Using 3D Technology to Image and Control Oil Flow

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Outline

• Background on Current Research
• 3D Visualization Technology
• Demo
• Research Group
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NSERC/AIEES/Foundation CMG Chair

Alberta Innovates Technology Future (iCORE) Chair

Research Consortium on Reservoir Simulation

Foundation CMG/Frank-Sarah Meyer Collaboration

Center: Simulation & Visualization

Global Initiative in Research in Unconventional Oil and Gas, Beijing Site
Background

The Chair was established in 2007 by Foundation CMG at the University of Calgary. This Reservoir Simulation Chair is unique in Canada and provides a focus on Canadian oil and gas reservoirs.
Missions, Roles and Strategies

Missions
• To maximize the value of energy resources and reduce the environmental footprints of their development
• To train high quality personnel

Roles
• To advance technology through the development and implementation of innovative modeling and simulation capabilities
• To respond to the institutional, industrial and government needs in the development of energy and environment technologies while reflecting social values

Strategies
• Innovative research
• Partnership and collaboration
• Attracting top quality personnel
Current Research

Studies of recovery processes for heavy oil and bitumen

Studies of unconventional oil and gas reservoirs

Development of accurate and fast solvers and simulators

Development of 3D Visualization Technology
Heavy Oil and Bitumen

Thermal Recovery Processes (CSS, SAGD and ISC)

Emerging Recovery Processes

> **Steam + Additive** Injection Process:
  - Additive: Solvent
  - Additive: Oxygen or air
  - Additive: Chemical
  - Additive: Non-condensable gases
  - Additive: Catalyst

> **Electrical Heating**
Unconventional Reservoirs

Tight and Shale Oil and Gas Reservoirs:

- Study of Mechanical Properties of Tight/Shale Reservoirs
- Gas Transfer in Nanopores of Shale Gas Reservoirs
- Phase Behavior of Fluids in Tight/Shale Reservoirs
- Optimization of Dynamic Hydraulic Fracturing
- Potential of Enhanced Oil Recovery in Tight Reservoirs
Reservoir Simulators

Realistic reservoir models and fast simulators that accurately represent petroleum reservoirs from the *pore scale* to the *kilometre-scale* are developed to reflect the real physics and chemistry of reservoirs, taking into account

- Thermal effects
- Composition
- Kinetics
- Geomechanics
- Wellbore

The results are utilized by the industry partners through technology transfer.
Reservoir Simulators

A Parallel Reservoir Simulation Platform:

- Black oil simulator
- Compositional simulator
- Wellbore
- Geomechanics
- Thermal simulator (ISC)
- Electrical Heating
3D Visualization Technologies

Selected Projects

- **Virtual Reality (VR)**
  - Immersive Interfaces for Well Placement Optimization in Reservoir Models
  - Dynamic Subsurface Cutaways

- **Augmented Reality (AR)**
  - Flying Frustum
  - PlanWell
Annual Technical Symposium

June 15 – 16, 2017

University of Calgary
Downtown Campus

40 Presentations by Graduate Students and PDFs
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Compute Resources

Enable
• Large simulations
• Big data
• Analytics
• Machine Learning

➢ How to interpret massive results?
Visualization of Massive Datasets

- Model and simulation size is increasing
  - The ability to generate data outpaced by the ability to analyze it

- Larger volume of data exceeds capacity of desktops

- Centralization of computational resources and big data visualization capabilities reduces need for investment in high-end desktops
Visualization of Massive Datasets

- Visualization is critical to understanding and sense making of complex datasets
- Many centers have been developed to combine big data analytics with visualization

From Interdisciplinary Immersive Analytics at the Electronic Visualization Laboratory: Lessons Learned and Upcoming Challenges. 2016.
Visualization and Interaction

The Reservoir Simulation Chair Research Program

Collaboration

- Modeling, Data Management & Knowledge Representation
- Data Visualization & Analytics
- Interaction Techniques & Technologies

Output
Selected Projects

- **Virtual Reality (VR)**
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Technology: Virtual Reality (VR)

Why use VR now?

• Technology is much more mature than even 10 years ago.

• Massive investment (billions) by big technology companies recently means rapid improvement in
  • VR hardware,
  • 3D user interface design,
  • Software development ecosystems.
Why Virtual Reality?

<table>
<thead>
<tr>
<th>Immersive Feature</th>
<th>Benefit</th>
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<tbody>
<tr>
<td>Stereoscopy, head tracking, Increased FOR</td>
<td>Improved spatial understanding, leading to faster and more accurate analysis of connected volumes and thus more optimal well placement.</td>
</tr>
<tr>
<td>Increased FOV</td>
<td>Reduced information clutter. Able to assess a larger area at once.</td>
</tr>
<tr>
<td>Increased FOR</td>
<td>Increased working space leading to reduced information clutter and greater ability to work on a large amount of data with different tools.</td>
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<tr>
<td>Natural interactions</td>
<td>Allow users to focus on the problem, rather than the interface. E.g., move head to look around a well.</td>
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Technology: Virtual Reality (VR)

Head Mounted Displays (HMD)
- For personal use

Large scale environments
- For industrial high resolution & big data scenarios
- For group collaboration

Courtesy of HP

Courtesy of Monash University
Selected Projects (VR)

Immersive Interfaces for Well Placement Optimization in Reservoir Models

- Tool that uses analysis of reservoir data to help determine superior well placements
- Leverages VR on consumer head mounted displays and industrial visualization centers
Selected Projects (VR)

