups, a global tutorial group for all students as well as homework assignments, additional materials for the students and an electronic cloud based repository solution enabling the active preparation of the course contents, see Fig. 1. Accompanying the lecture there was on average one test a week in one of the lectures. These tests served as a continuous feedback-loop and enhanced the course on a daily basis. For instance, the students got immediate feedback on their level of comprehension and improvement and we could

From left to right: Bernhard Heim, Mehiddin Al-Baali, and Florian Rupp at the “Third International Conference on Numerical Analysis and Optimization”.

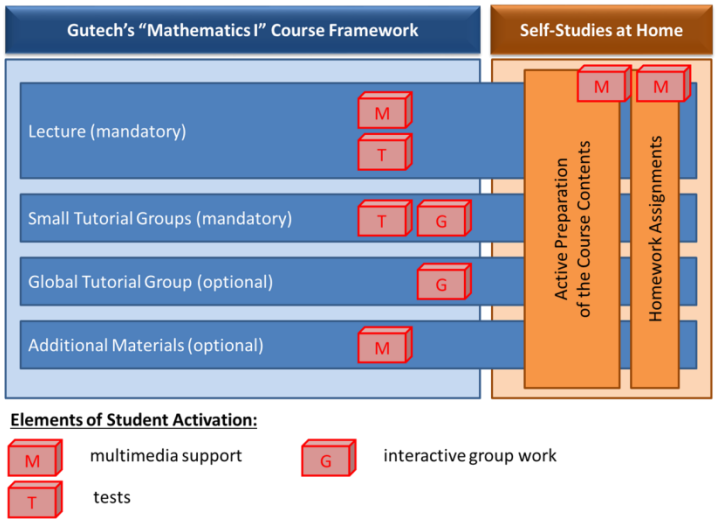


Figure 1: Structural framework of Math I together with the most common elements of student activation applied in each of them, some were mandatory some optional for the students.

tailor our teaching (lecture as well as tutorials) to the specific needs of the students by knowing exactly which concepts were understood and on which topics additional time had to be invested.

In industry such small cycles of “plan-do-study-act” and then progress are commonly accepted and associated to W. Edwards Deming's philosophy of Kaizen as an continuous change for the best. The amplitude of short tests allowed us to carry this philosophy in a meaningful way to academia, and led us to (more or less) daily evaluations of the course and its continuous improvement.

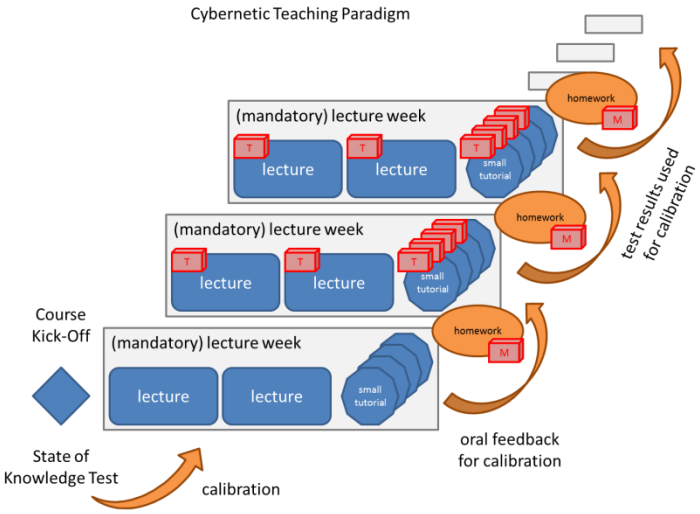


Figure 2: The cybernetic teaching approach that is in particular realized by the different lecture and tutorial tests and the immediate feedback gained through them.

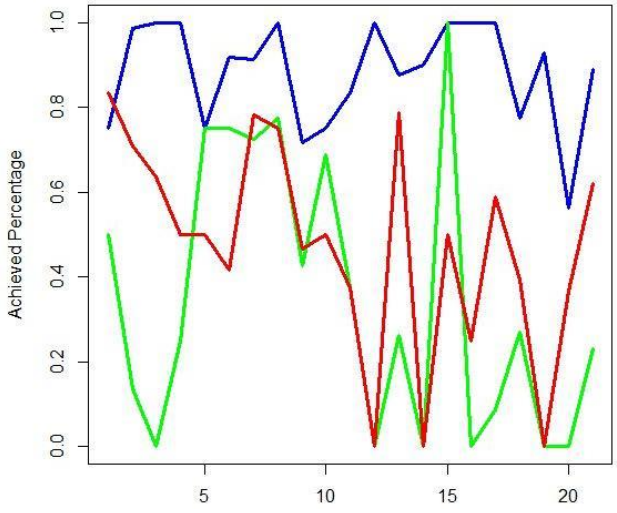


Figure 3: Test scores of three model students from the beginning of the semester until the midterm exam.

A comprehensive set of data was collected to measure the students performance and the effects of different elements of the Math I course:

Several **State of Knowledge Tests** were conducted to check the student's awareness of basic mathematical concepts that they should know from high school, like fractions, absolute value, differentiation, word problems, etc. The miserable results at the State of Knowledge Test 1 (first lecture) warned us that students will be facing severe problems with the new topics in Math I as fundamental prerequisites were missing. So the speed of the lecture was adjusted and exercises dealing with those prerequisites were incorporated into the course. Further State of Knowledge Tests in the 6th lecture week and in the 11th lecture week were used to collect information on the students progress on these topics.

The **online pre-learning exercises & homework assignments** can be considered as a small distant learning universe in itself supported by the platform MUMIE. During their pre-learning activities the students get in a playful and hands-on way into touch with new topics that are explained in depth in the next lecture.

