Hochschule für Angewandte Wissenschaften Hamburg
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Sketch Recognition

AW2 Colloquium by Hauke Wittern 28.05.2009

Agenda

- Introduction
  - Vision
  - Definition of sketch recognition
- Research on sketch recognition
  - Today's sketch recognition systems
  - Recent research topics
  - Using and recognizing sketches in software development
- Differentiation and relevance of related work
- Summary

Vision: Sketching of software models and prototypes on multitouch-tables

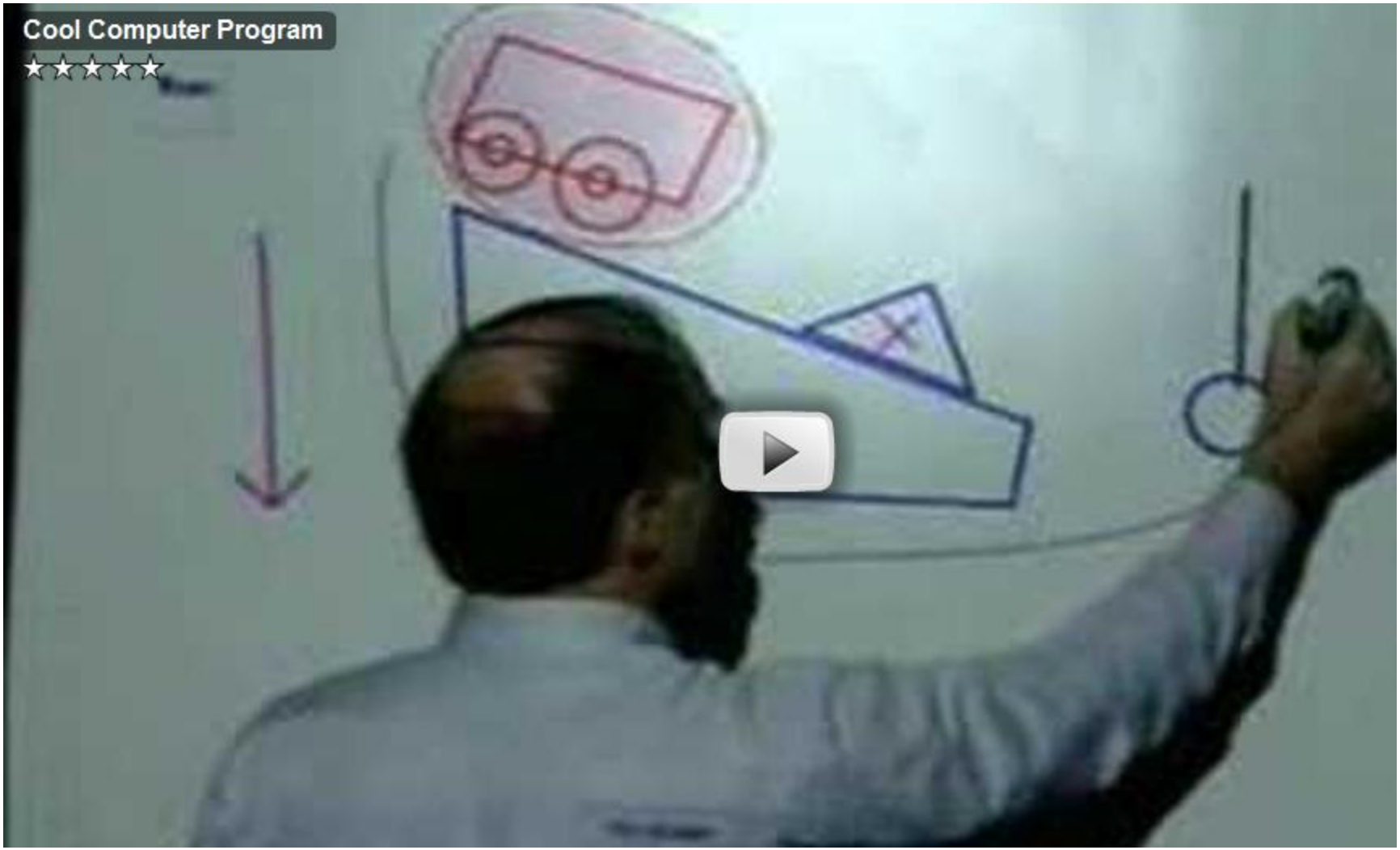
- Improve software engineering with multitouch-tables
- Freehand sketching of software models (UML etc.)
- Recognize sketches for
  - Prototyping
  - Simulation

