

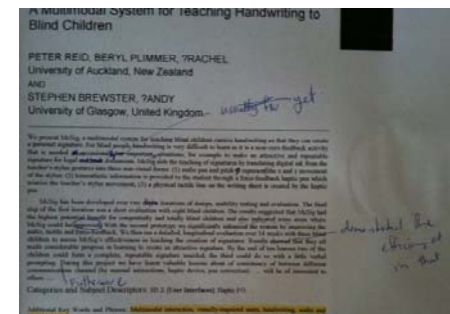
Pen-based Computer Interaction: Opportunities and Challenges

Beryl Plimmer
University of Auckland

March 2010

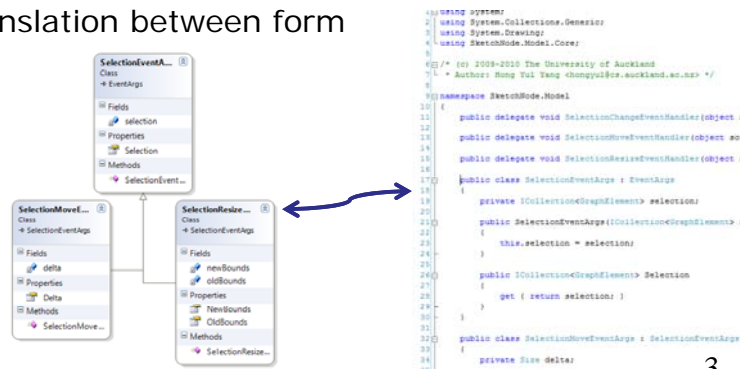
Paper is wonderful

- It's physical
- You can annotate it
- There are no rules!



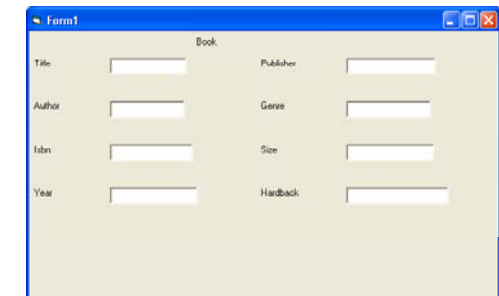
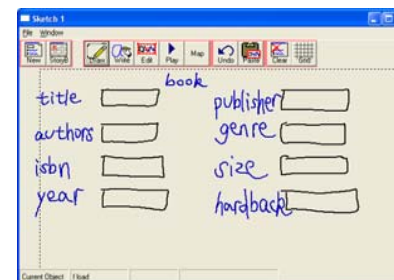
Computers are wonderful

- Editing is easy
- Archiving, email, sharing
- Translation between form



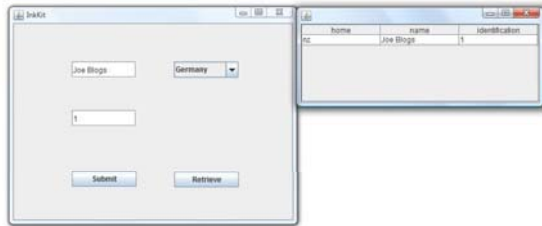
Fidelity of Presentation makes a difference

- These two designs are the same (bad) solutions to a problem
 - Sketch 8.6 changes
 - VB Form 6.5 changes



Translation

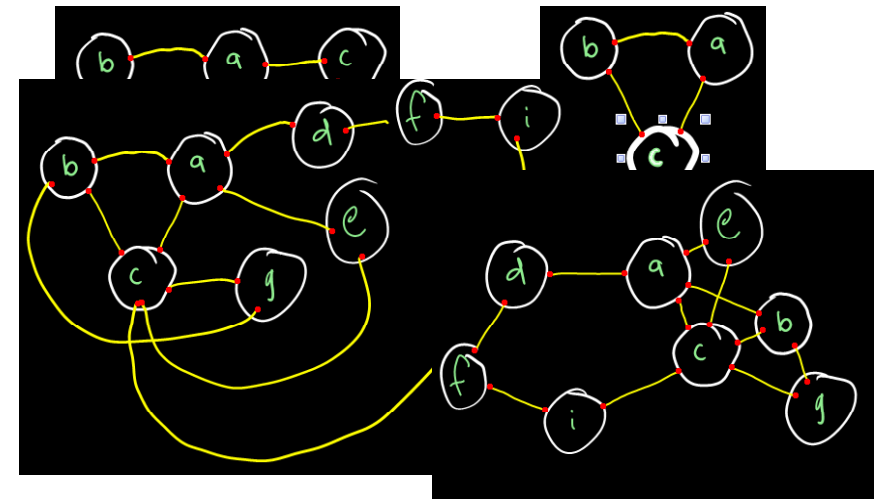
- User interface sketch -> form
- And
- ER diagram sketch -> database