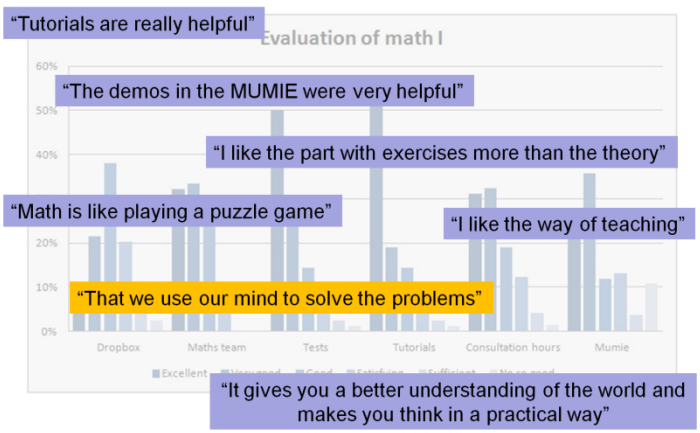
Lecture & Tutorial Tests: These two test types were designed for instant feedback about the progress of the course. The short tests at the beginning or end of the lecture check the understanding of new topics and allow us to react in the small and global tutorial groups with dedicated examples before the students go for their homework assignments. These tests consumed about 10 minutes and contained very easy exercises which the students were allowed to solve with their lecture notes.

Mock & Midterm Exam: Grading of the Math I course was based on 40% of the midterm and on 60% of the final exam. The midterm was conducted in the 8th lecture week containing the topics of sets, functions, absolute values, complex numbers, inequalities, induction, the Gaussian algorithm and Boolean algebra. Its level of difficulty was similar to the tutorial tests. In order to acclimatize our freshmen to exams at university, we provided a mock exam one week before the midterm. The mock exam was barely timed and more difficult than the actual exam, so the students could recognize those topics they have to practice more intensely. At the actual midterm exam, the students were granted more time, as we focused on what the students know and not how fast they reach the solution.

The continuous testing has the positive effects of imposing a strict routine on the students to continuously perform during the term and allows for a cybernetic teaching approach that measures students achievements and enables us to correct deviating developments immediately, cf. Fig. 2.

This method of realizing continuous processes is very closely related to **Kaizen**, a productivity improving idea that comes from Japan (Kai = change, zen = for the better). It is a philosophy of continuous improvement to reduce waste and thereby achieve better efficiency. Important is that Kaizen should be implemented top down. Higher management levels as well as simple workers need to have the same mindset of continuous improvement to achieve significant results.

Fig. 3 illustrates the test scores of three model students from the first test after the State of Knowledge Test 1 to the midterm exam (as the last data point in the graph). It is noticeable that the student who achieved nearly 90 points in



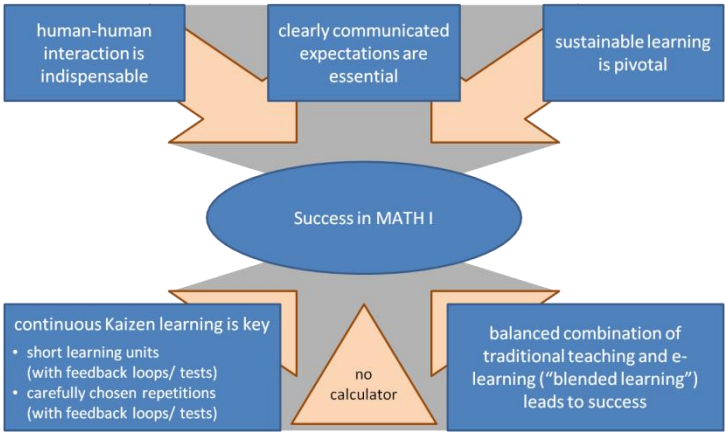


Figure 4: (left) some remarks of the students what they liked most about our course, and (right) summary of the influence factors for success in Math I.

the midterm exam (blue line) which is equivalent to an A has performed way above average over the whole semester. The average student (red line) missed a few tests, but was still able to achieve sufficient scores in the other ones. In the midterm exam he/ she received a B-. The 3rd student (green line) started the semester pretty strong, but seemed to have lost track later in the lecture. This combined with several missed tests led to an F in the final exam.

Moreover, we witness a performance drop of all students around the 10th test and it seems to be there when the separation of the three students actually took place. The best of them was able to get back to high percentages quickly and further defeats were adjusted. The 2nd student began to struggle with the material and oscillated in performance. The 3rd student more or less lost connection to the lecture and could not find the way back to the performance shown before this decline. Fig. 3 thus shows clearly that once you are lost in mathematics and you do not recoup, then you are lost for the rest of the semester. Moreover, as shown for the 2nd student, facing the struggles and challenges of the lecture continuously pays-off at the end.

In that respect, it is fair to conclude that without the continuous feedback and test loops installed (as it is the case at a traditional course that just provides a final exam) the 2nd student may have also be lost very soon. Moreover, when inspecting the initial phase of the students' performance in Fig. 3, we see that both the 2nd and 3rd student were starting with negative slope, but at some point seemed to realize this peculiar trend and then pushed themselves up again.

This engagement for the students was not un-witnessed: at the end of the semester the students told that they realized that "math is like playing a puzzle game" and that they were happy "that we use our mind to solve problems", see Fig. 4.

A plethora of factors leads to this uncommon appraisal of engineering students for a math lecture. The most prominent of them is the philosophy of Kaizen learning that we adopted from our experience at quality control in different global industrial company. Fig. 4 summarizes our findings:

a) **Human-Human interaction is indispensable.** A supporting item for this finding are the achievements of those students who had to take the oral exam. This interaction seemed to have encouraged them to boost their performance. Moreover, state of the art technology alone is not really accepted as help by the participants of Math I.

b) **Clearly communicated expectations are essential**, as every manager knows. At universities such a communication though is most often neglected. Implicitly, through the weekly tests, the expectations were communicated during the course, in particular, when recalling the timing of the lecture tests at the end of the lectures. In most cases, they explicitly contained exercises referring to what was just discussed in class and thus helped the students to focus on the essentials.

c) **Sustainable learning is pivotal**, because short-term learning is rather impossible. Although specific students were able to increase their performance drastically (as showed for those who had to pass an oral exam), the mock remained a significant indicator for the average student's success. Which indicates that if a student was not prepared at the mock he/ she could not increase his/ her level of understanding substantially during the week between the mock and the midterm.

d) **The strict no calculators policy** certainly added to the success of Math I implicitly. How crucial such a measure is, has to be evaluated. Though, we assume that not permitting calculators helps to realize that mathematics is not about numbers, but about structures and to obtain a

result, patterns have to be found in the equations most often. On a low level, such patterns like the prime factor decomposition of numbers are necessary for reducing fractions or the smart computation of numbers and the recognition of these of course has to be trained (which is no longer the case when relying too much on calculators).