Definition: Sketch Recognition

- “Sketch recognition is the automated understanding of a drawn diagram, attempting to recognize the intent of the user while allowing the user to draw unconstrained diagrams.” (Tracy Hammond, [1])

Example video

ASSIST: A Shrewd Sketch Interpretation and Simulation Tool



Source: http://www.youtube.com/watch?v=d7eGypGOlOc

Benefits of digital sketches

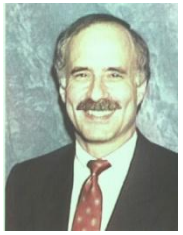
- Natural way of devising and communicating ideas
- More effective than diagram tools with mouse etc.
- No constraints

- Digital sketches support rich features:
  - editing
  - searching
  - layout
  - archiving

Today’s sketch recognition systems

Research Groups with most influence on today's Sketch Recognition systems

- Randall Davis, Massachusetts Institute of Technology



- Tracy Hammond, Texas A&M University (former MIT)

- Christine Alvarado, Harvey Mudd College (former MIT)

- Beryl Plimmer, University of Auckland

Single-Domain vs. Multi-Domain Sketch Recognition

- Single-Domain Sketch Recognition System: limited to he recogniton of a *specific domain*
  - Tahuti (UML Class Diagrams) (by Hammond and Davis 2002)

- Generic Multi-Domain Sketch Recognition System: Can be trained to recognize sketches from *any domain*
  - SketchREAD (by Alvarado and Davis 2005)
  - InkKit (by Plimmer et al. 2007)
  - DSketch (Brieler and Minas 2008)

Vision based vs. geometry based vs. gesture based recognition algorithms

Different approaches to recognize Sketches:

- Vision based (InkKit)
  - recognize shapes by what they look like
  - Template matching
- Geometry based (Tahuti, SketchREAD, DSketch)
  - Break down shapes into primitives
- Gesture based (SUMLOW ([4] 2003))
  - recognize shapes by how they are drawn
  - Single stroke paths are compared to templates

Incremental vs. complete recognition

- Complete recognition
  - Recognition is performed
    - on demand (e.g. InkKit) or
    - after idle time (e.g. SUMLOW)
  - Restricts the user

- Incremental / continuous recognition (e.g. SketchRead):
  - Recognition is performed after a stroke is drawn
  - More difficult to implement
    - The system must know when to wait for more information
  - Long recognition time might interrupt the user

Shape Definition Language vs. training with examples

Two methods to define the shapes in a domain:

- Shape Definition Language
  - E.g. LADDER, SkG, Xml (DSketch, [3])
- Training with examples
  - E.g. InkKit
  - Easy and quick development

Tradeoff between natural input and constrained sketches

- Sketching on Paper is a natural activity with no constraints
- Sketching on an electronic device is potentially as natural as on paper

- Problem:
  - unconstrained sketches are difficult to recognize
  - constrained sketching is not natural

