Pixel

Alex Anthony Cortes-Ose
Dillon Davis
Jessica Kim
Jessica Peng

AGENDA

01 Team Introduction

02 Our Inspiration

03 Pixel Language Details

04 Syntax and Grammar, Types and Operators, Built-in Functions

05 Open CV

06 Test Suites

07 Demo

Team

Alex Anthony Cortes-Ose

Language Guru

Dillon Davis

Manager

Jessica Kim

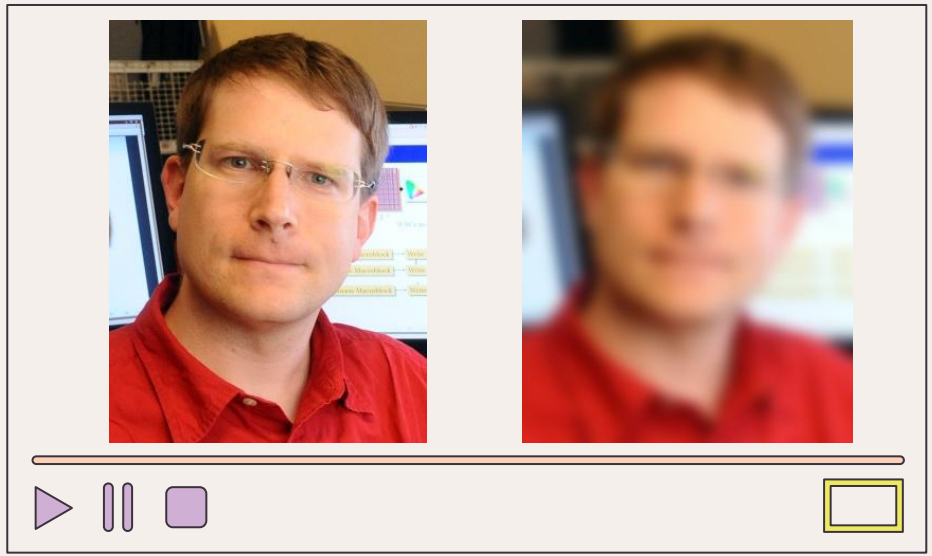
Tester

Jessica Peng

System Architect

Our Inspiration

- **Computer vision**: automated image-editing
- **Image editing**
  - Instagram
  - Photo-editing apps
- **Pixel manipulation**



Pixel Language Details

- Designed to process and manipulate images
- Can create filters and perform various tasks fundamental to basic image processing
- Images are represented by matrices
- Similar {bracket} syntax and type declaration as Java
- Similar matrix manipulation and lists as Python
- Types: int, str, float, matrix, void
- Keywords: if, else, while, for, fun, return, print

Syntax & Grammar

function declaration + return types

```
fun::void main() {
  image base = image_in("../img/flowers.JPG");
  matrix::float base_gray = base.grayscale;
  matrix::float final = zeros(base_gray.rows, base_gray.cols);
  int i;
  for (i = 0; i < base_gray.rows; i = i + 1) {
    int j;
    for (j = 0; j < base_gray.cols; j = j + 1) {
      if (base_gray[i,j] >= 0.58) {
        final[i, j] = 1;
      }
    }
  }

  image_out("../img/flower_centers.JPG", final);
}
```

typed variables

matrix cols and rows

matrix indexing

Python-style matrix literals

```
matrix::float
sobel_horizontal =
    [[1, 0, -1],
     [2, 0, -2],
     [1, 0, -1]];
```

Types and Operators

matrix multiplication:

```
matrix::float A = [
  [-1, 4],
  [2, 3]
];
matrix::float B = [
  [9, -3],
  [6, 1]
];
matrix::float C = A * B;
```

Image types have red, green, blue, and grayscale 2d Float Matrices.

Matrix types have rows, columns and a matrixAddr 2D float matrices.