e) **Continuous Kaizen learning is key**, as we have seen throughout the course and was attested by the very high appraisal the students had for the tests. In particular, this means a concise mix of short learning units (with feedback loops and tests) and of carefully chosen repetitions (also with feedback loops and tests) to calibrate the course to the students. Compared to many new forms of teaching, this very simple philosophy of student integration seems to get lost more and more in a world of massive open online courses (MOOCS) and didactic formats that seem to be implemented for their own sake and fanciness. The Kaizen approach may be a very well-suited alternative, tailored for the students and bringing back value to the university classes.

f) **Balanced combination of traditional teaching and e-learning ("blended learning") leads to success.** The pressure e-learning imposes on the students in terms of working soft- and hardware, self-discipline in allocating quiet time in front of a computer and in ensuring motivation to proceed with the electronic lectures and exercises day by day certainly adds to the regularly reported unease and relative failure of pure e-learning courses. As recognized by many, the multimedia enfolds its real potential when it is integrated in the social environment of a course. In particular for us, the correction capabilities of MUMIE and the well-designed textbook parts where a great advantage by saving time and providing the students extended lecture notes.

Finally, it has to be underlined that this course not only taught the syllabus successfully, but also equipped the students with valuable soft skills, like time management, a certain kind of a continuous study rhythm or as students told us that the lecture "gives you a better understanding of the world and makes you think in a practical way".

Source:

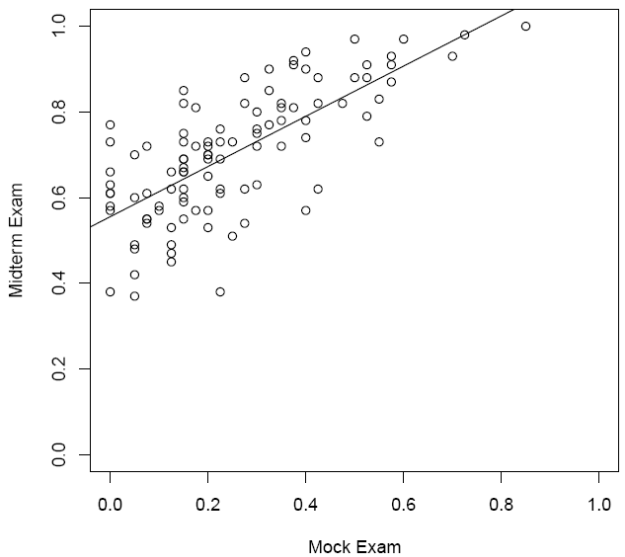
J. Gallenkämper, B. Heim, J. Kreuzer, F. Rupp, P. v. Stockhausen & N. Viet (2014)*: Driving Student-Centred Calculus: Results of a Comprehensive Case Study for Kaizen-Learning in the Sultanate of Oman*, International Journal of Mathematical Education in Science and Technology, accepted.

Mathematical Methodology:

Linear regression/ the least square method is a popular tool to fit empirical data to linear laws. Given empirical variables X_1, X_2, … one can construct, for instance, a linear model $Y = a + b_1 X_1 + \epsilon$, a quadratic model $Y = a + b_1 X_1^2 + \epsilon$, or a multi-linear model $Y = a + b_1 X_1 + b_2 X_2 + \ldots + \epsilon$ with constant coefficients a, b_1, b_2, … that governs the empirical realization. The condition under which this method can be applied to gain such correlation insights is that the (residual) error ϵ, which measures the deviation of the empirical data from the linear model, is distributed normally.

The main finding of our analysis is the strong correlation between the mock and the midterm exam with a correlation coefficient of 0.726 ($R^2 = 0.527$), see below. This means that there is almost a linear dependency between the mock results and those of the midterm, and about half of the variation we recognize in the midterm results seems to be due to this linear relation to the mock results. This supports significantly the hypothesis that effective learning during the short period between the mock and the midterm seems to be rather impossible although it helps in special cases. It seems that the continuity of learning and the early preparation for an exam are indispensable factors for the success of students.

Additional information to understand some features of this data cloud are that all students achieved over 27 points (out of 100) at the midterm and that all eight students that scored with zero points in the mock were invited to an oral exam. This seems to have had a great influence on their learning behavior and gave them a great performance boost. It is worth to note that after we distributed the midterm grades some of students envied those who had the oral and asked if they could have an oral exam also next time.

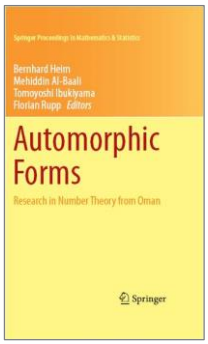


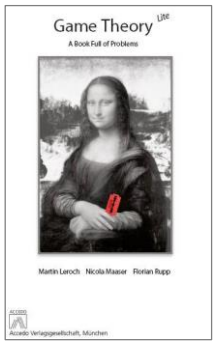
Achievements in Research

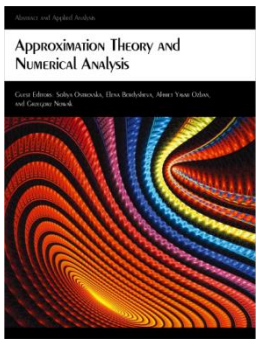
In 2013 and 2014 a number of books and articles could be published by us:

Books, Anthologies & Special Issues:

1. B. Heim, M. Al-Baali, T. Ibukiyama & F. Rupp (Eds., 2014): Automorphic Forms - Research in Number Theory from Oman, Springer Proceedings in Mathematics & Statistics (Vol. 115), Springer-Verlag.
2. S. Ostrovska, E. Berdysheva, A. Y. Ozban & G. Nowak (Eds., 2014): Special Issue "Approximation Theory and Numerical Analysis" of Abstract and Applied Analysis, Volume 2014.
3. T. Neckel & F. Rupp (2013): Random Differential Equations in Scientific Computing - Motivation, Theory & Simulation, Versita/ De Gruyter Publishing.
4. A. Johann, H.-P. Kruse, F. Rupp & S. Schmitz (Eds., 2013): Recent Trends in Dynamical Systems - Proceedings of a Conference in Honor of Jürgen Scheurle, Springer Proceedings in Mathematics & Statistics (Vol. 35), Springer-Verlag.
5. M. Leroch, N. Maaser & F. Rupp (2013): Game Theory Lite - A Book Full of Problems, Accedo Verlag, München.