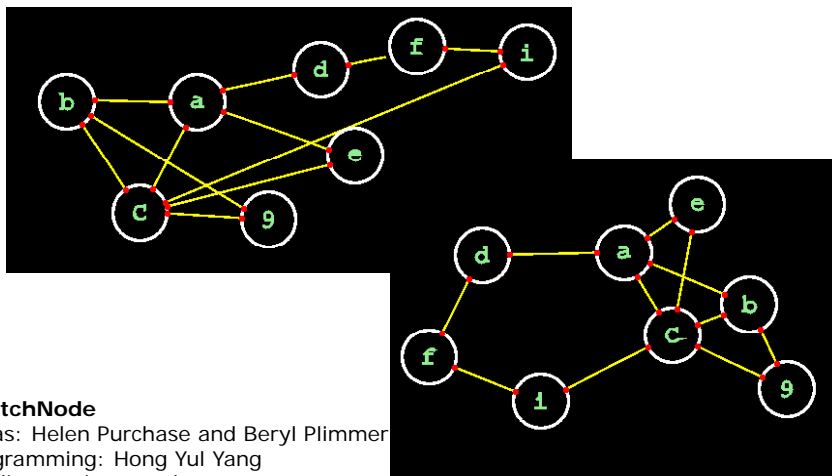
Schmieder, P., Plimmer, B., Vanderdonck, J., Generating Systems from Multiple Sketched Models, *Journal of Visual Languages & Computing*, 21, 2, (2010),

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Intelligent editing support



Maintain a formal visualization



SketchNode

Ideas: Helen Purchase and Beryl Plimmer
Programming: Hong Yul Yang
Studies: various students

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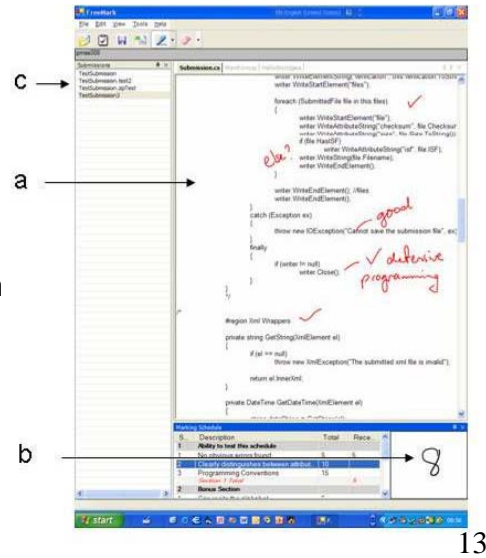
Overview

- Applications
 - Sketching
 - Annotating
 - Fully integrated
- Under the bonnet
 - Recognition
 - Ink anchoring and reflow
 - Interaction basics
- Wider application

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Penmarked

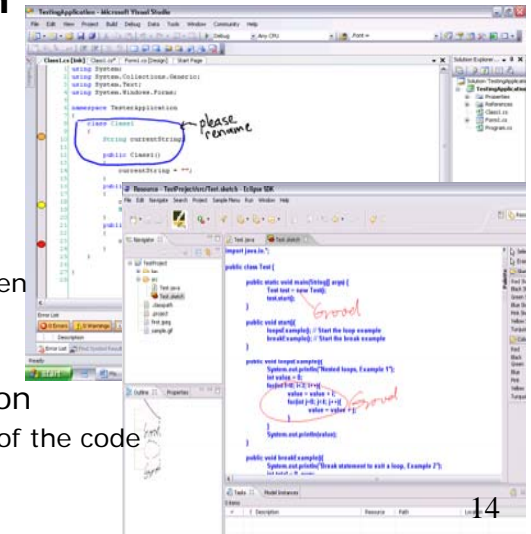
- Static documents
- Workflow support
- Minimal recognition



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IDE Annotation

- Visual Studio
Richard Priest
- Eclipse
– Xiaofan (Emily) Chen
- Significant limitation
– Annotating a copy of the code



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Web annotation

- The dream
 - Annotate any web page, save the annotation on a server, share annotations
 - The reality
 - Browser security doesn't let you do it!
- Either
- specifically designed web sites
- Or
- copy the web page



