Bij ons leer je de wereld kennen

Master in Computer Science

Master’s Information Day - 6 April 2016

Universiteit Leiden
Who is who

- **Director of Education**
  Prof. Dr. Thomas Bäck

- **Study Advisor**
- **Program Director Master CS**
  Dr. Marcello Bonsangue
  m.m.bonsangue@liacs.leidenuniv.nl

- **Study Coordinator**
  Riet Derogee
  m.derogee@liacs.leidenuniv.nl
Welcome

LIACS = the computer science institute of Leiden University
Willebrord Snel van Royen (1580 - 1626) was a professor of mathematics at the University of Leiden
The future (2021 - ...)
STRUCTURE OF THE MASTER
Some basics

- Completely in English, of course 😊
- Two years, full-time
- Total of 120 EC (1 EC = 28 hours)
- Master of Science in Computer Science
- Info on tuition fee: Plexus (071-527 8011) or visit our website
  http://en.mastersinleiden.nl/arrange/collegegeld
Admission

Admission based on
- BSc Computer Science
- HBO Computer Science (meeting with Study Advisor)

All other cases individually checked

Admission procedure:
- BSc CS degree, UL: via studielink
- Dutch BSc degree university/HBO: online application
- Foreign degree: through admissions office of university
LIACS education

LIACS Curricula

Bachelor Computer Science

Master Computer Science

Master ICT in Business

Master Media Technology

PhD Graduate School

Core Computer Science

Computer Science and Economy

Computer Science and Biology

Education in a research environment
LIACS education

Master Computer Science

- Computer Science and Advanced Data Analytics
- Bioinformatics
- Computer Science and Science based business
- Computer Science and Science Communication & Society

Education in a research environment
Future oriented computing techniques

Computer Science and Advanced Data Analytics

Knowledge discovery
Computer Science

Cutting edge areas of computing
- computations inspired by nature
- high performance computations
- image analysis and retrieval
- software circuits for coordination

and solid foundations
- algorithms
- embedded systems
- formal methods
- software engineering
Advanced Data Analytics

“We are drowning in data, but starving for knowledge!”

In 2020 the amount of data produced worldwide is projected to be 35000 exabytes

Examples:
• A gram of DNA can hold 455 exabytes.
• Google has ca. 10 exabytes on disk
• The sum of human-produced information (including all audio, video and text) until 1999 was about 12 exabytes of data
Advanced Data Analytics

- Data != Information != Knowledge
- Knowledge Discovery in data is the non-trivial process of identifying:
  - valid,
  - novel,
  - potentially useful
  - and understandable patterns in data.
Education in a research environment

 Algorithms and Software Technology (AST)

- Machine learning
- Data Mining
- Natural Computing
- Optimization
- Algorithms
- Theory of Software

 Computer Systems and Imaging (CSI)

- Bioinformatics
- High Performance Computing
- Embedded Systems
- Imaging and multimedia
- Media technology
Computer Science and Advanced Data Analytics
-- Programme Structure --

Start: 1 September or 1 February

First year
10 x courses (60 EC)

Second year
Research Project (18EC)
Master Thesis (42 EC)
Courses 2015-2016

Individual choice of 10 specializations courses (6 EC)

**Advanced Data Analytics**
- Databases and Data Mining
- Social Network Analysis for Computer Scientist
- Multicriteria Optimization and Decision Analysis
- Multimedia Information Retrieval
- Seminar Distributed Data Mining
- Seminar on Constraint Data Mining

Advance in Data Mining
- Evolutionary algorithms
- Complex Networks
- Bayesian Networks
- Neural Networks
New option: Data Science

1. Data science is multidisciplinary aspects

2. Interpretation of data analysis results is crucial

3. New options in Master Programs: unique cooperation between top institutes of Leiden University

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Data Science Option in Computer Science

YEAR 1 *

Sem. I
- Databases & Data Mining
- Advances in Data Mining
- Linear Models
- Swarm-Based Computation

Sem. II
- Parallel Programming
- Distributed Data Mining
- Bayesian Networks
- Neural Networks

Intro Data Science

YEAR 2

Sem. II
- Systems in Artificial Intelligence

YEAR 1 *

Research Project

YEAR 2

- Statistical Learning
- Advanced Computing

Thesis

Multivariate Analysis

* Freedom of choice in CS courses!