Dynamic Subsurface Cutaways

- Novel technique that allows rapid analysis and interaction with subsurface data
- Leverages VR on consumer head mounted displays and industrial visualization centers
Technology: Augmented Reality (AR)

- Visualizations augment the “real world”

Courtesy of Volvo

Courtesy of Microsoft

Courtesy of Trimble

Courtesy of Dr. Christian Jacob
Selected Projects (AR)

Flying Frustum

- Novel technique for drone control and monitoring
Selected Projects (AR)

PlanWell

- Collaboration tool for planning surface operations

EXPLORER MARKS A LOCATION AND SENDS IT TO THE OVERSEER

OVERSEER CAN DRAW A PATH

THEN THE OVERSEER MOVES A PETROLEUM WELL TOWARDS THE NEW MARK
Putting it all together

Technological Solutions

- Software
  - Visualization techniques
  - Interaction design
  - Big data techniques
  - Data analytics and machine learning

- Hardware
  - Collaborative visualization centers
  - Advanced display technologies
  - Augmented reality
  - Virtual reality

Business Benefits

- More efficient tools
- Fewer mistakes
- Reduced task completion time
- Greater collaboration
- Integrated workflows
- Projects on time and on budget
Collaboration and Technology Transfer

• Primary use is for our work (oil and gas applications)

• Other Applications:
  – Biology
  – Biophysics
  – Engineering
  – Architecture
  – Medicine
  – Outreach
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Graduated Since 2008

MSc (39): Celine Chen, Steve Chan, Mohammad Javad Shafaei, Baijie Wang, Wajih Naeem, Jian Sun, Anton Lysyanyy, Song Yu, Bessi Bao, Mark Zhong, Liyun Zhang, Zhen Wang, Yinzhe Fan, Sam Chen, Forough Adim Naghouni, Jenny Zhang, Mohammad Hossein Nikpoor, Frank Xiong, Qiuyue Song, Bo Yang, Jinze Xu, Fangfei Sun, Yayun Xiong, Menglu Lin, Hongbo Yu, Tianlin Zhang, Jiabei Han, Tianjie Qin, Xiaoduan Ye, Qingmao Li, Xueying Lu, Lauro Vargas, Moein Elahi, Lin Meng, Jin Zhao, Yi Hu, Roberta Cabral Mota, Andy Zhang and Qingquan Liu


Student Employment

- Devon
- Schlumberger
- Three Steam
- Suncor
- Nexen
- AMEC
- Surgutneftegas
- Sunshine
- ADCO, Abu Dhabi
- Laricina
- Alberta Innovates
- Canada Revenue Agency
- University of Calgary
- BP Canada
- Occidental Petroleum in Houston
- Many universities worldwide

- Sasol
- Cenovus Energy
- Penn West
- Husky Energy
- AJM-Deloitte
- Gushor
- Southern Pacific
- Weather Ford
- EnCana
- ConocoPhillips
- CMG Ltd.
- Jacobs
- Baker Hughes
- Apache
- CNR Ltd.
- Zonton Energy
- Koch
Current Research Group

Graduate Students: over 50 MSc and PhD

Post Docs and RAs: 11

Project Manager

Technical Managers

Administrative Assistants

Research Collaborators from Industry and Academia Globally
Multidisciplinary Program

Mathematics and Statistics

Computer Science

Geology (Geophysics)

Chemical and Petroleum Engineering

Electrical and Mechanical Engineering
Sponsors

5 Federal Funding Agencies

Natural Sciences and Engineering Research Council of Canada (NSERC)

Alberta Innovates Energy Environment Solutions (AIEES)

Alberta Innovates Technology Futures (AITF)
Informatics Circle of Research Excellence (iCORE)

Canada Foundation for Innovation (CFI)

Alberta Advanced Education and Technology (AET)
18 Industrial Sponsors

- Brion Energy
- CMG Reservoir Simulation Foundation
- Computer Modelling Group (CMG) Ltd.
- ConocoPhillips
- Devon Energy
- Husky Energy Ltd.
- IBM Canada
- Imperial Oil
- Kerui Group
- Laricina Energy Ltd.
- Shell
- Nexen
- PetroChina - RIPED
- Sherritt
- Statoil
- Suncor
- Swan Hill Synfuels Inc.
- IBM Alberta Centre for Advanced Studies
Research Resources

Advanced simulation (commercial and research) software

Computing hardware – EXAS IBM Cluster

CMG Simulation Laboratory

FCMG Frank and Sarah Meyer Collaboration Center for Simulation & Visualization Integration

Advanced oil/gas recovery laboratories
Enhanced Oil Recovery Labs

- Porous Media and Unconventional Oil Recovery Lab
- In Situ Combustion Lab
- Hydrocarbon Upgrading Lab
- Heavy Oil Properties (PVT, Viscosity, Phase Behavior) Lab
- SAGD (Steam Assisted Gravity Drainage) Lab
- Solvent Enhanced Recovery Process Lab
- Simulation and Visualization Lab
Unconventional Oil and Gas Labs

- Geo-physics
- Geo-chemistry
- Micro structure
- Formation stimulation
- Rock mechanics
- Reservoir simulation
Business Benefits

- Increasing reserves
- Reducing capital/operating costs
- Enhancing petroleum recovery
- Reducing environmental footprints
Further Information

For demos or discussions of the technology come visit our lab!

Dr. John Chen: zhachen@ucalgary.ca
Acknowledgements

Tech Manager: Stephen Cartwright

Research Associate: Roberta Cabral Mota and Hamidreza Hamdi

Many Grad Students: e.g., Nico Li

Collaborators: Ehud Sharlin and Mario Costa Sousa