

# CAP 6105 Pen-Based User Interfaces

Fall 2015

<http://www.cs.ucf.edu/courses/cap6105/fall2015/>

**Instructor:** Joseph J. LaViola Jr.

**Office:** Engineering III Room 383

**Hours:** Tues. 4:00pm-5:30pm

Wed. 6:00pm-7:00pm

**Pen Computing Lab:** Engineering III 208

**Email:** [jjl@eecs.ucf.edu](mailto:jjl@eecs.ucf.edu)

If you want to email me, MAKE SURE to enter in the subject line “**cap6105**” followed by **your name**.

## Course Objective and Topics

Pen-Based User Interfaces is a course designed to give students a thorough understanding of the latest techniques, algorithms, and evaluation methodologies used in designing and developing pen-, sketch-, touch-, and gesturally-based user interfaces. In addition to reading and presenting research papers, students will write several programs to reinforce concepts discussed in class and will produce a final project of their choice.

General Topics include:

1. Introduction and History of Pen- and Sketch-computing
2. C#, Visual Studio, and Windows Presentation Foundation
3. Ink Preprocessing
4. Gestural User Interfaces
5. Ink Segmentation
6. Classification Algorithms for Recognizing Ink
7. 2D Parsing
8. Sketch and Multi-touch based Interfaces
9. Evaluation Methodologies

# Syllabus

## Week 1

August 24, 2015 – Lecture - Introduction to Pen-based UIs

- go over course mechanics
- discuss the history pen computing
- present some challenges with pen computing
- present various applications

### *Readings*

Sutherland, I. SketchPad: A Man-Machine Graphical Communication System, Proceedings of AFIPS Spring Joint Computer Conference, 329-346, 1963.

Blackwell, F. and R. Anderson. An on-line symbolic mathematics system using hand-printed two-dimensional notation. Proceedings of the 1969 24<sup>th</sup> National Conference, 551-557, 1969.

Herot, C. Graphical Input Through Machine Recognition of Sketches, Proceedings of SIGGRAPH'76, 97-102, 1976.

August 26, 2015 – Talk about final projects Papers discussion

## Week 2

August 31, 2015 – Lecture - Visual Studio, C#, Tablet PC SDK

September, 2, 2015 – Lecture - Windows Presentation Foundation

### *Readings*

Nathan, A. *WPF 4.5 Unleashed*, Sams, 2013.

## Week 3

September 7, 2015 – Holiday – No Class

### **Assignment 1 Out**

September 9, 2015 – Lecture - Ink Preprocessing & Simple Features

- data representation
- filtering
- transformation invariance
- dehooking, cusps, and self intersections

## Readings

Wolin, A., Eoff, B., and Hammond, T. ShortStraw: A Simple and Effective Corner Finder for Polylines. *Eurographics 5th Annual Workshop on Sketch-Based Interfaces and Modeling*, Annecy, France, June, 2008, pp. 33-40.

Xiong, Y. and LaViola, J. Revisiting ShortStraw – Improving Corner Finding in Sketch-Based Interfaces, *Proceedings of the Sixth Eurographics/ACM Symposium on Sketch-Based Interfaces and Modeling 2009*, 101-108, August 2009.

Herold, J. and Stahovich, T. SpeedSeg: A Technique for Segmenting Pen Strokes Using Pen Speed *Computers and Graphics, Volume 35, Issue 2*, 2011, pp. 250-264

## **Week 4**

September 14, 2015 – Papers discussion

September 16, 2015 – Lecture - Gestural User Interfaces

- in computer graphics/modeling
- gesture structure - 1 or multi-stroke
- gesture invocation - buttons & button placement
- gesture learning - existing notations, tutorial, embedding in GUIs
  - visual (pre & post) feedback
- FSAs
- punctuated gestures

**Assignment 1 due Assignment 2 out**

## Readings

Zelevnik, R., K. Herndon, and J. Hughes. SKETCH: An Interface for Sketching 3D Scenes. *Proceedings of SIGGRAPH'96*, ACM Press, 163-170, 1996.

Igarashi, T., S. Matsuoka, and H. Tanaka. Teddy: A Sketching Interface for 3D Freeform Design. *Proceedings of SIGGRAPH'99*, ACM Press, 409-416, 1999.