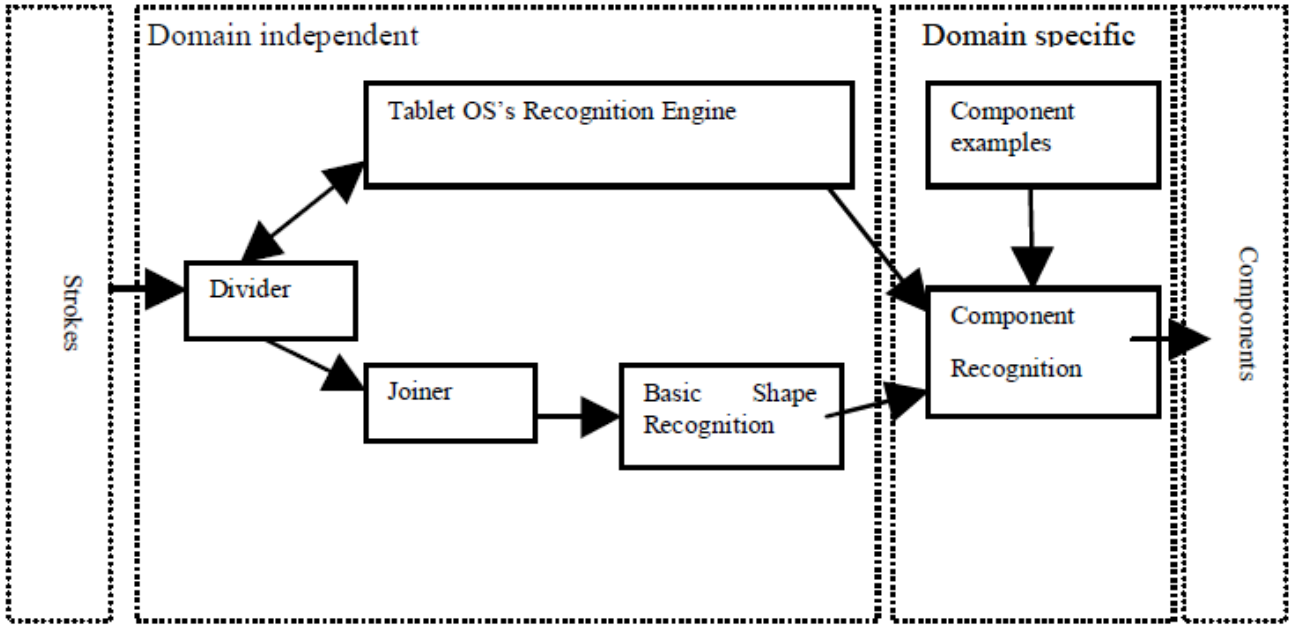
- Consequence:
  - Allow ambiguities and resolve them

Resolving ambiguities and error recovery

- Calculate probability of ambiguous interpretations
- Approaches to resolve ambiguities
  - Use diagram wide probabilities (InkKit)
  - Use context, semantic and syntactic information (SketchREAD, [Brieler and Minas])

Recognizing text – Approach by Plimmer & Freeman

- Idea: separate recognition of text and drawings
- Divider component
  - Analyzes strokes
  - Assigns each stroke a probability if it is a letter



Recent Resarch Topics

Collaborative Input on a single sketch

- Whose stroke is whose?
- Advantages:
  - Improved sketch recognition
  - Collaboration:
    - Correct drawing history
    - Enables users to ask the contributor what he intended
    - Documentation: who contributed what part

Collaborative Input on a single sketch - Approach by Eoff and Hammond [2]

- Differentiate users by tilt, pressure and speed
- Results:
  - The manner a user sketches is fairly consistent
  - Sketching mannerisms are distinct from user to user
  - Strokes can be classified with high accuracy

Collaborative Input on a single sketch - Approach by Eoff and Hammond [2]

