PROCEEDINGS OF THE MATHEMATICS IN INDUSTRY STUDY GROUP

2011

Mathematics in Industry Study Group South Africa
MISGSA 2011

The manuscripts for the Proceedings of the MISGSA were written by the problem moderators in consultation with the other members of the study group for that problem and the industry representative.

The Editor of the Proceedings was

Prof D P Mason (University of the Witwatersrand)

The Technical Reports were submitted to the Editor. Each Report was refereed by one referee. On the recommendation of the referees the Reports were accepted for the Proceedings subject to corrections and minor revisions. The Editor would like to thank the referees for their assistance by refereeing the Reports for the Proceedings.

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PREFACE

The eighth Mathematics in Industry Study Group (MISG) Workshop in South Africa was held in the School of Computational and Applied Mathematics at the University of the Witwatersrand, from Monday 10 January to Friday 14 January 2011.

There were fifty-seven participants at the MISG. Seven academic staff, one postdoctoral fellow, thirty-seven postgraduate students, seven industrial representatives and five overseas guests attended. The invited guests were:

Dr Jean Charpin	University of Limerick, Ireland
Professor Graeme Hocking	Murdoch University, Western Australia
Dr Sarah Mitchell	University of Limerick, Ireland
Professor Tim Meyers	Centre de Recerca Matematica, Barcelona, Spain
Professor Colin Please	University of Southampton, England

The South African Universities and Institutes which were represented were:

African Institute for Mathematical Sciences
University of the Witwatersrand
University of Pretoria
North-West University
Cape Peninsula University of Technology
University of KwaZulu-Natal
UNISA

The MISG Workshop was opened by Professor Yunus Ballim, Deputy Vice-Chancellor Academic at the University of the Witwatersrand.

The MISG Workshop followed the established format for Study Group meetings held throughout the world. South African industry had been approached to submit problems during 2010. Seven problems were submitted. On Monday morning each Industry Representative made a twenty-five minute presentation in which the problem was described and outlined. The academics and graduate students then split into small study groups and worked on the problems of their choice. Some participants worked on one

problem while others moved between problems and made contributions to several problems. Each problem was co-ordinated by a senior moderator and one or more student moderators. The role of the senior moderator was to co-ordinate the research on

the problem during the week of the meeting and also to do preparatory work including literature searches before the meeting. The main function of the student moderators was to present short reports at the end of each working day on the progress made that day. The moderators were in contact with the Industry Representative throughout the meeting. On Friday morning there was a full report back session to industry. Each senior moderator, with assistance from the student moderators, made a twenty-five minute presentation, summing up the progress made and the results that were obtained. Each Industry Representative then had five minutes in which to make comments on the progress and results which were reported. Work was done on only six of the seven problems submitted. There were not sufficient participants to work on the seventh problem which will be submitted to MISG 2012. The MISG ended at lunch time on Friday.

The MISG was preceded by a Graduate Workshop from Wednesday 6 January to Saturday 9 January 2010. The objective of the graduate Workshop was to provide the graduate students with the necessary background to make a positive contribution to the MISG the following week. The students were given hands-on experience at working in small groups on problems of industrial origin, some of which were presented at previous MISG meetings, at interacting scientifically and at presenting oral reports on their findings. The Facilitator of the Graduate Workshop was Professor Colin Please of the School of Mathematics, University of Southampton, England. He was assisted by Charis Harley and Masters student Franklin Djeumou of the School of Computational and Applied Mathematics, University of the Witwatersrand. Thirty graduate students participated in the Workshop. Four problems were presented to the graduate students:

An improved method for the knapsack problem
Lane-Emden equation for the density distribution of an isothermal gas sphere
Lane-Emden equation of the second kind
Turbulent fluid facture

The graduate students worked in small study groups on the problem of their choice. Each group presented their results at a report back session on Saturday afternoon.

