

Objectives

- Analysis and Design
- Interpreting programming languages
- Final Project: Picasso

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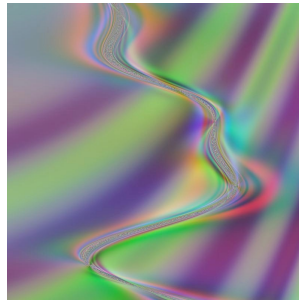
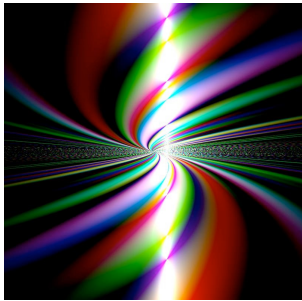
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Final Project: Picasso Specification

- User can enter expressions
 - Interactively or from file
 - Language is defined in specification
- Many possible extensions



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Project Deliverables Timeline

| Deliverable | Who | Weight | Due Date |
|-----------------------------|------------|--------|--------------------------------|
| Preparation Analysis | Individual | 10% | Fri, Nov 18 |
| Preliminary Implementation | Team | 15% | Fri, Dec 2 |
| Intermediate Implementation | Team | 15% | Fri, Dec 9 |
| Final Implementation | Team | 45% | Team decides → latest 12/15 |
| Analysis | Individual | 15% | Fri, Dec 16 |

Before class

Week 1: Understand code base, analyze/plan project

Week 2: Implement preliminary functionality

Week 3: Implement intermediate functionality

Week 4: Implement final version of application

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Teams

| | | | | |
|-------------------|-----------|---------|----------|---------|
| Fantastics | Charlotte | Jacob | Jared | Katie |
| Supremes | Colin | Drew | Hussiny | Yoseph |
| Dreamers | Julia | Malachi | Ngoc Anh | Stephen |

Teams, alphabetically by first name

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Teams

| | | | | |
|------------|-------|-----------|----------|---------|
| Innovators | Jake | Jaylen | Luke | Selly |
| Allies | Ignas | Jack | Joe | Uno |
| MVPs | Grace | Harry | Julie | Matthew |
| Legends | Beza | Elizabeth | Mitchell | Nick |
| Champions | Fekry | Matt | Ngoc | Petra |

Teams, alphabetically by first name

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ANALYSIS & DESIGN: FORMALIZED

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Analysis Phase

“Doohickey”

- Create an abstract model in client’s vocabulary
- Strategy:
 1. Identify classes that model (shape) system as set of abstractions
 2. Determine each class’s purpose or main responsibility
 - API
 - State
 3. Determine helper classes for each
 - Help complete responsibilities

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Analysis Phase Discussion

- Expect to **iterate**
 - Won’t find all classes at first
 - Especially helpers
 - Won’t know all responsibilities
- Uncertainty in problem statement
 - May be concerns that need to be settled
 - Try to understand requested software system at level of those requesting software
- Rarely one true correct best design



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Identification of Classes

- Potentially model the system
- Usually **nouns** from problem description or from domain knowledge
- Model real world/problem domain whenever possible
 - More understandable software
 - Helps during maintenance when someone unfamiliar with system must update/fix code

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Identifying Responsibilities

- Responsibilities convey purpose of class, its role in system
- Questions to Ask:
 - What are the other responsibilities needed to model the solution?
 - Which class should take on this particular responsibility?
 - What classes help another class fulfill its responsibility?

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Have You Modeled Everything?

- Strategy: Role playing
- Act as different classes: can you do everything you want in various scenarios?
 - Fill in missing classes, responsibilities
 - Methods: parameters, what returned
 - Restructure as necessary
 - No code yet so not actually refactoring
- Example **use cases**/scenarios:
 - A student tries to register for a class with no open seats
 - A professor looks at students' interim grades

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Definition of Use Case?

- Description of steps or actions between a user and a software system towards some goal

- What else can use cases be used for?
 - Test Cases!