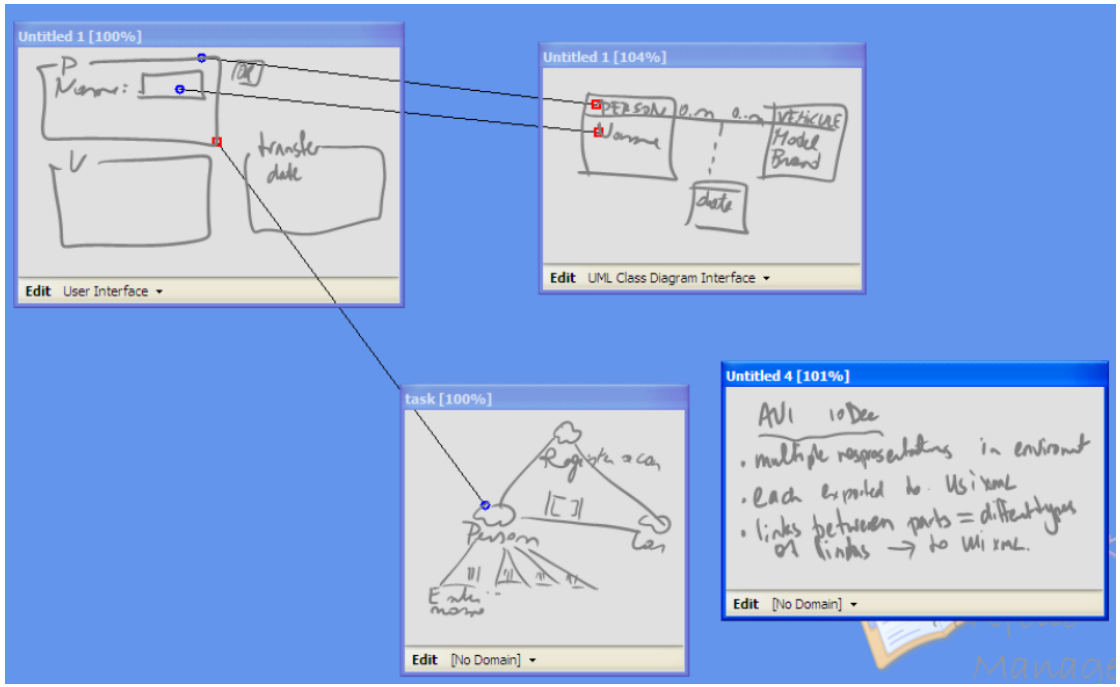
- Future Work:
  - Additionally use context information for identifying the creator of a stroke
  - User studies on more domains

Cross-Domain Sketch Recognition

- Scenario:
  - People are sketching different views of a system
  - The sketches are from different domains (e.g. ER, Classdiagram, Gui, Petri net, …)
  - The sketch recognition system interprets the sketches and its relationships correctly
  - This enables code generation or simulation

Cross-Domain Sketch Recognition

- Implementation by Plimmer et al.
  - Relationships between diagrams are expressed by connecting the elements with rubberbands