The sponsors of the Graduate Workshop and the MISG were:

- Hermann Ohlthaver Trust
- African Institute for Mathematical Sciences
- Oxford Centre for Collaborative Applied Mathematics (OCCAM)
- University of Limerick, Ireland
- Dean's Discretionary Fund, Faculty of Science, University of the Witwatersrand
- Professor Yunus Ballim, Deputy Vice-Chancellor (Academic), University of the Witwatersrand
- School of Computational and Applied Mathematics, University of the Witwatersrand

We thank the sponsors without whose support the Graduate Workshop and the MISG could not have taken place.

LIST OF DELEGATES

Academic

Ali, Montaz	University of the Witwatersrand
Bashe, Mantombi	University of the Witwatersrand
Charpin, Jean	University of Limerick, Ireland.
Hocking, Graeme	Murdoch University, Perth, Australia
Khalique, Masood	North-West University
Mason, David	University of the Witwatersrand
Mitchell, Sarah	University of Limerick, Ireland
Modhien, Naeemah	University of the Witwatersrand
Moitsheki, Joel	University of the Witwatersrand
Muchatibaya, Gift	Cape Peninsula University of Technology
Myers, Tim	Centre de Recerca Matematica, Barcelona, Spain
Please, Colin	University of Southampton, England

Postdoctoral Fellows

Kitio, Cedrik	African Institute for Mathematical Sciences

Graduate Students

Adem, Abodollahi	North-West University
Adem, Khadijo	North-West University
Ali, Zakaria	University of Pretoria
Bartels, Casey	University of the Witwatersrand
Bekezulu, Baba	University of the Witwatersrand
Chinemerem, Dennis	University of South Africa
Djeumou Fomeni, Faranklin	University of the Witwatersrand
Dintoe, Isia	University of the Witwatersrand
Fanucchi, Dario	University of the Witwatersrand
Fareo, Gideon	University of the Witwatersrand
Hamese, Maudu	University of the Witwatersrand
Hirpa, Dessalegn	African Institute for Mathematical Sciences

Hutchinson, Ashleigh	University of the Witwatersrand
Jacobs, Byron	University of the Witwatersrand
Kamga, Morgan	University of the Witwatersrand
Kgatle, Rahab	University of the Witwatersrand
Khumalo, Bhekamandla	University of the Witwatersrand
Manyisa, Jeremia	University of the Witwatersrand
Matebese, Belinda	North-West University
Mbebi, Alan	African Institute for Mathematical Sciences
Moepya, Obakeng	University of the Witwatersrand
Mzwana, Siboleke	University of the Witwatersrand
Ndlovu, Luyanda	University of the Witwatersrand
Nzotungicimpaye, Claude-Michael	University of the Witwatersrand
Okeke, Blessing	University of the Witwatersrand
Onanena,Gladys	University of the Witwatersrand
Rikhotso, Deals	University of the Witwatersrand
Rusogara, Innocent	University of the Witwatersrand
Seuneu Tchamga, Milaine	African Institute for Mathematical Sciences
Simelene, Simphiwe	University of the Witwatersrand
Tailor, Asha	University of the Witwatersrand
Tangpi, Ludovic	African Institute for Mathematical Sciences
Tchoukouegna Ngnotchouye, Jean Medard	University of KwaZulu-Natal
Terefe, Yibeljaladane	University of Pretoria
Ujeneza, Eva-Liliane	African Institute for Mathematical Sciences
Yohana, Elimboio	University of the Witwatersrand
Zama, John	University of the Witwatersrand

Industry Representatives

Adewumi, Aderemi	School of ComputerSecience, University of KwaZulu-Natal
Davis, Steve	Sugar Milling Research Institute, University of Kwa-Zulu-Natal

Dhorat, Ismail	Zyelabs, Johannesburg
Makungunugwa, Rumbidzai	Zyelabs, Johannesburg
Van der Merwe, Nielen	School of Mining Engineering, University of the Witwatersrand
Yilmaz, Halil	School of Mining Engineering, University of the Witwatersrand
Zizhou, Njodzi	Sugar Milling Research Institute, University of Kwa-Zulu-Natal

PROBLEMS

MOBILE DEVICE DETECTION BASED ON USER AGENT STRINGS

Industrial partner: Zyelabs

Industry Representatives

- Ismail Dhorat, Zyelabs, Johannesburg
- Rumbidzai Makungunugwa, Zyelabs, Johannesburg

Problem Description

Every browser, web crawler and mobile device when requesting a web page, sends its "user-agent". Within the context of the HTTP protocol, the User-Agent is simply a string passed in the request header that is used as a means to identify itself. The user-agent can be used for a variety of purposes such as formatting content appropriately for the device requesting the content.