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Courses 2015-2016

Algorithms and Software Technology

- Testing Object Oriented Systems
- Swarm based Computation
- Evolutionary algorithms
- Databases and Data Mining
- Seminar Combinatorial Algorithms
- Muticriteria Optimization and Decision Analysis
- System Development and Project Management

Complex Networks
- Neural Networks
- Coordination and Component Composition
- Bio-Modelling and Petri Nets
- Parallel Programming
Courses 2015-2016

Computer Systems, Imagery and Media

Multimedia Information Retrieval
Embedded Systems and Software
System Development and Project Management
Testing Object Oriented Systems
Microscopy, Modeling and Visualization
Coordination and Component Composition

Audio Processing and Indexing
Complex Networks
Multimedia systems
Parallel Programming

... and many more outside LIACS
Social Network Analysis for CS

Algorithms + Graph (theory) + Data Mining

Large datasets
online social networks with millions of users and hundreds of millions of friendships

Topics
graph evolution
Twitter
community detection
Bitcoin networks
graph compression
recommendations
economic networks
Webgraphs
PageRank
link prediction
Testing Object Oriented Systems

TimSort, Android’s, Java’s and Python’s sorting algorithm, is broken!!

To reproduce the bug:
git clone https://github.com/abstools/java-timsort-bug.git

<table>
<thead>
<tr>
<th>Language</th>
<th>Min. array length req. to trigger error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Android</td>
<td>65.536 ($2^{16}$)</td>
</tr>
<tr>
<td>Java</td>
<td>67.108.864 ($2^{26}$)</td>
</tr>
<tr>
<td>Python</td>
<td>562.949.953.421.312 ($2^{49}$)</td>
</tr>
</tbody>
</table>

How Fast Can We Sort?
- Selection Sort, Bubble Sort, Insertion Sort, Cocktail sort, Cycle sort: $O(n^2)$
- Smooth sort, Odd-even sort, Timsort: $O(n)$
- Heap Sort, Merge sort: $O(n \log n)$
- Quicksort:
  - Average: $O(n \log n)$
  - Best: $O(n \log n)$ (simple partition) or $O(n)$ (three-way partition and equal keys)
Embedded Systems and Software

- X-Ray sent through human body in heart operation
- X-Ray needs to be pre-processed to get good quality image
- Processing needs to take place in $\Delta t < 30$ msec (FDA requirement)
- Automatic translation from C code to hardware FPGA
Our context:

- *Bioscience* and *Fundamental of science* profiles of the Faculty of Science
- LUMC and Bio Science Park
- Leiden Center of Data Science
- CWI Amsterdam
- Many universities abroad
  - Europe
  - China (including key labs in Beijing, Xi’an, and Shanghai)
  - USA
Leiden Center of Data Science

Finding, analyzing and validating complex patterns in data
Masterclass

- In the second year, once every two weeks
- For all students working on research project/master thesis
- Support, exchange, stimulation, presentations, useful information
- At least two presentations per student
This is why you do it!
Recent Master Theses (2014-2015)