Journal Articles:

1. E. E. Berdysheva & B.-Z. Li (2014), *On L^p-convergence of Bernstein-Durrmeyer operators with respect to arbitrary measure*, Publ. Inst. Math., Nouv. Sér., in press.
2. E. E. Berdysheva (2014), *Bernstein-Durrmeyer operators with respect to arbitrary measure, II: pointwise convergence*, J. Math. Anal. Appl. 418 (2014), 734-752.
3. T. Flå, F. Rupp & C. Woywod (2014): *Bifurcation Patterns in Generalized Models for the Dynamics of Normal and Leukaemic Stem Cells with Signaling*, Mathematical Methods in the Applied Sciences, accepted.
4. J. Gallenkämper, B. Heim, J. Kreuzer, F. Rupp, P. v. Stockhausen & N. Viet (2014): *Driving Student-Centred Calculus: Results of a Comprehensive Case Study for Kaizen-Learning in the Sultanate of Oman*, International Journal of Mathematical Education in Science and Technology, accepted.
5. B. Heim & P. Garret (2014): *Hecke Duality of Ikeda lifts. Journal of Number Theory*, published online, Journal of Number Theory, Springer, in press.
6. S. Ohmagari, T. Hanada, Y. Katamune, S. Al-Riyami & T. Yoshitake (2014): *Carrier Transport and Photodetection in Heterojunction Photodiodes Comprising n-Type Silicon and p-Type Ultrananocrystalline Diamond/ Hydrogenated Amorphous Carbon Composite Films*. Jpn. J. Appl. Phys. 53 050307.
7. F. Rupp & J. Scheurle (2014): The Dynamics of the Jellyfish Joyride: Mathematical Discussion of the Causes Leading to Blooming, Mathematical Methods in the Applied Sciences, accepted.
8. S. Al-Riyami & T. Yoshitake (2013): *Chemical Bonding of Nitrogenated Ultrananocrystalline Diamond Films Deposited on Titanium Substrates by Pulsed Laser Deposition. ECS Journal of Solid State Science and Technology*, 2 (11) M33-M38.
9. S. Al-Riyami, M. Shaban, H. Gima & T. Yoshitake (2013): *Effects of Hydrogen and Nitrogen Atmospheres on Growth of Ultrananocrystalline Diamond/ Amorphous Carbon Composite Films by Reactive Pulsed Laser Deposition*, Jpn. J. Appl. Phys. 52, 06GG06.
10. S. Al-Riyami, H. Gima & T. Yoshitake (2013): *Nitrogenated Ultrananocrystalline Diamond/ Amorphous Carbon Composite Films Deposited on Titanium Substrates by Pulsed Laser Deposition*, ECS Transactions, Vol. 50, issue 20 (2013) pp.13-20. DOI: 10.1149/05022.0013ecst.
11. S. Al-Riyami, H. Setoyama, K. Sumitani, Y. Hirai & T. Yoshitake (2013): *Nitrogenation Effects on n-Type Electrical Conductivity of Ultrananocrystalline Diamond/ Hydrogenated Amorphous Carbon Composite Films Prepared by Pulsed Laser Deposition*, ECS Transactions, Vol. 50, issue 20 (2013) pp. 41-47. DOI: 10.1149/05022.0041ecst.

Journal Articles continued:

12. B. Heim & A. Murase (2013): *Symmetries for Borcherds lifts on Hilbert modular groups and Hizrebruch-Zagier divisors*, International Journal of Mathematics 24, 23 pages.
13. B. Heim & A. Murase (2013): *Symmetries for Siegel Theta Functions, Borcherds lifts and automorphic Green functions*, Journal of Number Theory 133, no. 10. 3485-3499.
14. B. Heim, A. Murase (2013): *Reversing Borcherds lifts*, accepted, to appear.
15. B. Heim & A. Murase (2013): *Additive and multiplicative lifting properties of the Igusa modular form*, accepted, to appear.
16. Y. Katamune, S. Ohmagari, S. Al-Riyami, S. Takagi, M. Shaban & T. Yoshitake (2013): *Heterojunction Diodes Comprising p-Type Ultrananocrystalline Diamond Films, Prepared by Coaxial Arc Plasma Deposition and n-Type Silicon Substrates*, Jpn. J. Appl. Phys. 52 (2013) 065801.

Articles in Refereed Proceedings & Anthologies:

1. E. E. Berdysheva & H. Berens (2014): *On a discrete Turán problem for l1 radial functions*, in press, in G. Schmeisser & A. Zayed (Eds., 2014): New Perspectives on Approximation and Sampling Theory - Festschrift in honor of Paul Butzer's 85th birthday, Birkhaeuser.
2. C. Riesinger, T. Neckel, F. Rupp, A. Parra Hinojosa & H.-J. Bungartz (2014): *GPU Optimization of Pseudo Random Number Generators for Random Ordinary Differential Equations*, Procedia Computer Science, Proceedings of the International Conference of Computational Science 2014 (Cairns, AUS), Volume 29, pp. 172 – 183.
3. F. Rupp & J. Scheurle (2013): *Analysis of a Mathematical Model for Jellyfish Blooms and the Cambric Fish Invasion*, Dynamical Systems and Differential Equations, DCDS Supplement 2013 Proceedings of the 9th AIMS International Conference (Orlando, USA), pp. 663-672.
4. T. Flå, F. Rupp & C. Woywod (2013): *Deterministic & Stochastic Dynamics of Chronic Myelogeneous Leukaemia Stem Cells with Hill-Function Like Signaling*, pp. 221-263, in A. Johann et al. (Eds., 2013): Recent Trends in Dynamical Systems - Proceedings of a Conference in Honor of Jürgen Scheurle, Springer Proceedings in Mathematics & Statistics (Vol. 35), Springer-Verlag.

Prof. Elena Berdysheva giving a presentation under the benevolent eyes of His Majesty Sultan Qaboos ibn Said.

Talks & Special Honors :

- Additionally, the members of the department gave 25 talks at scientific venues and contributed several posters at conferences and exhibitions.
- In particular Professor Dr. Bernhard Heim was an invited speaker at the Strategic Workshop at the Kyoto Sangyo Univeristy (Japan) to speak on this biography, his work in the Sultanate of Oman and research in front of students of the Faculty of Science.