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Overview

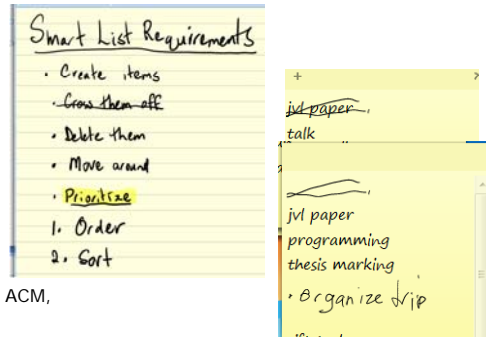
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Seamlessly Mixing Ink and Text

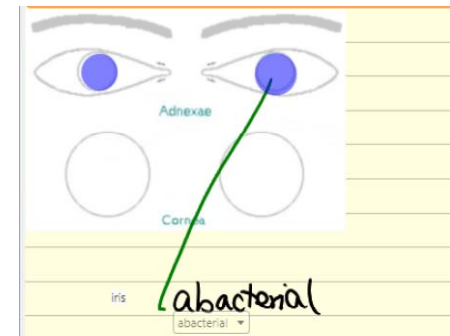
- There are no tools that do this justice.
 - MS word
- A 'To Do' list

Effect of beautification (modification and standardizing sizes) in the context that people performed better with the most formal representation. Bailey et al. [3] compared their sketch tool with a multi-media representation. Bailey et al. [3] compared their sketch tool with a multi-media representation.



Wang, T., Plimmer, B., SmartList: exploring intelligent hand-written list support, CHINZ, ACM, (2009), 61-64

Mixing Ink and Images



Nilanthi Seneviratne (2010)

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Digital ink recognition

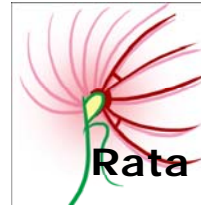
- Character recognition
 - Built into Windows Operating System
 - Uses dictionaries to reduce search space
- Drawing ink
 - Active area of research

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Our approach to diagram recognition

- Separate Writing and Drawing (divider) → 
- Recognize individual strokes → 
- Join strokes into basic shapes → 
- Join basic shapes to make components → 
- Apply semantics to understand diagrams.

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Rata Composed Recognizers

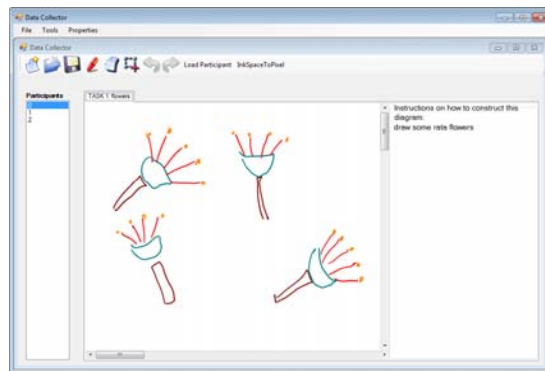
- Sample diagrams
- Extract ink features
- Build a 'model' for the recognizer using Data manager interface to Weka
- Software component recognizer

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Collect and label sample data

- About 15 examples of each class (type to be recognized)
- This set is
 - 3 people
 - X 4 flowers



Data Manager








Blagojevic, R., Plimmer, B., Grundy, J., Wang, Y., A Data Collection Tool for Sketched Diagrams SBIM, EG, (2008)

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Extract features

- For each stroke we calculate 119 features of each ink stroke
 - Categories

1. Curvature (e.g. the line above has a greater curvature than the line below). 	6. Pressure (measure the pressure applied to the screen when drawing a stroke. Pressure is dependent on the capabilities of the hardware). 
2. Density (e.g. the text has larger density of points than the shape). 	7. Size 
3. Direction (this is related to the slope of the stroke). 	8. Spatial context (with sub categories: curvature, density, divider results, intersections, location and size).
4. Divider Results (these features provide the results of text/shape divider algorithms). 	9. Temporal context (with sub categories: curvature, density, divider results, length, location/distance and time/speed).
5. Intersections (e.g. the diagram shows intersecting strokes). 	10. Time / speed (includes total, average, maximum and minimum times or speed).

