Ferienakademie 2016

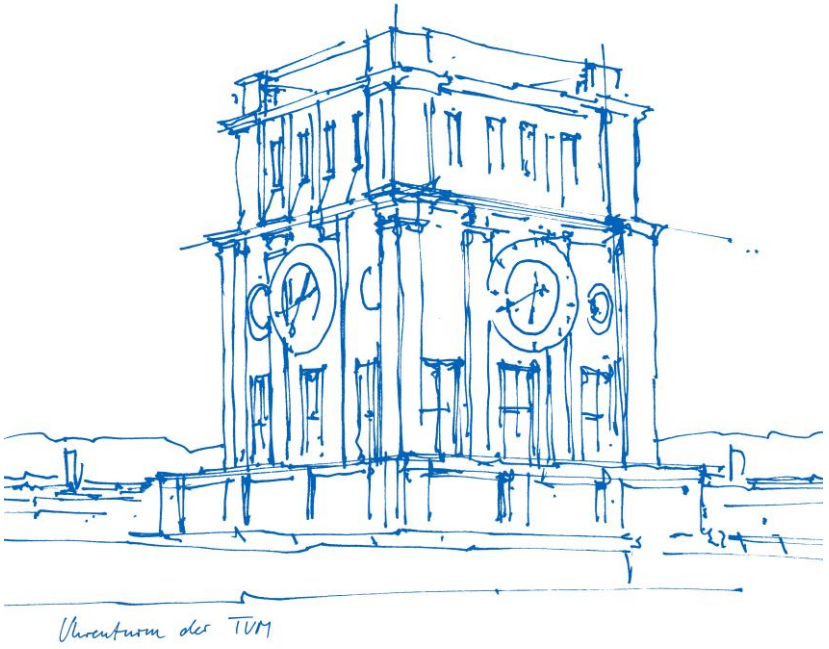
Playful Simulation – Serious Models in Interactive Applications

Technische Universität München

Fakultät für Informatik

Lehrstuhl für Scientific Computing

Garching, July 4th, 2016



Agenda

- General Introduction
- Project: SmartQuake for Android
- Course Organization
- Student Presentation Topics

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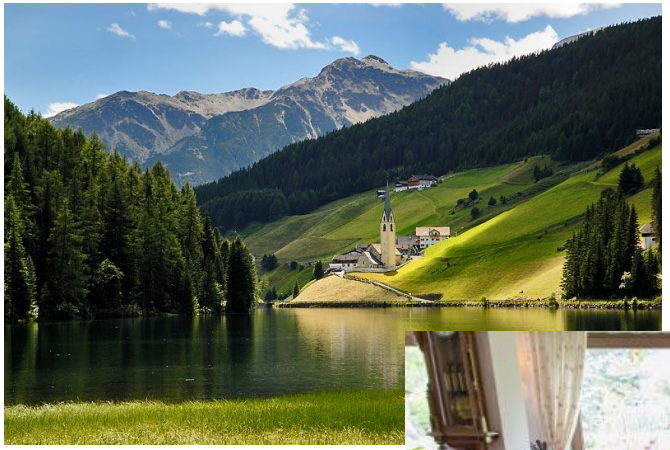
General Introduction