Special Research Activities in July/ August 2014:

- Professor Dr. Elena Berdysheva was invited for a research stay at Alfred Renyi Institute of Mathematics of the Hungarian Academy of Science (Budapest).
- Professor Dr. Bernhard Heim was invited for a research stay at the RWTH Aachen and gave invited talks at a international conferences in Bristol and at the Max Planck Institute for Mathematics (Bonn).
- Professor Dr. Florian Rupp was co-organizer of a special session at the 10th International Conference of the American Mathematical Society, and was invited for a research stay at the Norwegian center of excellence "Centre for Theoretical and Computational Chemistry" at Tromsø, Norway.

The Mouse on the Moon

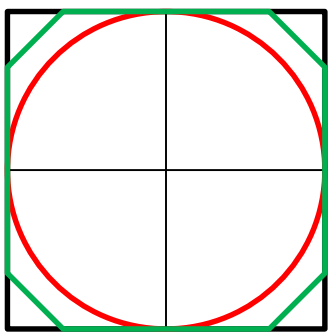
What would a science report be without at least one quiz? The following one is taken from the exercise collection Project Euler (http://projecteuler.net/) where it is stated as problem number 314.

Welcome to the future: The moon has been opened up, and land can be obtained for free, but there is a catch. You have to build a wall around the land that you stake out, and building a wall on the moon is expensive. Every country has been allotted a 500 m by 500 m square area, but they will possess only that area which they wall in. 251001 posts have been placed in a rectangular grid with 1 meter spacing. The wall must be a closed series of straight lines, each line running from post to post.

The bigger countries of course have built a 2000 m wall enclosing the entire 250 000 m² area. The Duchy of Grand Fenwick, has a tighter budget, and has asked you (their Royal Programmer) to compute what shape would get best maximum enclosed-area/wall-length ratio.

You have done some preliminary calculations on a sheet of paper. For a 2000 meter wall enclosing the 250 000 m² area the enclosed-area/wall-length ratio is 125. Although not allowed , but to get an idea if this is anything better: if you place a circle inside the square area touching the four sides the area will be equal to $\pi \cdot 250^2$ m² and the perimeter will be $\pi \cdot 500$ m, so the enclosed-area/wall-length ratio will also be 125.

However, if you cut off from the square four triangles with sides 75 m, 75 m and $75\sqrt{2}$ m the total area becomes 238750 m² and the perimeter becomes $1400 + 300\sqrt{2}$ m. So this gives an enclosed-area/wall-length ratio of 130.87, which is significantly better.



Task: Find the maximum enclosed-area/wall-length ratio. Give your answer rounded to 8 places behind the decimal point in the form abc.defghijk.

Leonhard Euler (15th of April 1707 until 18th of September 1783) was a pioneering Swiss mathematician and physicist. He made important discoveries in fields as diverse as infinitesimal calculus and graph theory. For instance, the famous number e is named in his honor as well as the Euler graphs that helped to solve the Königsberg bridge problem. Euler introduced much of the modern mathematical terminology and notation, particularly for mathematical analysis, such as the notion of a mathematical function. He is also renowned for his work in mechanics, fluid dynamics, optics, astronomy, and music theory.

Euler was considered to be simple, upright, affectionate and having a strong religious faith. His single and unselfish devotion to the truth and his joy at the discoveries of science whether made by himself or others, were striking attributes of his character. Without doubt he is the pre-eminent mathematician of the 18th century and one of the greatest mathematicians to have ever lived. A statement attributed to Pierre-Simon Laplace expresses Euler's influence on mathematics: "Read Euler, read Euler, he is the master of us all".

Project Euler is a series of challenging mathematical/ computer programming problems that will require more than just mathematical insights to solve. Although mathematics will help you arrive at elegant and efficient methods, the use of a computer and programming skills will be required to solve most problems. The motivation for starting Project Euler, and its continuation, is to provide a platform for the inquiring mind to delve into unfamiliar areas and learn new concepts in a fun and recreational context.

The intended audience include students for whom the basic curriculum is not feeding their hunger to learn, adults whose background was not primarily mathematics but had an interest in things mathematical, and professionals who want to keep their problem solving and mathematics on the cutting edge.

Special Events

New Ways of Geometrical Thinking Introduced at GUtech: Constructing the Largest Tetrahedron Fractal in Oman

To enhance geometrical thinking, students of the German University of Technology in Oman (GUtech) have built a large paper tetrahedron (pyramid shape) in the amphitheater of the university. Around 60 students of the Foundation Year and the Bachelor of Science programs as well as staff members participated in this special mathematical activity that may best be illustrated by one composed of many, in Latin "e pluribus unum".

"With this special activity we introduce a tangible way of geometrical thinking. This is new to most students and has not been taught earlier at high school," said Professor Dr. Florian Rupp of the Department of Mathematics and Science at GUtech who initiated the activity. "We are studying in the Foundation Year, Applied Geosciences. I think these fractals are similar to the structures we see in rocks and minerals," said Fatma Al Farsi, GUtech student.

Many students think that geometry can only be taught in class and on the white board. That becomes very boring after some time. "We enhance spatial thinking and encourage the students to think in a playful and easy way, so that they also forget that they are doing geometry," said Prof. Florian Rupp. GUtech strongly supports this new and very smart way of teaching: "It brings the most effective recent discoveries of teaching to Oman," said Prof. Dr. Bernhard Heim, Dean of Science at GUtech. Professor Florian Rupp recently joined the Department of Mathematics and Science. He previously worked at the renowned Technical University of Munich (Germany).

The about two meter high tetrahedron fractal was constructed of 1024 small tetraheda. "These fractals are familiar to what we see in our everyday lives, for example in minierals, rivers, mountains, but as well in cauliflowers," said Professor Florian Rupp.

Prof. Dr. Florian Rupp explains the fractals to the students Fatima Al Farsi, Hajir Al Felahi, Najat Al Fudahili.

A fractal is a geometric object which is constructed from a "simple" initial shape and arranged to form self-similar patterns across different scales and with fractal dimensions. To most of the students this task was new. They had been surprised that high advanced mathematics can be exciting and showed strong interest in having more math courses in the near future.