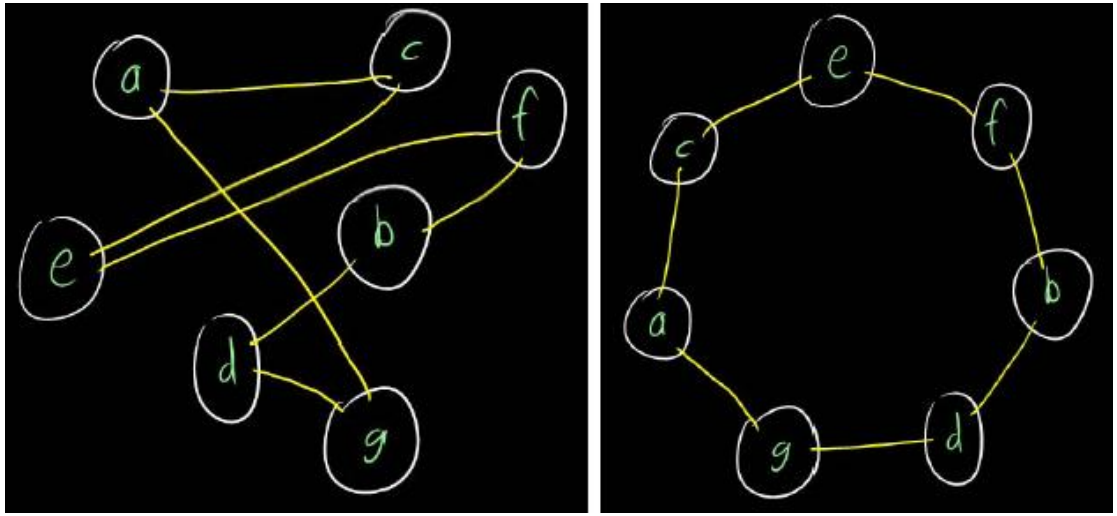
Cross-Domain Sketch Recognition

Two possible implementations of the interpreter proposed by Plimmer et al.:

- Information carrier (shared object)
  - Easy to implement
  - Implementation order must be predifined
  - Interpretation of each diagram only once therefore the required information may be not available
- Communication protocoll
  - Information on demand
  - Implicit coordination of the interpretation order

Applying Layout Algorithms

- Diagrams with optimized aesthetics are easier to read and understand (crossing edges, symmetry, …)
- Goal: transform the diagram while preserving its informal character



Applying Layout Algorithms – Approach by Reid, Plimmer et al.

- Existing layout algorithms are used for positioning elements
- Edge morphing is used to maintain the informal character of the edges
  - Compress or stretch
  - Maintain normal incidence angles
  - Maintain appearance intersections

- Problem:
  overstretched edges are looking like a formal line

Applying Layout Algorithms

- Open questions:
  - How to remain much of the users drawing style?
  - Evaluate the effects on the users when applying layout algorithms
  - Compare hand-drawn, optimized and formal graphs

Usability of Sketch Recognition Systems

- How to create an ergonomic sketching UI?
  - How to trigger recognition
  - How to give recognition feedback
  - How to inform users about recognition errors

Usability of Sketch Recognition Systems

- Results by Alvarado et al. [5]:
  - Recognition triggers should be user-triggered
  - Recognition feedback should provide minimal clutter and transform users' strokes as little as possible.
  - Users are willing to correct errors after they are done drawing
  - Errors must be predictable and/or understandable

Using and recognizing sketches in software development

Using and recognizing sketches in early phases of software development

- Modelling Tools:
  - Tahuti
  - SUMLOW
  - Calico
- Sketching is prefered over traditional uml tools

Using sketches in early phases of software development

- The kind of modeling in early design phases differs from modeling in later stages
- In early design phases Models are
  - exploratory
  - incomplete
  - informal
  - of mixed abstraction levels
- According to Mangano et al. software engineering can therefore benefit from sketching tools

Differentiation and relevance of related work

Differentiation from my work

- Primary objective of my work differs:
  - How to improve software engineering with multitouch tables?
  - Can sketch tools make modeling easier? How?
- Different hardware with different capabilities: multitouch table instead of whiteboard or tablet pc
  - No experiences with sketching on multitouch tables yet
  - How well does sketching on multitouch tables work?
  - What are the differences?
  - What do we have to take into consideration?

Relevance of related work

- Results of the research on sketch recognition engines is the basis for developing a sketch tool for multitouch tables
- Results of the research on collaborative input, usability of sketch tools and layout algorithms must be taken into account to ensure the usability and suitability

Relevance of related work

- Studies substantiate that sketching tools can improve software development. Thus my future research about sketching software models on multitouch tables is promising
- The research on Cross-Domain Sketch Recognition is important for simulation and prototyping

Summary

Summary

- Today's sketch recognition systems
  - can reliably recognize sketches from multi domains
  - are a basis for future sketch recognition systems
- Research currently focuses on
  - Improving reliability and usability
  - Collaboration
- Research on sketching in software development should be intensified

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