Built-in Functions

- **image_in** -> takes in [String; String] and return Image
- **Image_out** -> takes in [String; Image; String] and returns Void
- **convolute** -> takes in [Matrix; Matrix] and returns Matrix
- **join** -> takes in [Matrix; Matrix; Matrix] or [Matrix] and returns Image

OpenCV + Image Processing

```
struct matrix {
    int rows;
    int cols;
    float** matrixAddr;
};
struct image {
    matrix* red;
    matrix* green;
    matrix* blue;
    matrix* grayscale;
};
```

```
matrix* initMatrix(float* data, int num_rows, int num_cols) {
   Mat newMatrix = Mat::zeros(num_rows, num_cols, CV_32F);
   for (int i = 0; i < (num_rows * num_cols); i++) {
       newMatrix.at<float>(i) = data[i];
   }

   matrix* result = (matrix*) malloc(sizeof(struct matrix));
   result->cols = num_cols;
   result->rows = num_rows;
   result->matrixAddr = getMat(newMatrix);

   return result;
}
```

```
Mat GS = Mat::zeros(grayscale->rows, grayscale->cols, CV_32F);
  for (int i = 0; i < grayscale->rows; i++) {
      for (int j = 0; j < grayscale->cols; j++) {
          GS.at<float>(i, j) = grayscale->matrixAddr[i][j];
      }
  }

  image* result = (image*) malloc(sizeof(struct image));
  result->grayscale = initMatrix(get1D(getMat(GS), GS.rows,
                                 GS.cols), GS.rows, GS.cols);
  return result;
```

- OpenCV -> float**
- custom convolution
- image IO
- matrix flattening helper functions
- merge and split color channels
- Image data corrections

Code Samples

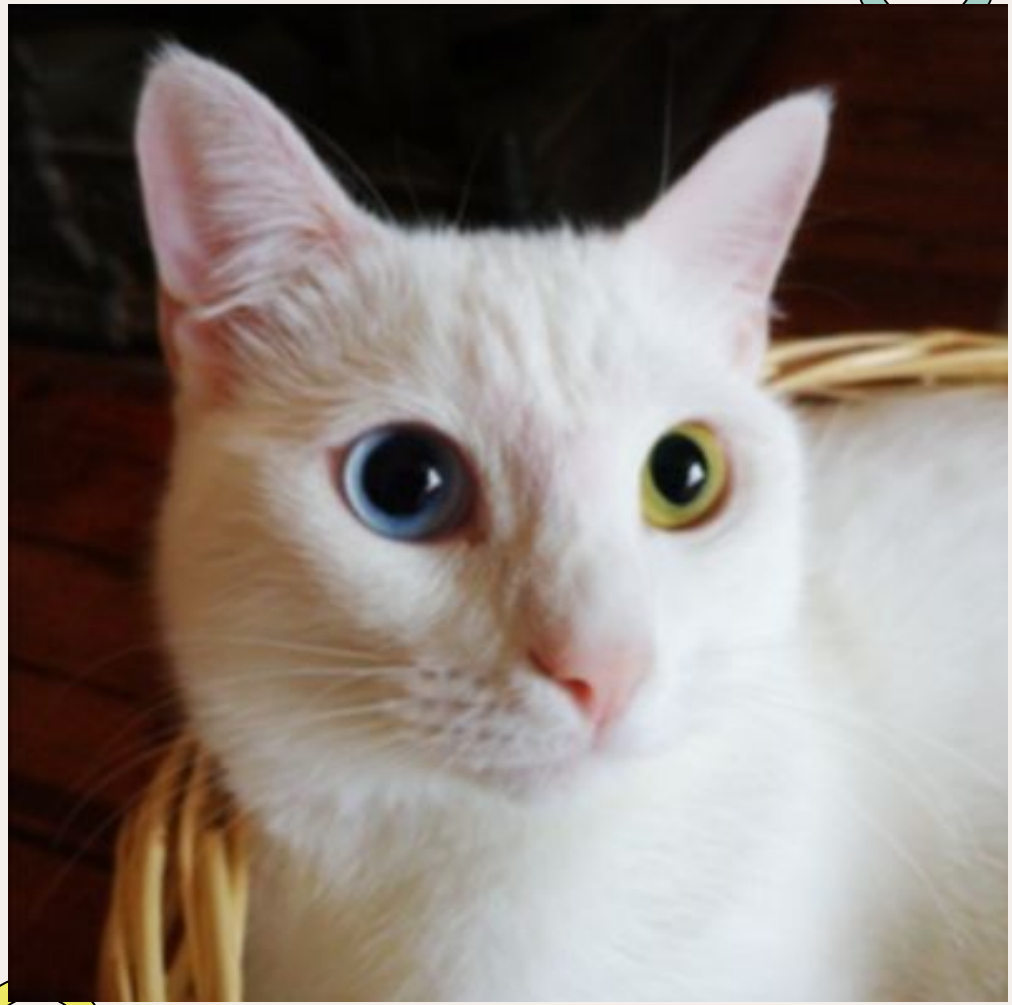
Blur

```
fun::void main() {
  image base = image_in("../img/cat.png");
  matrix::float box =
    [[1, 1, 1],
     [1, 1, 1],
     [1, 1, 1]];
  matrix::float fr = convolute(base.red, box) * 0.11;
  matrix::float fg = convolute(base.green, box) * 0.11;
  matrix::float fb = convolute(base.blue, box) * 0.11;

  image final = join(fr, fg, fb);
  image_out("../img/blurred-cat.png", final);
}
```