• Blom, Koen van der: Insect Division of Labour Applied to Online Scheduling
• Cheng, Xiwen: Application of Text Mining on Spatial Visual Sentences
• Es, Eli K. van: An Improved Maximum-Likelihood Solver for the Analysis of Graph Ensembles
• Harenslak, Bas: Content-based tag recommendation algorithms for unstructured data
• Hoogenboom, Jerry: Characterisation and Filtering of Systemic Noise in NGS Data with Applications in Forensics
• Leuven, Joost T.: Introducing User-Derived Information in the Optimization of Highly Constrained Truck Loading
• Liem, Michael: Characterizing mapk signaling in different cancers Through large public datasets
• Liu, Wei: An Evaluation Method for Nodes in Multiple Dynamic Networks
• Mirtar, Mahyaa: Mining population Movement Patterns from Cellphone Data During Natural Disasters
• Mus, Derk A.: Autonomous Simulated Car Racing through Apprenticeship Learning
• Nes, Matthijs van de: Developing Efficient Concurrent C Application Programs Using Reo
• Neuteboom, Jonathan: Protein structure prediction by Iterative fragment Assembly (PITA)
• Pilios, Emmanouil: Contracting practices in traditional and agile software development
• Smeden, Frank van: A Framework for Scheduling and Analysis of Real-Time Applications without the use of Worst-Case Execution Times
• Winter, Michael de: A Missing Value Ignoring Approach for Whole Time Series Clustering of Longevity Corebody Temperature Data
• Xia, Zhihan.: A Metadata Validation Process Design for an Automated High-Throughput Screening Workflow - Case Study in Metadata of CytomicsDB
Our characteristics

• Small scale, easy interactions students-staff
  - Growth in itself is not a target for us.
  - Quality of education and the academic level of the students at the end of their study is what matters.

• Broad offer of courses + Freedom in choosing your courses

• International environment + easy to study abroad

• Choose your favorite project area by yourself
  - Data analysis, Data Science,
  - Algorithms and software technology
  - Computer systems, imaging and media
Few figures (2015)

Ca. 100% staff members have basic qualification for education (BKO)

24 new student Master CS + 7 track Bioinformatics

40% of the students is from abroad

Percentage of students graduated in three years = 50%

Average final grade between 7.2 and 8.7
YOUR CAREER
A few examples

Zhihan Xia
Software Engineer, Pegasystems

Robin van den Broek
Software Engineer, JEM-id BV

Alexej Tessaro
Software Engineer, Expend

Alberto Baggio
Co-founder Listupp

Jan van Rijn
PhD candidate at LIACS

Jan van Rijn
Product Developer, UL

Ralph Bos
Sales manager, Landscape

Roxanna Popa
Data analyst, Euro Testing Software
Our statistics

TODAY: 96.9% of all LIACS graduates have a full-time job, and they find a job within an average time of 1.3 months.

AND IN THE FUTURE: Computer Science is a field with employment outlook ranging from average to much faster than average over the next several years.

✓ 9 of top 50 fastest growing careers in US for 2010-2020 are CS related [U.S. Department of Labor]

✓ 4 of the top 10 best and highest pay jobs in US of 2012 are CS related [U.S. News And World Report]
WHAT STUDENTS SAY
# NSE Evaluations

## DE MASTERS: OVERZICHT EN OORDELEN

### HBO/WO COMPUTER SCIENCE

<table>
<thead>
<tr>
<th>University</th>
<th>Department</th>
<th>Start/End</th>
<th>Language</th>
<th>Feiten</th>
<th>Studentenoordeelen</th>
<th>Expertoordeel</th>
<th>Score</th>
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<tbody>
<tr>
<td>Eindhoven TU/e</td>
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<td>+</td>
<td>+</td>
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<td>-</td>
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<tr>
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<td>+</td>
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<td>0</td>
<td>68</td>
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<tr>
<td>Nijmegen RU</td>
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<td>+</td>
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<tr>
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<td>+</td>
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<td>+</td>
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<tr>
<td>Utrecht UU</td>
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<td>-</td>
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<td>Groningen RUG</td>
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<tr>
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<td>-</td>
<td>0</td>
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<td>52</td>
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<tr>
<td>Amsterdam VU</td>
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<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>52</td>
</tr>
</tbody>
</table>
Strengths (Student’s view)

• Research at LIACS

• Choices, flexibility (courses, software project)

• Small groups, easy interaction with researchers

• Easy to find supervisor

• Good course schedule

• Company opportunities
AND FINALLY ...
Asking for help

Every staff member (professors and others)
has gone through a master study before
is willing to giving advice
is expected to give advice
is generally good at giving advice

At LIACS this means
25+ experts to advise you
plus all other students who may also have useful insights
Still have Questions?
Talk to our staff, student or alumni

Or send an e-mail to:
m.m.bonsangue@liacs.leidenuniv.nl