Research Methods in Computer Science
Lecture 6: Research methods

Ullrich Hustadt

Department of Computer Science
University of Liverpool
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13 Scientific method
   - Elements

14 Intellectual discovery
   - Deduction
   - Abduction
   - Induction
   - Process model

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Topics

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- Overview
- Experiments
- Questionnaires
Classifying research (1)

Research can be classified from **three different perspectives:**

1. **Field**
   Position of the research within a **hierarchy of topics**
   **Example:**
   Artificial Intelligence → Automated Reasoning → First-Order Reasoning → Decidability

2. **Approach**
   Research methods that are employed as part of the research process
   **Examples:**
   Case study, Experiment, Survey, Proof

3. **Nature**
   - Pure theoretical development
   - Review of pure theory and evaluation of its applicability
   - Applied research
Classifying research (2)

- **Pure theory:**
  Developing theories and working on their consequences, with regard to experimentation or application

- **Descriptive studies:**
  Reviewing and evaluating existing theories, including describing the state of the art, comparing predictions with experimental data

- **Exploratory studies:**
  Investigating an ‘entirely’ new area of research, exploring a situation or a problem
  See http://www2.uiah.fi/projects/metodi/177.htm

- **Explanatory studies:**
  Explaining or clarifying some phenomena or identifying the relationship between things
Classifying research (2)

- **Causal studies:**
  Assessing the causal relationship between things

- **Normative studies:**
  Producing a theory of design (or of other development) like recommendations, rules, standards, algorithms, advices or other tools for improving the object of study

- **Problem-solving studies:**
  Resolving a problem with a novel solution and/or improving something in one way or another

- **Development and Application studies:**
  Developing or constructing something novel
Quantitative and qualitative research methods

- **Quantitative research methods**
  - Methods associated with *measurements* (on numeric scales)
  - Stemming from natural sciences
  - Used to **test hypotheses** or create a *set of observations* for inductive reasoning
  - Accuracy and repeatability of vital importance

- **Qualitative research methods**
  - Methods involving case studies and surveys
  - Stemming from social sciences
  - Concerned with increasing understanding of an area, rather than an explanation
  - Repeatability usually a problem
Research methods (1)

- **Action research:**
  - Pursues action (or change) and understanding at the same time
  - Continuously alternates between action and critical reflection, while refining methods, data and interpretation in the light of the understanding developed in the earlier cycles

  **Example:** Reflective teaching

- **Case study:**
  - In-depth exploration of a single situation
  - Usually generates a large amount of (subjective) data
  - Should not merely report the data obtained or behaviour observed but attempt to generalise from the specific details of the situation observed

  **Example:** Case study of open source software development
Research methods (2)

- **Survey:**
  - Usually undertaken using questionnaires or interviews
  - Questionnaire and interview design important!
    (See Dawson 2005 for details)
  - Determination of sample size and sample elements important!
    (See specialist literature for details)

**Example:** Survey on the popularity or use of programming languages

- **Experiment:**
  - Investigation of causal relationships using test controlled by the researcher
  - Usually performed in development, evaluation and problem solving projects

**Example:** Evaluation of processor performance
Key elements of an experiment

- A precise **hypothesis** that the experiment will confirm or refute
- A completely specified **experimental system**, which will be modified in some systematic way to elicit the effects predicted by the hypothesis
- Quantitative **measurement** of the results of modifying the experimental system
- Use of **controls** to ensure that the experiment really tests the hypothesis
- **Analysis** of the measured data to determine whether they are consistent with the hypothesis
- **Report** of procedures and results so that others can replicate the experiment
Key issues for questionnaires

Consider the following questions

- What are the key issues for conducting a survey by questionnaire?
- Regarding the questionnaire itself, what types of questions do you know and what is each of them used for?

(7 minutes group discussion)
Key issues for questionnaires

- Determining the **target audience**
- Determining the most appropriate **medium**
- Achieving an acceptable **response rate**
- Ensuring **anonymity** if necessary
- Obtaining additional information about the **respondents**

**Questionnaire design**
- Layout and size (not too long, uncluttered)
- Question types
  1. Quantity or information
     - How many hours ...
  2. Classification
     - Gender
  3. List or multiple choice
     - How do you keep informed?
  4. Scale
     - How easy is ...
  5. Ranking
     - Rank in order of importance
  6. Complex grid or table
     - Multiple classifications
  7. Open-ended
     - What do you think about ...