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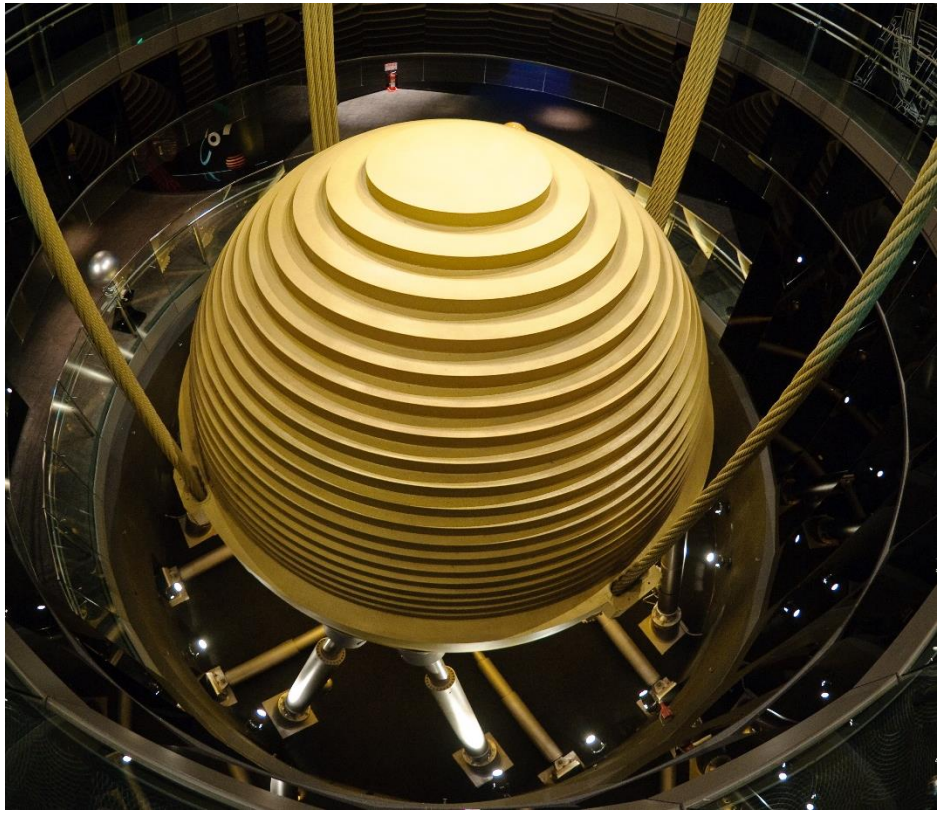
Baustatik und Baudynamik
Universität Stuttgart

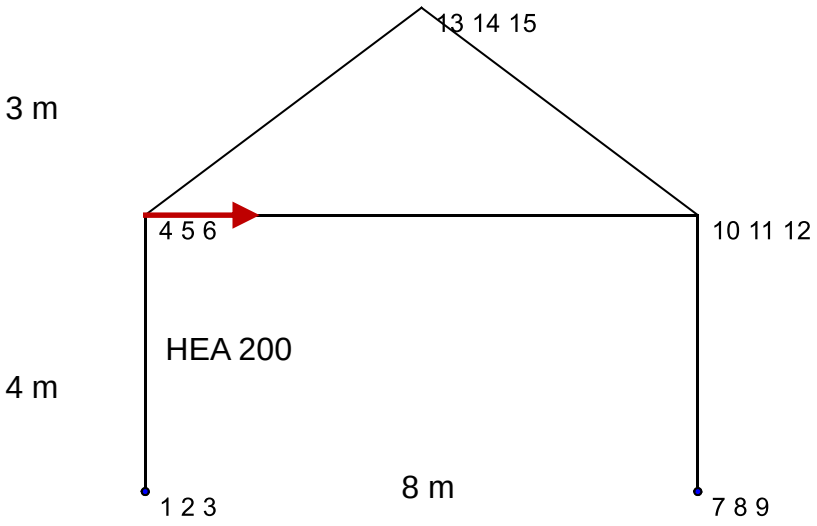
Model:
- linear dynamics of elastic 2D frame structures
- beam finite elements in space
- 2. order ODE in time

