ECPS 203
Embedded Systems Modeling and Design
Lecture 12

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Lecture 12: Overview

- Course Administration
  - Midterm course evaluation, results
- Project Discussion
  - Status and next steps
- Assignment 5
  - Test bench model of the Canny Edge Detector
- Assignment 6
  - Structural refinement of the DUT module
    - Model development on the whiteboard
  - Profiling of the Canny Edge Detector functions
    - Discussion

Course Administration

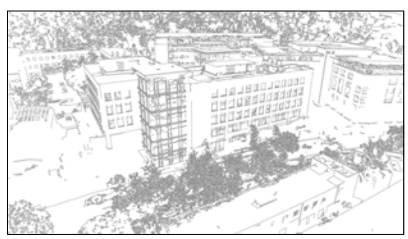
- Midterm Course Evaluation: Results
  – 6 out of 17 responses: indicative, but not representative
  – Very positive feedback
  – Few suggestions for changes
  – Very good scores
  – Letter grade "A"

  ➢ Thank you!

ECPS 203 Project

- Application Example: Canny Edge Detector
  – Embedded system model for image processing:
  Automatic edge detection in a video camera of a drone

Engineering012.png



Engineering012_edges.pgm

  – Video taken by a drone flying over UCI Engineering Plaza
    - Available on the server: **`~ecps203/public/DroneFootage/`**
    - High resolution, 2704 by 1520 pixes
    - Representative sample, using 30 extracted frames for test bench model

Project Assignment 5

- Task: Test bench for the Canny Edge Detector
  - Convert C++ model to SystemC model
  - Add a test bench structure around the C++ model
  - Wrap DUT into a platform model with explicit I/O units
- Steps
  1. Create test bench structure: Stimulus, Platform, Monitor
  2. Create platform model: DataIn, DUT, DataOut
  3. Localize functions and use **`sc_fifo`** channels for communication
     - ➢ Pay attention to stack sizes for every thread
- Deliverables
  - SystemC source code and text file: **`Canny.cpp`**, **`Canny.txt`**
- Due
  - Wednesday, November 6, 2019, 6pm

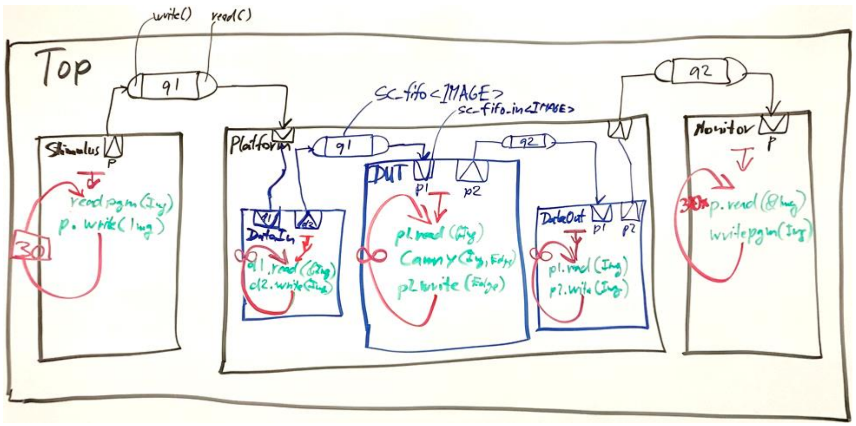
Project Assignment 5

- Task: Test bench for the Canny Edge Detector
  - Expected instance tree

```
Top top
|------ Monitor monitor
|------ Platform platform
|       |------ DUT canny
|       |------ DataIn din
|       |------ DataOut dout
|       |------ sc_fifo<IMAGE> q1
|       \------ sc_fifo<IMAGE> q2
|------ Stimulus stimulus
|------ sc_fifo<IMAGE> q1
\------ sc_fifo<IMAGE> q2
```

Project Assignment 5

- Task: Test bench for the Canny Edge Detector
  - Discussion on whiteboard: Top-level and Platform structure



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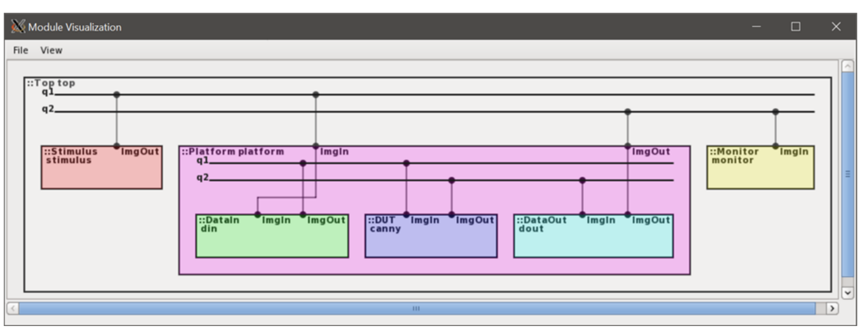
Project Assignment 5

- Task: Test bench for the Canny Edge Detector
  - Expected graphical structure with RISC v0.5.0 **`visual`** tool