3rd International Mathematics Conference held at SQU in January 2014

Professors of the Department of Mathematics and Science of the German University of Technology in Oman (GUtech) participated in the upcoming "Third International Conference on Numerical Analysis and Optimization" that was held between the 5th to 9th of January 2014 at the Sultan Qaboos University (SQU). The conference was organized by the Department of Mathematics of the College of Science at SQU and brought together internationally recognized experts in the field to share and discuss their latest discoveries. "We had speakers from UK, Japan, Italy, Canada, Germany, China, New Zealand, as well as U.S.A., all are high ranking scientists in the field of numerical analysis," specified Prof. Dr. Bernhard Heim, member of the conference's organizing committee.

"After the success of the previous International Mathematics Conferences in Muscat, we organized this conference in cooperation with a number of colleges and universities in Oman, UAE and Italy" explained Prof. Dr. Bernhard Heim. Numerical mathematics and optimization are the cornerstones of all industrial endeavors, may they concern vaccination strategies, the exploitation of oil fields or landing a man on the moon. The conference was open for everybody who was interested in the field of Applied Mathematics, in particular for students and Mathematics teachers. "We were looking forward to this third conference and were expecting a large number of participants from academia and from various private sectors that are in need for effective and efficient mathematical algorithms," emphasized the head of the organizing committee Prof. Dr. Mehiddin Al-Baali of the Department of Mathematics and Statistics at SQU. "Mehiddin is the father of this conference series he initiated and we all are extremely thankful that he is in charge of bringing such a valuable opportunity to Muscat to strengthen the international reputation of the Sultanate", added Prof. Dr. Bernhard Heim.

From GUtech, the majority of the Faculty of Mathematics participated and gave presentations ranging from approximation theory to stochastic dynamical systems. To cite just two examples:

Prof. Dr. Elena Berdysheva gave a presentation on “Bernstein Basis Polynomials and their Applications”. Being introduced in 1913 by the Russian mathematician Sergey Bernstein in the frame of theoretical approximation theory, Bernstein basis polynomials are today of particular importance in applied areas as well, like statistics, machine learning, and computer graphics. So next time, you or your kids start their video games it may not be unlikely that what you see is related to Prof. Dr. Elena Berdysheva’s research.

Prof. Dr. Florian Rupp’s presentation was about “Numerical Analysis and Simulation of Random Partial Differential Equations with Boundary Excitations”. The mathematical treatment of random effects as they occur in nature is still in its beginning, “we have quite good approximations, but real noise is still hard to analyze. Thus, it is quite satisfying to these types of random perturbations under control for the most prominent physical applications, like wind or earthquake induced shakings of buildings and bridges or deformations due to random stress and shear forces,” mentioned Prof. Dr. Rupp. As a special highlight and of general interest for the public, Prof. Dr. Bernhard Heim used the opportunity of this conference, to share recent results on improving student learning in Calculus including the key drivers for student’s success in the Sultanate of Oman.

The construction of the tetrahedron was a great example of teamwork.

GUtech and GSO held seminar-cum-exhibition on crystals

GUtech and the Geological Society of Oman (GSO) jointly organized a seminar-cum-exhibition recently on ‘Crystals, Forbidden Symmetries and Quasi-Crystals’ at the PDO Oil and Gas Exhibition Center in Qurum. The event coincided with the 100th anniversary of the conferment of Nobel Prize in Physics on Max von Laue in 1914 for his path-breaking work on crystals, and marked the UNESCO’s observance of year 2014 as the International Year of Crystallography.

The lectures and exhibition were conceived and coordinated by Prof Florian Rupp, and Prof Michaela Bernecker, with support from GSO. The session began with an introductory talk by Prof Florian Rupp, followed by talks by Applied Geosciences (AGEO) students of GUtech. Prof Florian in his speech narrated the scientific milestones in crystallography studies that significantly contributed to today’s understanding of crystalline structures.

Elaborating how crystallography is connected to oil and gas, Prof Michaela said: “The crystals of the mineral Dolomite form a sedimentary rock, and this can be a reservoir rock for oil and gas, provided the required porosity and permeability between the crystals are present.

She added, “The minerals found in nature are crystalline. In Oman you can find Quartz (as sand in the desert) or Calcite in limestone (used as building stones) and ore minerals like Pyrite and Chromite (used as industrial minerals) in the mountains of Oman.” The talks highlighted the trailblazing discoveries till date including Steno’s Law, Planar and Spatial Packing classifications, and X-ray diffraction, among others. A discussion on the role of symmetries and detailed analyses of allowed and forbidden rotations in crystals made the talks quite informative. A 5-fold rotation symmetry was considered to be strictly forbidden, but the discovery of the same in an alloy crystal in the 1980s proved to be a game-changer in the world of crystallography. What made this forbidden rotation symmetry possible was discussed as also possible forbidden symmetries that can occur in crystalline structures known as quasi-crystals.

GUtech Applied Geosciences (AGEO) students presented special talks on Mineral Symmetries, Symmetries of Quasi Crystals, Optical Properties of Crystals, and Crystals under the Microscope.

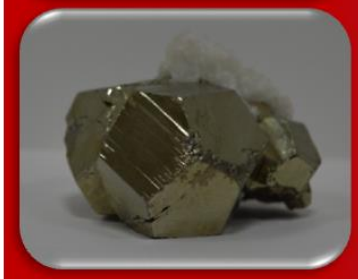
2014

international year of crystallography

United Nations Educational, Scientific and Cultural Organization · International Union of Crystallography

Partners for the International Year of Crystallography 2014

Pyrite fascinates by its plethora of forms. Join us to find out why they exist!



الجمعية الجيولوجية العمانية
Geological Society of Oman

The Departments of Applied Geosciences and Mathematics & Science of the German University of Technology in Oman (GUtech), supported by the Geological Society of Oman proudly present

Crystals, Forbidden Symmetries & Quasi-Crystals

Prof. Dr. Michaela Bernecker & Prof. Dr. Florian Rupp
together with
Students of Applied Geosciences at GUtech

Wednesday, 28th of May
Oil and Gas Exhibition Center

5:00 pm Reception
5:15 pm Introductory talk by Florian Rupp
5:45 pm Special student talks

7:00 pm Official opening of the exhibition

Abstract: The talks "Crystals, Symmetries and Quasi-Crystals" form the opening ceremony of an exhibition along with activities of the 2014 UNESCO year of crystallography at which we celebrate the 100th birthday of the awarding the Nobel Price in Physics to the deciphering of the inner structure of crystals due to X-ray diffraction.