Hinckley, K., Yatani, K., Pahud, M., Coddington, N., Rodenhouse, J., Wilson, A., Benko, H., and Buxton, B. Pen + Touch = New Tools. In *Proc. UIST 2010 Symposium on User interface Software and Technology*, 27-36, October 2010.

Zelevnik, R., Bragdon, A., Adeputra, F., and Ko. H. Hands-On Math: A Page-based Multi-touch and Pen Desktop for Technical Work and Problem Solving. In *Proceedings of the 23rd Annual Symposium on User Interface Software and Technology (UIST 2010)*, 17-26, October 2010.

## Week 5

September 21, 2015 – Papers discussion

September 23, 2015 – Lecture - Ink Segmentation  
-- spatial segmentation  
-- temporal segmentation

### *Readings*

Gennari, L., L. Kara, and T. Stahovich. Combining geometry and domain knowledge to interpret hand drawn diagrams, *Computers and Graphics*, 29(4):547-562, 2005.

Herold, J., and Stahovich, T. ClassySeg: A Machine Learning Approach to Automatic Stroke Segmentation. In *Proceedings of the Eighth Eurographics/ACM Symposium on Sketch-Based Interfaces and Modeling 2011*, 109-116, August 2011.

Tevfik Metin Sezgin and Randall Davis. Sketch Interpretation Using Multiscale Models of Temporal Patterns. In *IEEE Journal of Computer Graphics and Applications*, Volume: 27, Issue: 1, pp: 28-37, 2007.

## Week 6

September 28, 2015 – Papers discussion

September 30, 2015 – Lecture - Classification Algorithms for Recognizing Digital Ink (Part 1)  
-- Feature Extraction

**Assignment 2 due Assignment 3 out**

## Week 7

October 5, 2015 – Lecture - Classification Algorithms for Recognizing Digital Ink (Part 2) -- Classifiers  
-procedural, template matching  
-linear classifiers  
-SVMs  
-K-nearest neighbor  
-AdaBoost

### *Readings*

LaViola, J., and Zeleznik, R. "A Practical Approach to Writer-Dependent Symbol Recognition Using a Writer-Independent Recognizer", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 29(11):1917-1926, November 2007.

Rachel Blagojevic, R., Chang, S., and Plimmer, B. The Power of Automatic Feature Selection: Rubine on Steroids, In *Proceedings of the Seventh Eurographics/ACM Symposium on Sketch-Based Interfaces and Modeling 2010*, 79-86, June 2010.

Wobbrock, J. O., Wilson, A. D., and Li, Y. 2007. Gestures without libraries, toolkits or training: a \$1 recognizer for user interface prototypes. In *Proceedings of the 20th Annual ACM Symposium on User interface Software and Technology UIST '07*. ACM, New York, NY, 159-168.

Li, Yang 2010. Protractor: a fast and accurate gesture recognizer. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*. ACM, New York, NY, USA, 2169-2172, April 2010

October 7, 2015 – Papers discussion

### **Week 8**

October 12, 2015 – Lecture - Parsing Ink

- parsing mathematics
- multi-stage
- parsing drawings
- parsing diagrams
  - 2D grammars
  - graph rewriting
  - procedurally coded syntax rules
  - stochastic grammars

**Assignment 3 due Assignment 4 out**

#### *Readings*

D. Blostein and A. Grbavec, "Recognition of Mathematical Notation," in Handbook of Character Recognition and Document Image Analysis, Eds. H. Bunke and P. Wang, World Scientific, 1997, pp. 557-582.

Chan, Kam-Fai and Dit-Yan Yeung. An Efficient Syntactic Approach to Structural Analysis of On-Line Handwritten Mathematical Expressions. *Pattern Recognition*, 33(3):375-384, March 2000.

Ye, Ming, and Paul Viola. Learning to Parse Hierarchical Lists and Outlines Using Conditional Random Fields. *International Workshop on Frontiers in Handwriting Recognition*, 2004.

Taranta, E. and LaViola, J. "Math Boxes: A Pen-Based User Interface for Writing Difficult Mathematical Expressions", *Proceedings of the 2015 ACM International Conference on Intelligent User Interfaces (IUI 2015)*, 87-96, March 2015.

October 14, 2015 – Papers discussion

### **Week 9**

October 19, 2015 – Lecture - Sketch-based Interfaces and Understanding

- multi-domain sketch understanding frameworks

#### *Readings*

LaViola, J. and Zeleznik, R. "MathPad2: A System for the Creation and Exploration of Mathematical Sketches", *ACM Transactions on Graphics (Proceedings of SIGGRAPH 2004)*, 23(3):432-440, August 2004.