Before

After



Matrix Addition

```
fun::void main() {
  matrix::float A = [
    [1.0, 1.0],
    [1.0, 1.0]
  ];
  matrix::float B = [
    [2.0, 3.0],
    [4.0, 5.0]
  ];
  print(A + B);
}
```

```
[[3.0, 4.0],[5.0, 6.0]]
```

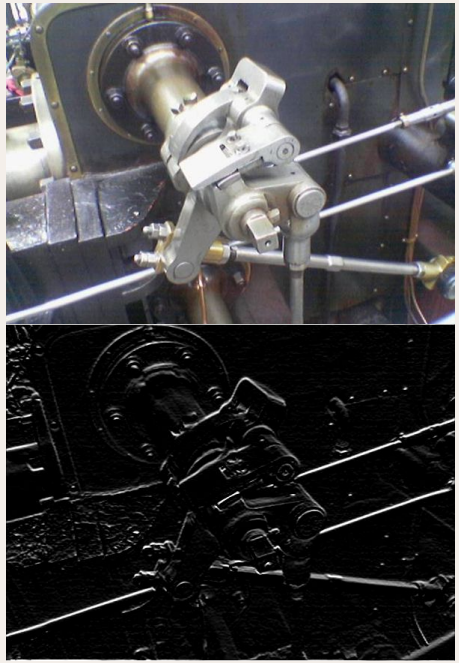
Edge Detection

```
fun::void main() {
  image base = image_in("../img/steam-engine.png");
  matrix::float base_gray = base.grayscale;
  matrix::float sobel_horizontal =
    [[1, 0, -1],
     [2, 0, -2],
     [1, 0, -1]];
  matrix::float horiz = convolute(base_gray, sobel_horizontal);

  matrix::float sobel_vertical =
    [[1, 2, 1],
     [0, 0, 0],
   [-1, -2, -1]];
  matrix::float vert = convolute(base_gray, sobel_vertical);

  matrix::float fhoriz = horiz * horiz;
  matrix::float fvert  = vert  * vert;
  matrix::float final = (fhoriz + fvert) ** (1/2);

  image_out("../img/steam-engine-edges.png", final);
}
```



Testing

- Test suites for syntax, grammar, functionality, etc.
- Tests for cases that should produce errors as well as sample program output
- Over 60 tests in the repository

Sample Test Suites

```
fun::int main() {

  int i;

  for (i = 0; i < 10 ; i = j + 1) {} /* Error: j is undefined */

  return 0;

}
```

- Tests that an undefined variable raises an error

Sample Test Suites

```
1  fun::int add(int a, int b)
2  {
3    int c;
4    c = a + b;
5    return c;
6  }
7
8  fun::int main()
9  {
10   int d;
11   d = add(52, 10);
12   print(d); /* Should print 62 */
13   return 0;
14 }
```

- Tests that function calling, integer addition and printing work

Pixel Demo

Thank You