Center for Active Learning of Microelectronics and Photonics
Java Enabled Opto-Electronic Learning Tools
and A Supporting Framework
Pratibha Gopalam, A. N. Cartwright ,
Electrical Engineering
Bina Ramamurthy
Computer Science and Engineering
University at Buffalo
Motivation

- Java Applets for supplementary instructional material
  - Extend the power of Java and the Internet to educational tools
  - Present information in a more visually appealing manner
  - Create a dynamic and stimulating learning environment
  - Address various learning styles in students

- Develop a supporting software framework that
  - Provides guidelines for developing ideal instructional tools
  - Follows good software design and development practices
  - Captures the experience of instructors and software developers
  - Helps instructors to effortlessly develop educational applications (Applets)
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### Preferred Learning Style | Corresponding Teaching Style
--- | ---
Sensory Intuitive | Concrete Abstract | Content
Visual Auditory | Visual Verbal | Presentation
Inductive Deductive | Inductive Deductive | Organization
Active Reflective | Active Passive | Student Participation
Sequential Global | Sequential Global | Perspective

Dimensions of Learning and Teaching Styles (Felder and Silverman (1988)).

Educational Applets address the styles appearing in blue.
Teaching and Learning Styles

• To address various learning styles, instruction should
  – Introduce new concepts by building on fundamental principles
  – Help visualization of complex systems
  – Facilitate context based learning with demonstrations of real life scenarios
  – Encourage experimentation
  – Call for understanding information in a global context
Educational Java Applets and Learning Styles

• Educational Java Applets
  – Provide user configurable and data probing tools to help inductive style of learning
  – Promote global understanding of large-scale systems using context based case studies
  – Explain complex systems using vivid simulation schematics to favor visual learners
Educational Java Applets and Learning Styles

Gain Mechanism (Rate Equations)

- Educational Java Applets
  - Provide helpful demonstrations of theoretical concepts
  - Provide virtual experimentation
  - Provide graphical interfaces to allow active learners to dynamically change the behavior of the system

Applets when used in conjunction with traditional lectures help approach an ideal teaching style
OOD: Design Patterns and Frameworks

- Essence of true Object Oriented Software
  - Simplicity, Modularity, Reusability, Extensibility
- OO languages provide implementation support
- Design Patterns Provide:
  - Insights required for making reusable software
  - Experiences required for Robust and Scaleable solutions
- Frameworks
  - Collection of domain specific design solutions
  - OO reuse technique serving as the skeleton of an application
  - Reusable “semi-complete” application with built-in flexibility to transform itself into custom applications
  - Help in rapid, minimal effort, development of similar applications
Key Elements Of The Framework

- Framework
  - Toolkit provides utility classes
  - Strategy Object: defines interactions
  - Singleton Object: defines rules
  - Components: encapsulate data
  - Visitor Objects: probe components

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Example Implementation of the Framework

This Applet the Gain Mechanism using Rate Equations in a 4 level Energy System. Examples of the various elements of the framework are labeled.
Key Elements Of The Framework

- **Components**
  - Encapsulate Data
  - Either Active or Passive
  - Typically have a graphical interface
  - Developers: Undergraduate students

- **Strategy Objects**
  - Define governing principles for component-to-component interaction
  - Handle computational algorithms
  - Developers: Experienced programmers

- **Singleton Objects**
  - Define rules(units) for uniformity
  - Provide global access to rule information
  - Developers: Experienced programmers
Key Elements Of The Framework

• Visitor Objects
  – Probe and change the status of components
  – Allow dynamic run-time configuration
  – Employ graphical user interface objects
  – Developers: Experienced programmers

• Toolkit
  – Comprised of utility classes
  – Evolve over time with new additions from users
  – Developers: Depends on complexity

• Container
  – Placeholder for interdependent elements
  – Makes constituent elements aware of each other
  – Designer: Domain expert
User Configurable Virtual Laboratory Applets

- 2X Beam Expander
- Fiber Optics - Slab Dielectric Surrounded by Air
- Cavity Stability using Ray Tracing
- Diode Pumped Laser Cavity

Camp website: www.ee.buffalo.edu/~camp

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User Configurable Virtual Laboratory Applets

Right Hand Polarized Light

Left Hand Polarized Light

Right Hand and Left Hand Polarized Light
Filtered by Rotating Linear Polarizer

Polarization Modulator
(Halfwave Plate between Cross Polarizers)

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User Configurable Design Applets

Optical Design System
- Optical components
  - Graphically represented.
  - Menus used to dynamically change parameter values
  - HTML tags used to statically design systems
- Students are allowed to experiment with various configurations of lenses, mirrors, polarizers, and sources

Polarization Applet
- Polarization Modulator (Halfwave Plate between Cross Polarizers)

```xml
<applet code="JonesSys.class" width="450" height="350">
  <param name=separator VALUE=",">
  <param name=JonesVector0 value="50,0,50,0,10,-10,1">
  <param name=Polarizer0 value="0, 10, 80, 0">
  <param name=Polarizer1 value="1, 60, 80, 0">
  <param name=WavePlate0 value="90, 35, 80, 0">
  <param name=RotateElement value="1">
  <param name=StartZ value="-20">
  <param name=StopZ value="80">
  <param name=DeltaZ value="0.1">
</applet>
```
Conclusions

- Developed a number of Education Java Applets as learning aids in Photonics
  
  www.ee.buffalo.edu/~camp/applets/index.html

- Developed a generic, portable, set of objects for the proposed framework that can be effortlessly used by other educators

- Successfully used these Applet based simulation systems in an undergraduate course on Lasers and Photonics (EE 492)
Future Work

- Standardize the development of user configurable virtual laboratory environments to serve as supplementary educational resources for various science and engineering subjects.
- Furthermore, extend them to be used as simulation tools in research.
- Adopt the software component technology using JavaBeans™ to further enhance the developed framework.
Applet Resources for E-Laboratories

- **E-Laboratory**
  - An online environment to support Internet-based scientific collaboration
    * Sharing of research instruments.
    * Dissemination of basic knowledge (through Applet resources)
  - Applets could provide
    * Simulation tools
    * Information-rich learning environments
    * Guidance and reference
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