Solver:
- implicit or explicit time integration
- modal reduction

Platform:
- Android
- Java

Phenomena:
- tuned mass dampers
- base isolation
- failure of structure

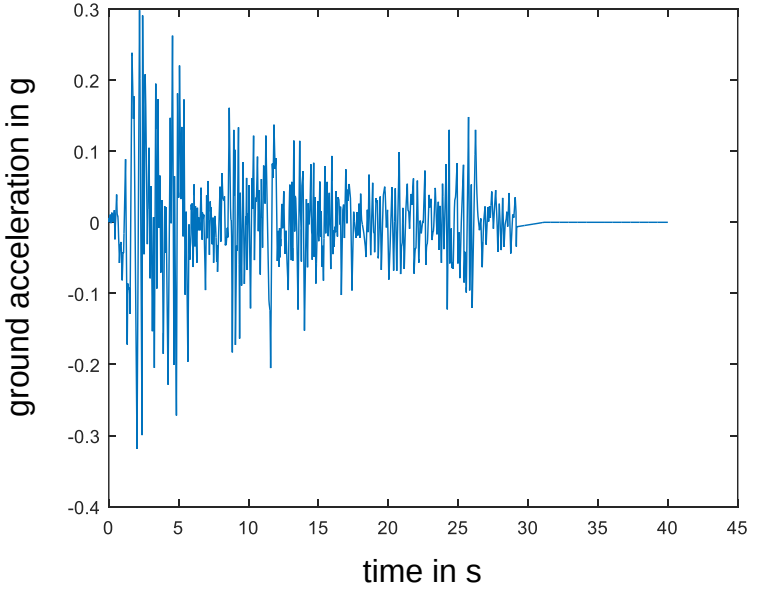


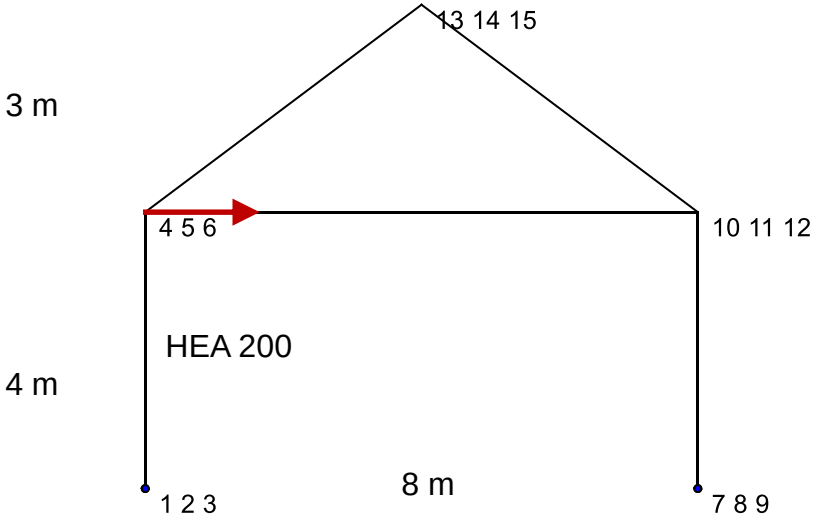


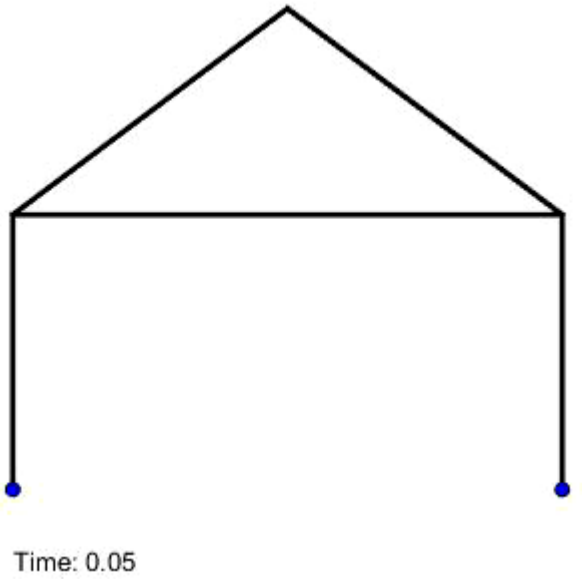
Linear dynamics with explicit time integration:

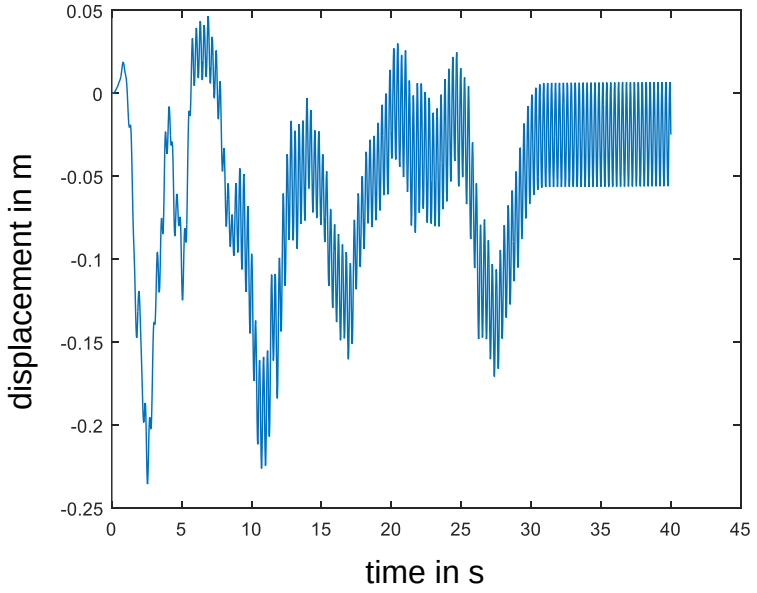
80,000 time steps, $\Delta t = 5 \cdot 10^{-4}\,\mathrm{s}$

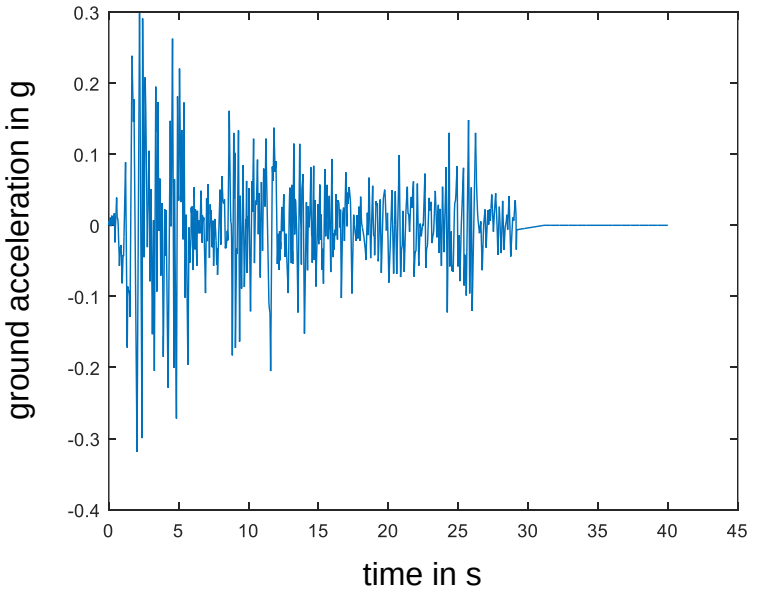
ground acceleration: El Centro earthquake




13 14 15
3 m
4 5 6
10 11 12
HEA 200
4 m
1 2 3
8 m
7 8 9


Time: 0.05


displacement in m
time in s
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
5
10
15
20
25
30
35
40
45


ground acceleration in g
time in s
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
5
10
15
20
25
30
35
40
45

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Course Organization

- Professors:
  - Univ.-Prof. Dr. Hans-Joachim Bungartz (TUM)
  - Univ.-Prof. Dr.-Ing. habil. Manfred Bischoff (Universität Stuttgart)
- Teaching assistants:
  - Dr.-Ing. Malte von Scheven (Universität Stuttgart)
  - Emily Mo-Hellenbrand, M.Sc. (TUM)
- Course Duration: 2 weeks
  - 19. September – 30. September
  - 1-2 Hiking days ☺
- Technical Goal ➡ A working Android app **SmartQuake**
- **Prerequisites**
  - Presentation prepared
  - Bring your own laptop (something you can code on)
  - **Git**, **Android Studio** installed

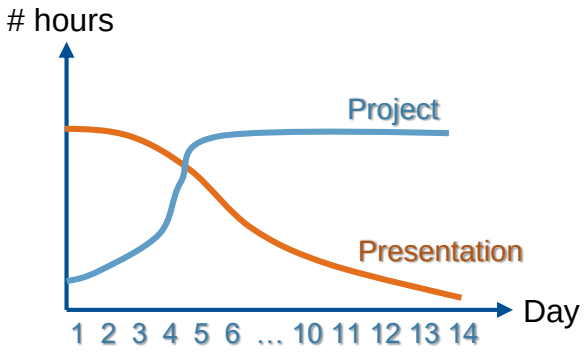
Course Organization (cont.)