In our talks, we highlight the main steps leading to today's understanding of crystalline structures and their symmetries by discussing the ground-breaking discoveries of the last centuries: Stenos Law, classifications of planar and spatial packings, and X-ray diffraction. In particular the role of symmetries is outlined and why only certain rotations are allowed in crystals and others are strictly forbidden, like 5-fold rotations. To the great surprise of the scientific community exactly such a forbidden 5-fold rotation symmetry was realized in an alloy crystal in the 1980s. We illustrate why this is possible and what further types of forbidden symmetries occur in crystalline structures now known as quasi-crystals. For solving the riddle of the quasi-crystals the 2011 Nobel Price in Chemistry was awarded.

Special talks by students of Applied Geosciences at GUtech dedicated to the deeper understanding of certain topics round up the evening, before the exhibition is officially opened.

The students of Applied Geosciences together with Prof. Dr. Michaela Bernecker after the successful presentations (left) and some of their posters (right).

The exhibition showcased the various crystals and quasi-crystals, various illustrations and important achievements in the area of crystallography. The display of the many fascinating forms of pyrite, a commonly found mineral in a variety of geological formations, was the center-piece of the exhibition.

"The Applied Geosciences department (AGEO) of GUtech is working with the Geological Society of Oman to build a network of geoscientists that will enable a wider understanding of the beautiful and fascinating geology of Oman and also its protection, apart from educating its younger generation about the same", Prof Michaela said.

Special Session "Applied Analysis and Dynamics in Engineering and Sciences" at the 10th International Conference of the American Institute of the Mathematical Sciences in Madrid

Over 2500 experts in the fields of dynamical systems, differential equations and their applications gathered form July 07 to July 11, 2014 in Spain's capital at the campus of the Instituto de Ciencias Matemáticas and the Universidad Autónoma de Madrid.

At this highly recognized meeting Prof. Thomas Hagen from the University of Memphis and Prof. Florian Rupp organized a special session on "Applied Analysis and Dynamics in Engineering and Sciences". The goal of this session is to bring together mathematicians who work in different areas of applied mathematics and might thus not meet and exchange ideas and points of view. "Consequently", Prof. Hagen said, "the session program addresses a cross section of theoretical and computational developments and their applications to fluid dynamics, solid mechanics and life sciences."

One such example arises when the interesting defense mechanism of the Florida Palm Beetle is discussed from the point of view of mathematics: When attacked, it exerts a strong adhesive force to suck itself to the ground. This adhesion mechanism consists of a series of connected, fluid-filled channels opening to the outside. The adhesive force is generated by controlling the flow through these channels. Inspired by this adhesion strategy, van Lengerich, Vogel and Steen (Physica D, 2009) studied networks of channels (pipes) filled with a Newtonian liquid. Each channel ends in a hole where the liquid forms a partial droplet due to interaction with the ambient air. The pressures acting on the droplets depends on the size of each droplet. Pressure-driven, non-turbulent pipe flow is, of course, well-understood and adequately modeled by the Hagen-Poiseuille law in case of viscous liquids. In our investigation we will concentrate on shear-thinning behavior. In order to study the stability of steady droplet configurations, we devise Lyapunov and Chetaev function techniques since equilibria are generally not hyperbolic. As typical, numerical simulations support these conclusions for Prof. Hagen that were jointly derived with Ben Jenkins.

Prof. Rupp illustrates the further topics of the special session: "Areas of analytical interest include the theory of linear/ nonlinear differential equations, the qualitative behavior of solutions, stability and asymptotics, control-theoretic issues, and related aspects. The areas of application range from fluid dynamics and wave phenomena to industrial flows and applications in mathematical biology and material science. A key aspect of this session is its focus on the impact of theoretical results on the study of real-world problems."

Towards Optimal Fire Fighting

Florian Rupp and
Tobias Weinzierl (Durham University)

Globally ascending temperature extremes combined with long lasting droughts increase the probability and extend of large-scale wildland fires as suffered almost annually by people in Australia, California or Mediterranean countries such as Spain or Greece. This raises the urgency for effective and efficient extinction strategies guiding the limited number of fire fighting units through the area of interest. Algorithmic and paradigmatic aspects of such strategies are in the focus of our work.

Tobias Weinzierl (left) and Florian Rupp (right) discussing research results with students and collaborators. Fotos by Astrid Eckert and Andreas Heddergott from the TU München.

Ground or surface fires (up to about two meters) as well as brush field fires can be considered as a series of ignitions:

> "Heat is supplied from the fire to the potential fuel, the surface is dehydrated, and further heating raises the surface temperature until the fuel begins to pyrolyse and releases combustible gases. When the gas evolution rate from the potential fuel is sufficient to support combustion, the gas is ignited by the flame and the fire advances to a new position. Finally, a constant rate of spread is achieved; this is called the "quasi-steady state" wherein the fire advances at a rate that is the average of all the elemental rates", [1], p. 2.

Once advancing in the quasi-steady state, the flame front spreads in a diffusive manner.

In our work, we utilize a computational domain that is sufficiently big with respect to the covered, downscaled if necessary, region of interest with burning. This allows us to choose boundary conditions of our choice (homogeneous Dirichlet), as the fires do not approach the domain boundary. We furthermore assume the fire to be instantly in the quasi-steady state. The advance of a flame front then can be modeled by an anisotropic reaction diffusion equation. The results of such a simulation with three different initial ignition centers is displayed in Fig. 1 on the right-hand side of this page. There, the already introduced space-time character of our computations becomes visible as the flame fronts progress in time (top left to right and from there to bottom left to right) and, so to say, burn holes in this space-time cube.