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Data manager interface to weka

Feature file

Algorithm or ensemble

Test file

Model

Manual test

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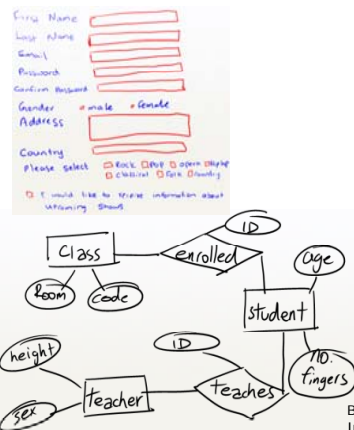
Using the recognizer component

- Load it


```
inkPanelClassifier = ClassifierCreator.GetClassifier (
                "C:\\Users....rata.model");
```
 - Pass ink strokes


```
string result = inkPanelClassifier.classifierClassify(
                myDrawingInk.Ink.Strokes,
                myDrawingInk.Stroke[i]);
```
- ```
if (result.Equals("stem"))
 myDrawingInk.Stroke[i].Color.BurlyWood;
else
```

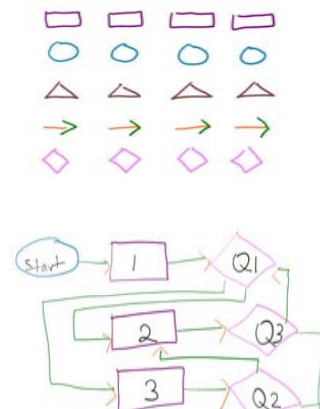
## Recognition rates - Divider



| Divider         | % Correct | % Text | % Shapes |
|-----------------|-----------|--------|----------|
| <b>New</b>      |           |        |          |
| LADTree         | 95.2      | 98.3   | 88.5     |
| LogitBoost      | 95.0      | 98.1   | 88.4     |
| <b>Existing</b> |           |        |          |
| Our Old Divider | 86.9      | 93.1   | 73.5     |
| Entropy         | 83.3      | 98.7   | 50.5     |

Blagojevic, R., Plimmer, B., Grundy, J., Wang, Y., Building Digital Ink Recognizers using Data Mining: Distinguishing Between Text and Shapes in Hand Drawn Diagrams, in proc IEA-AIE 2010, (2010), in press

## Recognition rates



| Algorithms                  | ShapeData |       | FlowChart |       | Avg  |
|-----------------------------|-----------|-------|-----------|-------|------|
|                             | 1-10      | 11-20 | 1-10      | 11-20 |      |
| <b>Our Recognizers</b>      |           |       |           |       |      |
| Ensemble (best 3)           | 96.6      | 97.5  | 99.4      | 99.7  | 98.0 |
| Bayes Net                   | 94.1      | 97.9  | 98.5      | 99.1  | 96.9 |
| Logic Boost                 | 91.2      | 97.9  | 99.1      | 97.9  | 96.0 |
| Bagging                     | 93.3      | 97.5  | 93.1      | 94.3  | 94.9 |
| <b>Existing Recognizers</b> |           |       |           |       |      |
| PaleoSkeleton               | 92.9      | 96.3  | 93.7      | 88.4  | 89.7 |
| S1                          | 85.0      | 85.8  | 80.2      | 85.3  | 86.3 |
| CALI                        | 83.3      | 84.1  | 88.9      | 79.4  | 83.5 |
| DTW                         | 80.4      | 82.9  | 76.3      | 77.6  | 81.5 |
| Microsoft Recogniser        | 40.0      | 40.0  | 14.9      | 15.2  | 24.8 |
| Average (Exclude MS)        | 86.3      |       | 83.7      |       |      |



## So Far

- Divider (Rachel Blagojevic)
- Single stroke recognizers (Sam Chang)
  - Both at final tuning stage
- Enabling tools – data collection, labeling, recognizer evaluation, weka interface, software component generation
- Next
  - Using divider and SSR together
  - Joiner for multi stroke basic shapes
  - Spatial features for putting components together and relationships between features

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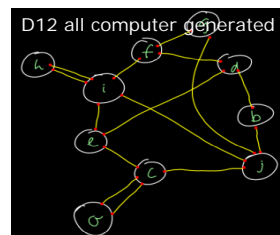
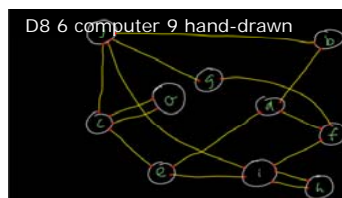
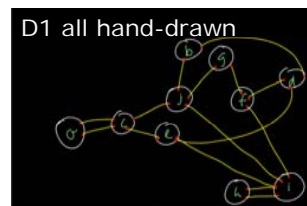
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## In sketches

- Which of these ink strokes were computer generated?
- Why do we care?