➢ Course Structure:

- **Component 1: Student Presentations**
  - Each participant gives 30 min. talk + 15 min. discussion
  - Topics ranging from
    Physics Modeling Numerics to Implementation Software Tools
  - Talks spread over entire course period:
    More talks in the beginning, more coding later on
  - Necessary components for the project
  - Independent research on topic, good insight, expertise
  - Presentation should be prepared before FA (Presentation order TBD!)

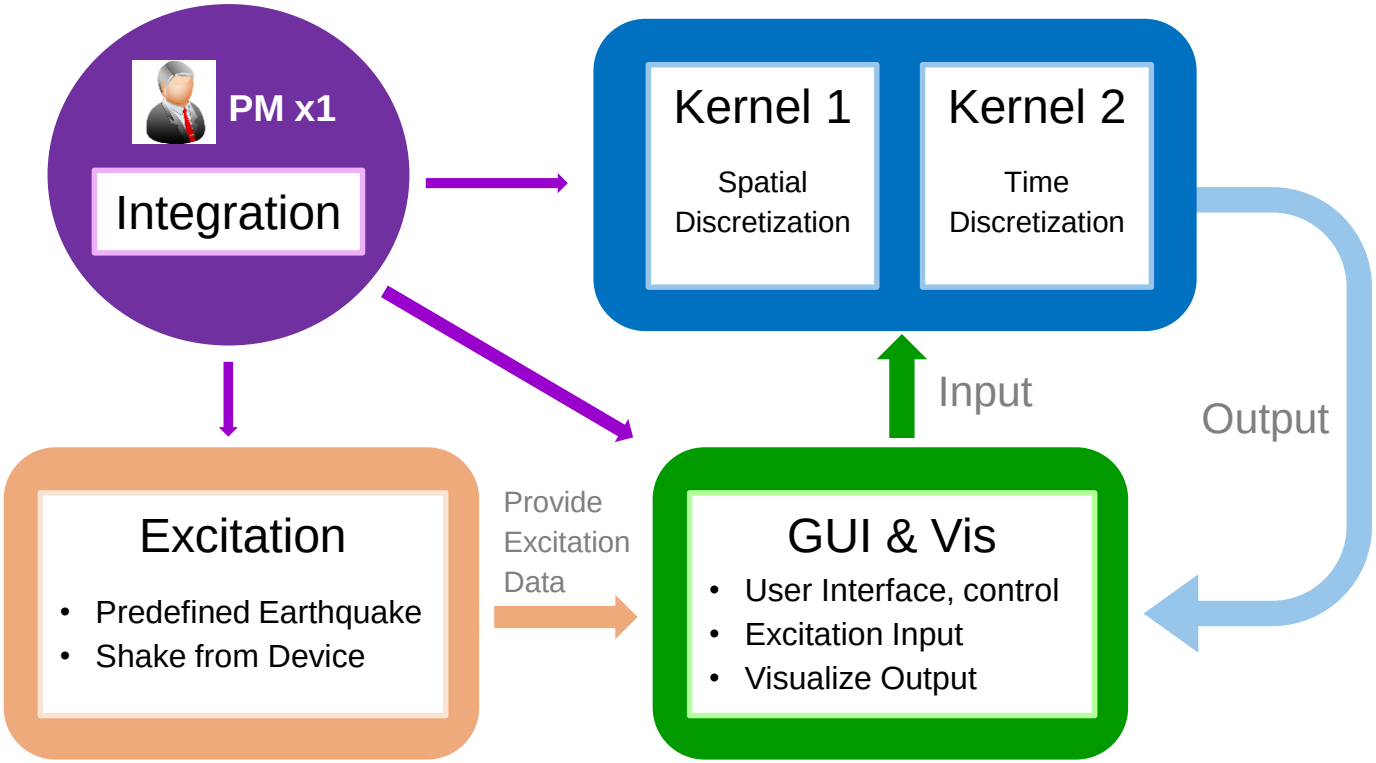
- **Component 2: Project**

  5 teams:
  - PM & Integration
  - GUI & Visualization
  - Kernel 1: spatial discretization
  - Kernel 2: time stepping
  - Excitation



Course Organization (cont.)