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TEAM FINAL PROJECT

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Project Metrics

- >1700 lines of code
 - Even more by the time your team is done
- Good for gaining experience
 - Large (for a course) piece of existing code that you need to build on
- Good for job interviews
 - Know the number of lines of code

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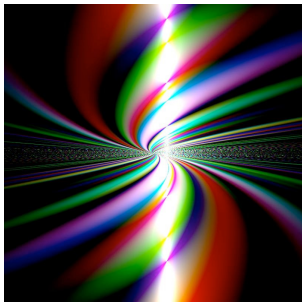
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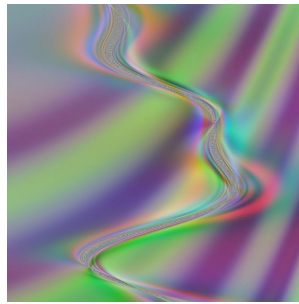
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Final Project: Picasso Specification

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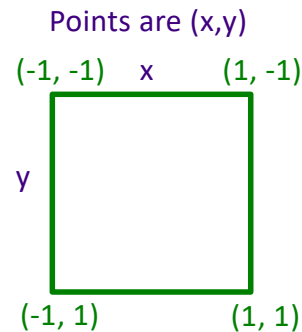


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Picasso Project Overview

- Goal: Generate images from expressions
- Every pixel at position (x,y) gets assigned a color, computed from its x - and y -coordinate and the given expression
 - Range for x and y is $[-1, 1]$
- Colors are represented as RGB (red, green, blue) values
 - R, G, B component's range: $[-1, 1]$
 - Black is $[-1,-1,-1]$
 - Red is $[1,-1,-1]$
 - Yellow is $[1, 1,-1]$



How is white represented?

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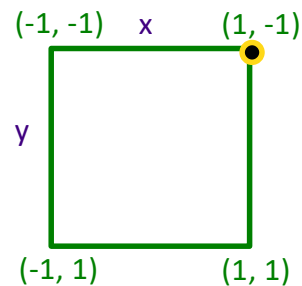
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Generating Images from Expressions

- **Expressions** at a specific (x,y) point/pixel evaluate to *RGB colors* $[r,g,b]$
 - `pixels[x][y] = expression.evaluate(x, y)`
- **x** evaluates to RGB color $[x, x, x]$
- In top right corner,
 - x evaluates to $[1, 1, 1]$
 - y evaluates to $[-1, -1, -1]$



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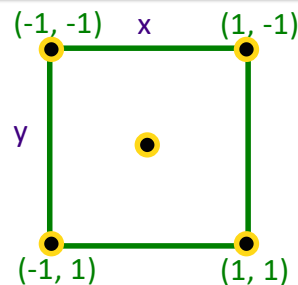
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Generating Images from Expressions

```
For all x:
  For all y:
    pixels[x][y] = expression.evaluate(x, y)
```

Consider evaluating expression as
 $f(x, y) = \text{expression}$
 at various points in the image



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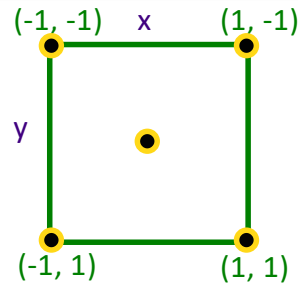
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Generating Images from Expressions

```
For all x:
  For all y:
    pixels[x][y] = expression.evaluate(x, y)
```

Consider evaluating expression as
 $f(x, y) = \text{expression}$
 at various points in the image