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Project Assignment 6

- Task: Structural refinement of the DUT module
  - Refine the structural hierarchy of the DUT module
  - Refine the structural hierarchy of the Gaussian Smooth module
  - Profile the relative complexity of the Canny functions
- Steps
  1. Create structure in DUT: Gaussian Smooth, …, Apply Hysteresis
  2. Create structure in Gaussian Smooth: Input, Gauss, BlurX, BlurY
  3. Profile the algorithm, obtain relative computational complexity
- Deliverables
  - **`Canny.cpp`** (refined structural model)
  - **`Canny.txt`** (profile of relative complexity of the DUT modules)
- Due
  - Wednesday, November 13, 2019, 6pm

Project Assignment 6

- Step 1: Refined structure of the DUT module
  - Expected module instance tree

```
Platform platform
|------ DataIn din
|------ DUT canny
|       |------ Gaussian_Smooth gaussian_smooth
|       |------ Derivative_X_Y derivative_x_y
|       |------ Magnitude_X_Y magnitude_x_y
|       |------ Non_Max_Supp non_max_supp
|       \------ Apply_Hysteresis apply_hysteresis
\------ DataOut dout
```

Project Assignment 6

- Step 2: Refined structure of the Gaussian Smooth block
  - Expected module instance tree

```
DUT canny
|------ Gaussian_Smooth gaussian_smooth
|       |------ Receive_Image receive
|       |------ Gaussian_Kernel gauss
|       |------ BlurX blurX
|       \------ BlurY blurY
|------ Derivative_X_Y derivative_x_y
|------ Magnitude_X_Y magnitude_x_y
|------ Non_Max_Supp non_max_supp
\------ Apply_Hysteresis apply_hysteresis
```

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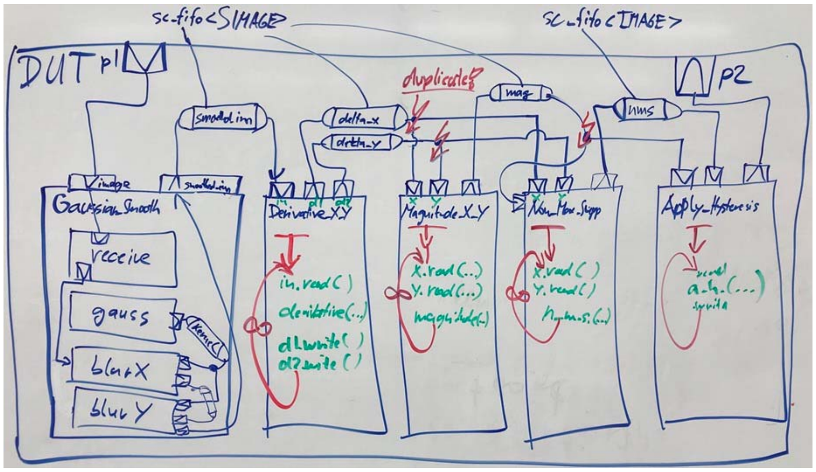
Project Assignment 6

- Task: Structural model of the Canny Edge Detector
  - Discussion on whiteboard: Refined DUT structure



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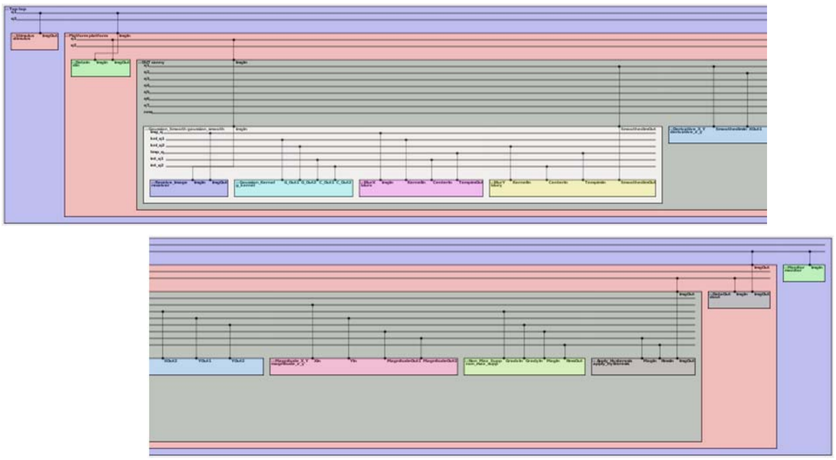
Project Assignment 6

- Task: Structural model of the Canny Edge Detector
  – Expected DUT structure with RISC v0.5.0 **`visual`** tool



Project Assignment 6

- Step 3: Profile the Canny functions
  - ➢ Performance profiling of the Canny Edge Detector
  - ➢ Determine the relative complexity of the Canny functions
    - Is there any performance bottleneck?
    - If so, where?
  – Use the GNU C/C++ profiling tools
    - ➢ **`g++ -pg`**
    - ➢ **`gprof`**
    1. Compile the SystemC source code with option **`-pg`**
    2. Run the simulation once with instrumentation, obtain **`gmon.out`**
    3. Run the profiler: **`gprof Canny`**
    4. Validate the reported call tree
    5. Analyze the “flat profile” for the DUT components (**`self`**)

Project Assignment 6

- Step 3: Profile the Canny functions, obtain relative computational complexity
  - Expected complexity comparison (in **Canny.txt**):

```
Gaussian_Smooth                          ...%
|------ Gaussian_Kernel  ...%
|------ BlurX            ...%
\------ BlurY            ...%
Derivative_X_Y                           ...%
Magnitude_X_Y                            ...%
Non_Max_Supp                             ...%
Apply_Hysteresis                         ...%
                                         100%
```