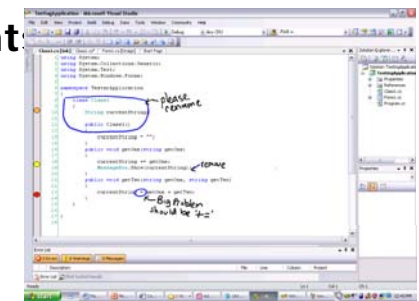


Plimmer, B., Purchase, H., Yang, H. Y., Laycock, L., Preserving the Hand-drawn Appearance of Graph, in proc Visual Languages, (2009), 347-352

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## On text document

- Needs accurate grouping
- Good attachment points
- More studies on how to handle messy situations
  - Split annotations



```
System.out.println("Test");
//1d
//2d
//3d
//4d

//9d
//10d
//11d
//12d
//13d
//14d
```

*Good*

*Grass*

$ab < a'b'$

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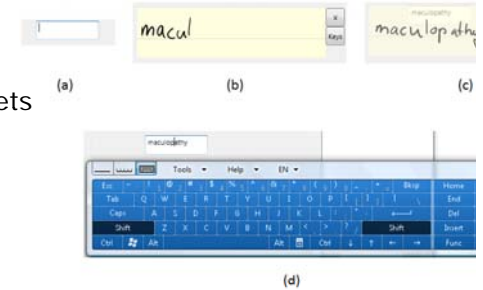
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## Pen interaction is *touchy*

- We tried 9 versions of this textbox
  - When to activate the writing panel (air packets or tap)
  - When to close, tap or time
  - When to recognize
  - Are extra dictionaries effective
  - When/where to display keyboard



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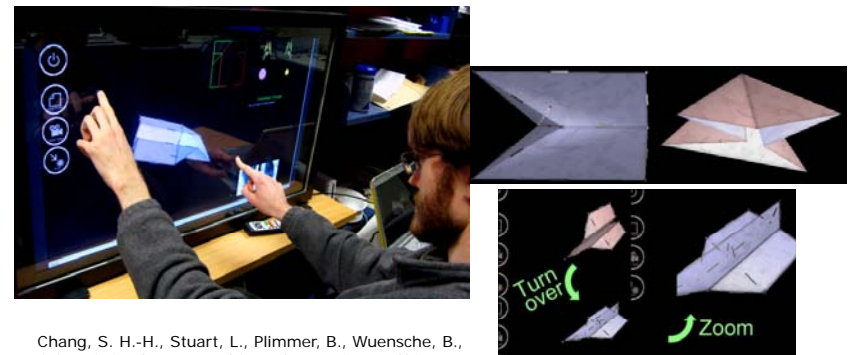
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## Touch and Multi-touch Screens

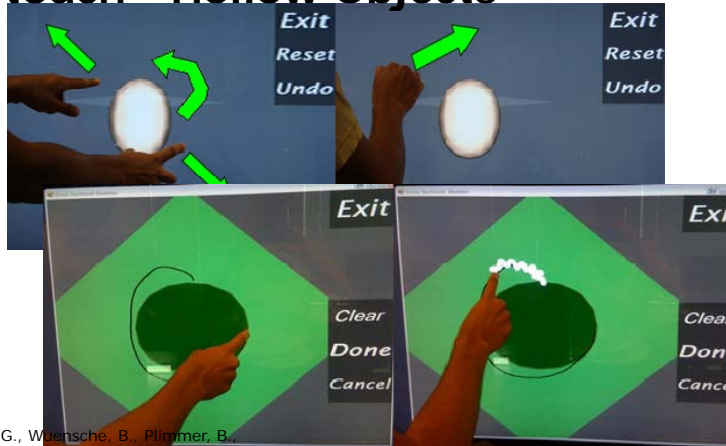
- Origami



Chang, S. H.-H., Stuart, L., Plimmer, B., Wuensche, B.,  
Origami simulator: a multi-touch experience, Chi 09,  
ACM, (2009), 3889-3894

36

## Multi touch - Hollow Objects



Joshi, A., Robertson, G., Wiersche, B., Plimmer, B.,  
Bubbleworld builder - 3D modeling using twotouch and  
sketch interaction, in proc 5rd International Conference  
on Computer Graphics Theory and Applications (GRAPP  
2010), (2010), in press

37

## Tablet and Haptics



Plimmer, B., Crossan, A., Brewster, S., Blagojevic, R., Multimodal collaborative  
handwriting training for visually-impaired people, in proc Chi2008, ACM, (2008),  
393-402

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## Ways forward

- Better recognition is a must have!
- Core software components ink aware (WPF helpful)
- Lots of creative design
- Lots of usability testing

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## Finally

- Thank you
- Questions?
- More detail

<http://www.cs.auckland.ac.nz/research/hci/>