Example: expression is $x+y$



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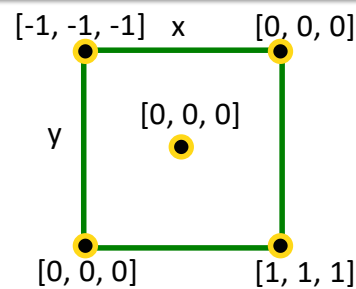
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Generating Images from Expressions

```
For all x:
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```

Consider evaluating expression as
 $f(x, y) = \text{expression}$
 at various points in the image

Example: expression is $x+y$



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Generating Images from Expressions

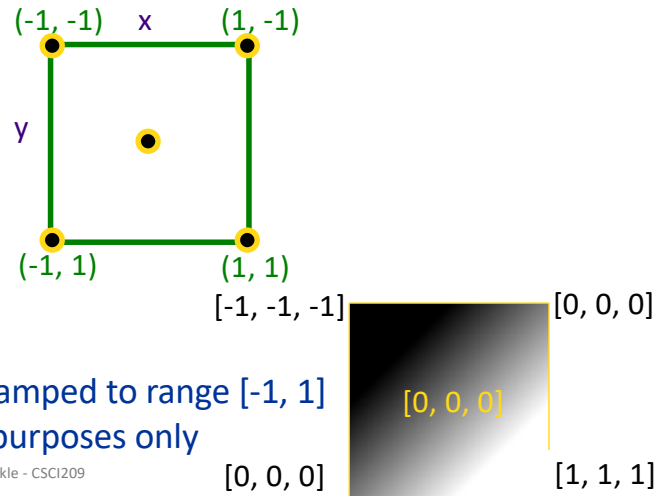
```
For all x:
  For all y:
    pixels[x][y] = expression.evaluate(x, y)
```

Consider evaluating expression as
 $f(x, y) = \text{expression}$
 at various points in the image

Example: expression is $x+y$

Resulting image:

- Recall that color range is clamped to range $[-1, 1]$
- Yellow outline for framing purposes only



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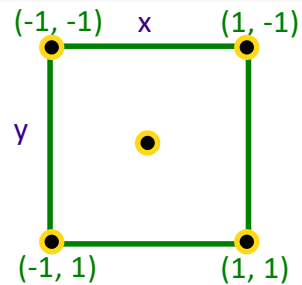
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Generating Images from Expressions

```
For all x:
  For all y:
    pixels[x][y] = expression.evaluate(x, y)
```

Consider evaluating expression as
 $f(x, y) = \text{expression}$
 at various points in the image



What is the resulting image if the *expression* is

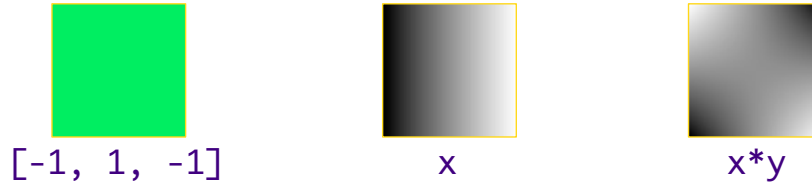
- $[-1, 1, -1]$?
- x ?
- $x*y$?

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Generated Images from Expressions



```
For all x:
  For all y:
    pixels[x][y] = expression.evaluate(x, y)
```

If you click "Evaluate" in Picasso currently,
it evaluates the expression `floor(y)`

PROCESSING PROGRAMMING LANGUAGES

Programming Language Syntax & Semantics

- What does an assignment statement look like in Java?
 - What can be on the left hand side?
 - What are the rules for an *identifier* in Java?
 - What can be on the right hand side?
- What does a multiplication expression look like?
- How do we evaluate arithmetic expressions?

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Programming Language Design

- Must be unambiguous
 - Programming Language defines a ***syntax*** and ***semantics***
- Interpreting programming languages
 1. Parse program into tokens
 2. Verify that tokens are in a valid form
 3. Generate executable code
 4. Execute code

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Parsing into Tokens

- Example: $x = 4 * 3;$ →

```
<id> <assignment> <num> <mult> <num> <endofstmt>
```

- Example: $x = * 3 5;$