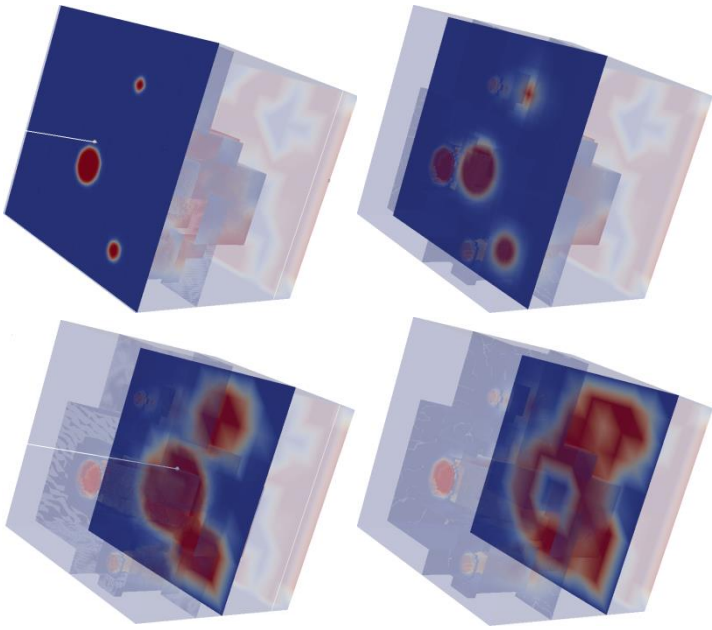


Fig. 1: Simulation of the advance of flame fronts in a space-time setting starting at the picture displayed at the top left and burning down to that at the bottom right.

Next, a rather advanced optimization method is utilized to gain what is called the adjoint equation. This adjoint equation stores the gradient information of the flame front in the future and thus helps us to detect where the increase in the flames is the largest. Thus, it yields to statements on what optimal extinction strategies fire fighters would look like if they were omnipresent and could forecast the optimal spread. of the fire. To actually compute the adjoint to a partial differential equation (the state equation) with control parameters, we first write down the derivative of the state equation with respect to the control variable. Second, we switch to a weak form as it is standard when dealing with finite element approaches for partial differential equations. Finally, we re-interpret the result as a strong form with respect to the test-functions of the weak formulation.

As the adjoint equations run backward in time, they are typically difficult and expensive to solve – in particular in terms of computer memory.

Our approach combines adaptive spacetree data structures with space-time grids, i.e. it resolves the whole computational domain throughout the whole observation time at once, see [2] for details. A strictly element-wise operator evaluation allows us to solve both the forward and the adjoint problem in a matrix-free manner without memory overhead. Starting from this griding and solver paradigm, we next discussed the feasibility of actual fire fighting approaches in the sense of steered particle swarms.

To be specific, we studied a unit movement strategy that sent different units from a common starting point to the highest expected fire spread. That strategy can be computed strictly element-wisely as well and it uses the adjoint solution plus the fact that an adaptive space-time grid facilitates the representation of unit trajectories. Prototypical experiments, cf. Fig. 2, validate that the proposed algorithms and paradigms can become the basis for realistic and sophisticated fire fighting expert systems as well as a starting point for future research on space-time algorithms and time-dependent optimisation strategies.

The fundamentally new concept of our work is that we obtain the results for the solution of the combined state and adjoint equations by solving them simultaneously on one space-time cube instead as sequence of problems. As mentioned this computationally highly interesting paradigm is based on spacetree data structures, see [2]. Here, the space-time domain is adaptively embedded into a cube and this cube is then cut equidistantly into three parts along each coordinate axis. This yields a regular Cartesian grid with nine cells. For each cell, we decide independently whether to refine further. The process continues recursively. The resulting data structure is a space-time-tree, a generalisation/ application of the quadtree/ octree idea to tree-partitioning on a space-time domain. With each additional refinement level of the tree, we introduce a new grid defines the level, i.e. the number of refinement steps needed at least to end up with any nine cells of the new grid. These grids are regular, but they might be ragged, i.e. decomposed into several fragments. Finally, a union of all the grids yields an adaptive Cartesian grid for the space-time domain that is memory-efficiently realized even on todays Laptops. Thus fire fighter can use our optimal steering tools in real-time as they drive towards the region that is in danger.

[1] R.C. Rothermel (1972): A Mathematical Model for Predicting Fire Spread in Wildland Fuels, USDA Forest Service, Research Paper INT-115.

[2] T. Weinzierl and M. Mehl (2011): Peano - A Traversal and Storage Scheme for Octree-Like Adaptive Cartesian Multiscale Grids, SIAM Journal on Scientific Computing 33(5): 2732--2760.

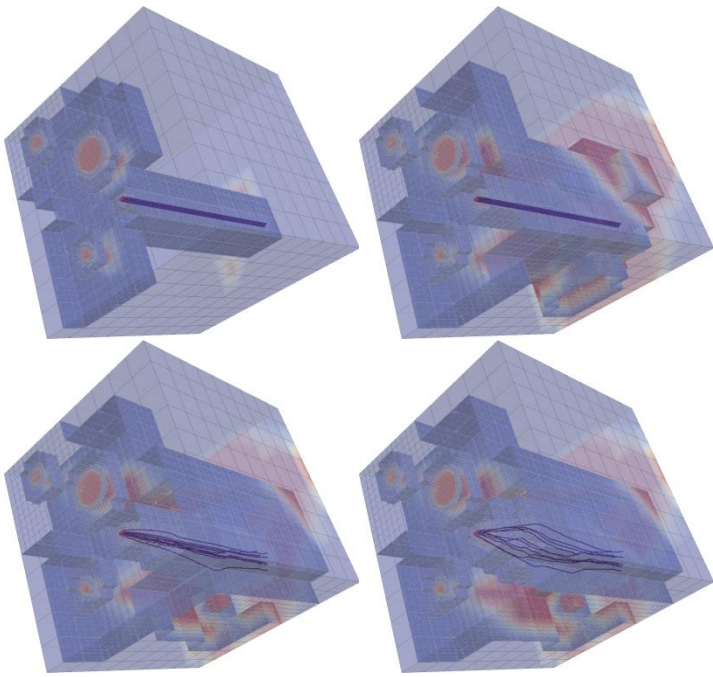


Fig. 2: Simulation of the optimal navigation of fire fighting units according to the advance of flame fronts in a space-time setting, cf. Fig. 1. As time progresses and more and more information of the actual fire spread is present the trajectories of the single units incorporate, so to say, this information and show a thus accordingly diversified pattern.

About the Activity Report 2013/ 2014

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