Christine Alvarado and Randall Davis. SketchREAD: A Multi-Domain Sketch Recognition Engine. In *Proceedings of UIST 2004*, pp.23-32. New York, New York, October 24-27 2004.

Lockwood, K., Lovett, A., Forbus, K., Dehghani, M., and Usher, J. Automatic Interpretation of Depiction Conventions in Sketched Diagrams. *Proceedings of the Eurographics Workshop on Sketch-Based Interfaces and Modeling*, 167-174, 2008.

Hammond, T., and R. Davis. Ladder: A Sketching Language for User Interface Developers, *Computers and Graphics* 29, 518-532, 2005.

October 21, 2015 – Papers discussion

### **Week 10**

October 26, 2015 – Lecture - Evaluation Methodologies

- user studies
- qualitative vs. quantitative
- summative vs. formative

#### **Assignment 4 due**

#### *Readings*

LaViola, J. "An Initial Evaluation of a Pen-Based Tool for Creating Dynamic Mathematical Illustrations", In the proceedings of the Eurographics Workshop on Sketch-Based Interfaces and Modeling 2006, 157-164, September 2006.

LaViola, J., Leal, A., Miller, T., and Zeleznik, R. "Evaluation of Techniques for Visualizing Mathematical Expression Recognition Results", *Proceedings of Graphics Interface 2008*, 131-138, May 2008.

Bragdon, A., Zeleznik, R., Williamson, B., Miller, T., and LaViola, J. "GestureBar: Improving the Approachability of Gesture-based Interfaces", *Proceedings of ACM CHI 2009*, 2269-2278, April 2009.

October 28, 2015 – Papers discussion

#### **Project proposals due**

### **Week 11**

November 2, 2015 – Student paper presentations

#### **Project proposal decisions made**

November 4, 2015 – Student paper presentations

### **Week 12**

November 9, 2015 – Project status updates

November 11, 2015 – Veteran's Day, No class

### **Week 13**

November 16, 2015 – Student paper presentations

November 18, 2015 – Project status updates

### **Week 14**

November 23, 2015 – Student paper presentations

November 25, 2015 – No Class

**Week 15**

November 30, 2015 – Project status updates

December 2, 2015 – Student paper presentations

**Week 16**

December 7, 2015 – Project status updates

December 14, 2015 – **DEMO DAY!!!**

## Collaboration Policy

Students must do their own work but are encouraged to collaborate with others in the form of discussion of concepts and implementation details pertaining to Visual Studio, C#, and Windows Presentation Foundation. For final projects, teams of up to two students are encouraged.

## Assignments

**Paper Presentations** – Students will have to present 1-2 papers of their choice, outside of the assigned readings and give a 25 minute presentation on it.

**Guided Discussion** – During the paper discussion sections, students will lead the discussion on a particular paper that was assigned in class.

## Programming Assignments

1. Intro – Students will replicate Windows Journal to get them acclimated to Visual Studio, C#, Windows Presentation Foundation, and pen and multi-touch input. This application will also be a test bed for the other assignments in the course.
2. 2D SKETCH – Students will develop a 2D shape recognition program to create and manipulate circles, rectangles, squares, and triangles. Students will explore how to best combine pen and multi-touch input for the various operations needed. The focus of the assignment will be on heuristic gesture recognition.
3. Math Symbol Recognizer (Research Contest) – Students will compare Anthony and Wobbock's \$N symbol recognizer with a modified version of Taranta et al.'s Penny Pincher algorithm and try to improve overall recognition accuracy for both pen and touch data.
4. Pen Calculator – Using the math symbol recognizer created in assignment 3, students develop a pen-based calculator that will recognize and evaluate mathematical expressions. Students will use both pen and multi-touch input for different parts of this assignment.

## 5. Final Project

Students will do a final project of their choice that explores a particular concept in pen-, sketch-, or multi-touch-based user interfaces. They must first write a short proposal and get it approved by the professor.

## Tentative Grading Scheme:

Assignment 1	10%
Assignment 2	10%
Assignment 3	10%
Assignment 4	10%
Paper discussions	5%
Paper presentations	5%
Final Project	50%

The instructor reserves the right to use plus/minus grading in this course.