- Course Structure:
  - **Day 4-end: Project phase**



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Student Presentation Topics

- Instruction: Choose 3 topics, give priority

  Email to Emily at hellenbr@in.tum.de by July 5th.

Note: Topic numbers do not represent presentation order.

- Physics Modeling Numerics topics:

1. Dynamics I

- Overview, phenomena
- Governing equations

  Analogy to electric circles (electrical engineering)
- Damping

  Simple harmonic oscillator

2. Dynamics II

- Mehr-Massenschwinger
- Solution procedures
- frequency response characteristic

Student Presentation Topics (cont.)

3. Direct stiffness method for trusses

- System breakdown and assembly
- Transformation into global coordinate system
- Loads, consistent nodal forces
- Solution and post processing

4. Bernoulli beam theory

- Dimensional reduction for beams
- Assumptions of Euler-Bernoulli beams
- Governing equations
- Discretization
- Stiffness matrix, properties
- Mass matrices (consistent, lumped)

5. Transfer matrices (Übertragungsmatrizen)

- Calculation of result values (displacements, forces) in the elements from nodal values
- Static case
- Extension to the dynamic case

Student Presentation Topics (cont.)

6. Modeling hinges in frames and damage

- Ways to model arbitrary complex hinges
- Discussion of pros and cons
- Cut-off criterion for damage
  - Adding hinges/removing elements

7. Dynamics III:

- Exact vibration of Bernoulli beam
- Separation of variables

8. Explicit time integration (central differences)

- Overview
- Properties
- Theory and implementation of central difference method

Student Presentation Topics (cont.)

9. Implicit time integration (Newmark-β)

- Overview
- Properties
- Theory and implementation of Newmark-beta method

10. Modal analysis

- Modal decomposition
- Participation factor

11. Reduced order modeling

- Idea and application
- Types of reduced order modeling
- Modal reduction

Student Presentation Topics (cont.)

12. Earthquakes

- Seismological basics
- Resulting loads on structures
- Provide ground accelerations of real earthquakes

13. Tuned mass dampers

- Working principle
- Types
- Application (in civil engineering)
- Examples
- Base isolation

Student Presentation Topics (cont.)

- Implementation Software Tools topics:

14. Android Development Suite:

- Android Studio, Eclipse
- Tutorial

15. Linear Solvers for Java, Android

- Linear solver libraries for Java/Android
- Overview of common/popular libraries
- Candidate libraries for this project (introduction & How-to tutorial)

16. Eigenvalue solvers

- Eigenvalue problem and Generalized eigenvalue problem
- Solution of gen. eigenvalue problem
- Overview of libraries
- Candidate libraries for this project (introduction & How-to tutorial)

Student Presentation Topics (cont.)

17. Android GUI design

- Guideline, tools, libraries, etc.
- Identify candidate libraries/tools for this project (Tutorial)

18. Drawing in Android

- Real time, buffering

19. Android sensors

- Tutorial on how to invoke
- program for android sensors

20. Multi-threading/Performance tuning in Android

- Methods, Tools, Libraries, Tips, Dos & Don’ts
- Real-time input data stream and output visualization
- Heat / Energy / Power concerns

Student Presentation Topics (cont.)

21. Software engineering models

- Overview of software development methodology / life cycles
  - Which models fits to our project
  - Challenge, key component to success

22. Version control systems: GIT

- Tutorial

23. Quality assurance, debugging tools, bug tracking/resolving procedures

- Candidate QA tools (Jenkins?)