```
<id> <assignment> <mult> <num> <num> <endofstmt>
```

- Tokenizer doesn't care if statement is not valid
 - handled in next step
- Error example: $1x = 4 ** 3;$
 - $1x$ and $**$ are not valid tokens in Java

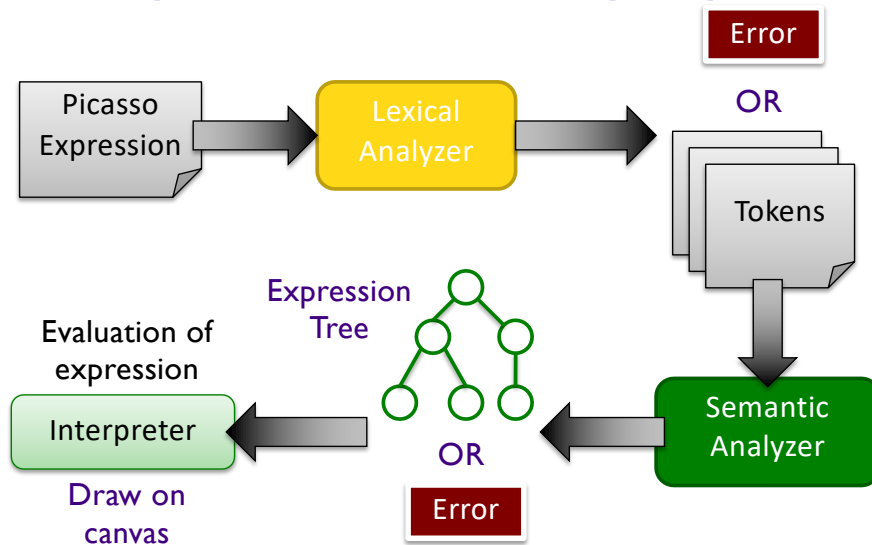
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Interpreting the Picasso Language



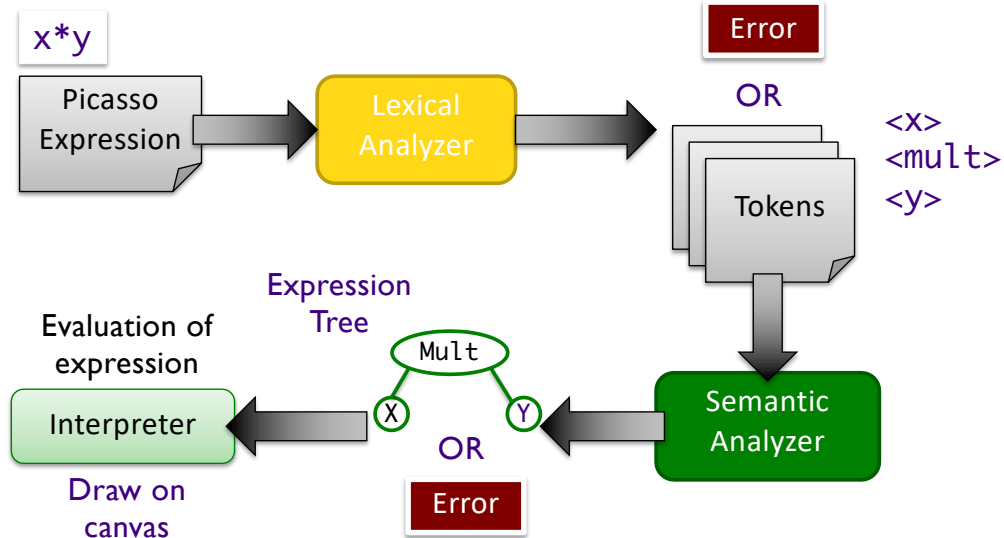
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Interpreting the Picasso Language



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What We Need to Do/Represent

- Lexical Analysis
- Semantic Analysis
- Evaluation

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What We Need to Do/Represent

- Lexical Analysis
 - Recognize/create tokens
 - Report errors in creating tokens
- Semantic Analysis
 - Convert infix tokens into postfix
 - Report errors
 - Parse tokens into *expressions* (expression tree)
 - Report errors
- Evaluation
 - Evaluate expressions

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Process of Understanding Code: Building Your Mental Model

- Apply spiral model to understanding code
- Review problem specification (low-cost effort)
- Explore project at the top-level (low-cost effort)
 - Look at packages, class names
 - Don't take a deep-dive until you have the bigger picture

<https://cs.wlu.edu/~sprenkles/cs209/projects/picasso/doc/>

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Understanding the Code

- How does the given code map to lexical analysis, semantic analysis, and evaluation components?
 - Look for packages, classes that map to these steps

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Process of Understanding Code: Building Your Mental Model

- Look for important words/terms from problem domain
- Look for terms from design patterns
- Put code in black boxes or group code together

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Process of Understanding Code: Building Your Mental Model

- After you have the big picture, look at most important classes
- Decide: Does this class merit a closer look? Or do I just need the big picture of what it does?
 - Lean towards the latter towards the beginning
- Iterate!
 - Grow your mental model
 - What a “closer look” means changes over time
 - Early: what methods does the class have? What classes does this object interact with?
 - Later: what do these methods do? How does this class interact with other objects?

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Understanding the Code

- How does the given code map to lexical analysis, semantic analysis, and evaluation components?
 - Look for packages, classes that map to these steps

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TODO

- Project Analysis due Friday