It is often much simpler to detect desktop browsers and render content appropriately since the features available are pretty well known. In addition the list of possible UA's are few when compared to mobile device user agents. A simple string matching algorithm could be used to detect desktop browsers without affecting performance of your website or service.

The problem is that there are thousands of different mobile devices, each with their own screen sizes, features and versions of browsers. Even devices that share the same core operating system may often have different features. This makes detecting and rendering content specific to a mobile device difficult.

One of the solutions is to make use of the WURFL (Wireless Universal Resource File) which is a big repository that catalogues these mobile device UA's. The WURFL can be used to detect the device of the user and serve the appropriate content. The query however needs to be optimized and return a response within a reasonable time frame. Currently Heuristics, Levenshtein distance and reduction of the string has been used to reduce the query time.

The challenge is to detect mobile devices and their relevant properties such as screen size, in an optimized manner based on the User Agent. This can be achieved by either optimizing the existing algorithms or introducing a hybrid of newer, faster algorithms.

COAL MINE PILLAR EXTRACTION

Industry: Mining

Industry Representatives

- Nielen van der Merwe, School of Mining Engineering, University of the Witwatersrand, Johannesburg
- Halil Yilmaz, School of Mining Engineering, University of the Witwatersrand, Johannesburg

Problem Description

While it is common practice in coal mining to leave large unmined pillars in situ to support the overburden, many South African coal mines are considering to mine those pillars on the retreat in a secondary operation in order to improve resource utilization. Pillar extraction is not a new mining method and few problems arise when it is planned from the beginning, when it is possible to design pillars to a size that will facilitate safe secondary mining.

The challenge is to extract the older, smaller pillars that were left in situ several decades ago and were not specifically designed to be extracted. In any pillar extraction operation, the pillars are never extracted completely. Small pillar remnants, called snooks, are left for safety reasons. The requirements for successful pillar extraction are that the overburden has to fail in order to prevent undue build-up of abutment stresses on the as yet unmined pillars, implying that some distance behind the working area, the snooks have to fail while they have to be stable in the immediate vicinity of the working area.

The overburden rock mass is layered and can be treated as a series of beams of different thickness with known tensile strength and elastic modulus. The snooks underneath the beams can be treated as point support that have finite strength and quantifiable compression characteristics.

The challenge is to quantify the interaction between the snooks and the overlying rock mass and predict under which conditions the smooks and the overlying rock beams will fail.

ROUGH OR SMOOTH BALLS? THAT IS THE QUESTION

Industrial partner: Bidvest Wits Football Club

Industry Representative

- Dennis Tshabalala, Bidvest Wits Football Club

Problem Description

In a Cup match all teams use the ball given to them by the South African Football Association but in a League match, the home team chooses the soccer ball. Nike supplies three different types of soccer ball to Wits Soccer Club all within the required specifications of circumference, weight and material. The three soccer balls given to the Wits Soccer Team are: T90, Tracer and Omni.

The Study Group is asked to recommend which of the three soccer balls Wits Soccer Team should use for its home matches.

The criteria for a good soccer ball are that it must behave predictably, it must not sweve and it must be stable while moving through the air. The Study Group is asked to take into account the types of grass used in South Africa (rye and kikuyu), the effect of high and low altitude on the trajectory of the ball, on the drag and on the transition from turbulent to laminar flow and to consider the flight of the soccer ball at corner kicks, free kicks and goal kicks.

TRANSFORMING SA SUGARCANE FACTORIES TO BIOREFINERIES

Industry: Sugar

Industry Representatives:

- Steve Davis, Sugar Milling Research Institute, University of KwaZulu-Natal
- Njodzi Zizhou, Sugar Milling Research Institute, University of KwaZulu-Natal

Problem Description

Rising oil prices and climate change are increasing the viability and necessity to produce plant based, as opposed to fossil based products, such as bio-plastics, bio-polymers, bio-fuels and other renewable energies. When it comes to converting radiation and water into biomass, sugarcane is one of the two most productive plants known to man. Also, sugarcane is already a commercially cultivated crop and is therefore a good bio-refinery feedstock candidate. Worldwide there has been a significant drive within the sugar industries to research and develop bio-refinery technologies. There are now more bio-refinery technologies available than what we can install at any single sugarcane factory. Sugarcane comprise of various compounds, such as fibre, sucrose, glucose, fructose and starch. These compounds make up the feedstock for different bio-products and it is therefore most viable that more than one bioprocess will be installed at a single sugarcane factory. A suitable combination of processes hence needs to be selected for a specific sugarcane producing area. This selection should ideally be based on economics, the typical composition of cane in the region, exposure to risk and the existing infrastructure on the ground. The purpose of this project will be to demonstrate how mathematical optimisation methods (and perhaps other approaches) could assist the sugar industry with this combinatorial problem.

OPTIMAL ASSIGNMENT OF BLOOD IN A BLOOD BANKING SYSTEM

Industry: Hospital and National Blood Bank

Industry Representative

- Aderemi Adewumi, School of Computer Science, University of KwaZulu-Natal

Problem Description

Blood compatibility has many aspects and is determined not only by the blood types (O, A, B, AB), but also, by blood factors (Rh, Kell, etc.). The risk of a serious transfusion reaction can be minimized if the donor unit is both ABO-compatible and Rhesus (Rh)-compatible. Type O and Rh negative blood can be given if the recipient's blood group is not known, as may happen in an emergency. However, the scarcity of type O and Rh negative blood types requires that available blood has to be properly assigned among potential recipients depending on their own blood type and group. It is believed that the number of possible ways assignment can be done essentially gives rise to an NP-Hard problem. This classification of blood and the natural restriction in the blood donation/transfusion system makes it mandatory to determine the best way to assign available blood resources in the blood bank to recipients so as to minimize the quantity of blood imported from outside the system and stabilize the quantities assigned on a daily basis. The challenge is to model the problem and find an optimal way of blood assignment that will guarantee efficient usage of available blood types. This will contribute to the good management of a blood donation-transfusion system. It will determine the best assignment of blood resources to demand, which minimize the quantity of blood imported from outside the system and stabilizes the quantities assigned daily.

OPTIMAL MODEL FOR CAMPUS PARKING SPACE ALLOCATION

Industry: University and industry in general

Industry Representative

- Aderemi Adewumi, School of Computer Science, University of KwaZulu-Natal

Problem Description

The uncertain nature of the demand for parking in many organizations has led to some major planning problems. Parking facilities, allocation and conflicts are among the most common problems facing traffic managers. The problem can be in terms of scarcity (few available spaces compared to demand) or management (inefficient usage of available facilities). Specifically, parking is considered a major land use problem in campus planning. The surge in the number of non-resident, staff and visitor car owners coupled with the limited parking space makes parking space allocation (PSA) a difficult one. Planners and Managers tend to proffer a "blind" solution to the problem without proper understanding of its nature and best solution techniq1ue. Shortage of parking space near activity centres is worsened as car ownership and registration on campus increase especially on campuses located in urban centres, Given the administrative rules, regulations and restrictions regarding campus parking, there is an urgent need to find an optimal way of allocating parking space based on specific constraints and requirements.

Many people have looked at the problem from the administrative and management point of view. However, it is believed that mathematical modelling and perhaps optimization can provide a substantial guide to its solution. The challenge is to develop a model of the problem that determines how best to use existing land in the competitive and policy-driven university campus environment. Major constraints and parameters that traffic managers consider essential to optimal parking need to be investigated. The ultimate goal is to come up with practical solutions that will assist in proper planning, design and allocation of campus parking space and facilities.

Technical Reports