ArtC++

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Contents

1 Introduction

ArtC++ is a unique image manipulation language that aims to make image-editing fun and easy. It borrows inspiration from several languages and libraries like C/C++, Java, Python, NumPy and Pillow. While it uses types, it supports several inbuilt functions, and behaves similarly to functional programming languages. In addition to this, ArtC++ supports several unique features, like printing images to the terminal. The language can also support basic video manipulation, and can play frames of the video in the terminal.

ArtC++ is compiled to C++, ensuring that the code is fast and efficient.

2 Lexical Specifications

2.1 Keywords

img	grey_img	num	real	and
or	spiral	presuming	otherwise	break
continue	return	def	void	

2.2 Identifiers

As in several other languages, identifiers begin with a letter or underscore, and are followed by a sequence of letters, underscores or digits. Identifiers are case-sensitive. For example :-

```
abcdef
_23n32_
343491h # Invalid identifier
*()_  # Invalid identifier
```

2.3 Comments

Single-line comments start with a # symbol. For example :-

```
# This is a single-line comment
```

Multi-line comments are enclosed by #∗ and ∗#. For example :-

```
#* This
is a
multi-line comment *#
```

2.4 Whitespace

As in C++, whitespaces (including tabs and spaces) is ignored. It is however recommended to include them to improve readability. The newline character is however used to define statements, like in Python. Curly braces {} are used to define scope.

3 Datatypes

Data Type	Description
Primitive	
img	multicolor image
grey_img	greyscale image
num	integer
real	float
Derived	
img[]	video, an array of images with a fps
grey_img[]	greyscale video, an array of grey_images with a fps
num[]	array of integers
real[]	array of real numbers

4 Operators

Operator	Example	Description
Binary Arithmetic		
`+`	`a + b`	Here, `a` and `b` are either numbers (or reals), or have to be of the same image datatype (RGB or Grayscale). The image shapes have to broadcastable. If a value exceeds 255, it is clipped back to 255. In addition to this, `a` and `b` can be videos (of the same datatype). If this is done, the frames are concatenated.
`-`	`a - b`	The operands are the same as for `+`. If a pixel value goes below 0, it is clipped back to 0.
`*`	`a * b`	The operands and behaviour are similar to `+`
`@`	`a @ b`	`@` is used for convolutions. `a` is an image or a greyscale image. `b` can be a image array of size 3 (this outputs an RGB image) or a single image (this outputs a greyscale image). The number of channels in the right operand should equal the channels in the left operand.
Unary Arithmetic		
`~`	`a~`	`a` is an image or a real. The post-decrement operator will decrease the value of `a`.
`--`	`a--`	`a` is a number or a real. The post-decrement operator will decrease the value of `a`.
`++`	`a++`	`a` is a number or a real. The post-increment operator will increase the value of `a`.
Relational and Logical		
$>$, $>=$	a $>$ b, a $>=$ b	The greater-than and greater-than or equal-to operate on numbers (or reals), and are defined as in other programming languages
$<$, $<=$	a $<$ b, a $<=$ b	The less-than and less-than or equal-to operators also operate on numbers or reals
`and`	P_1 `and` P_2	Here, P_1 and P_2 are predicates, and equate to true or false.
`or`	P_1 `or` P_2	The `or` operator also operates on two predicates.
!	$!P_1$	`!` flips the truth value of the predicate it operates on
!=, ==	$P_1 == P_2$, P_1 != P_2	== and != are the standard equality and not-equality operators.

5 Statements

All statements in ArtC++ end with a newline ('\n') character. This keeps the code clean, and ensures that every statement is on a separate line.

5.1 Declarations

- Numbers:
  - `num num_name = value`
    - Here, `value` is a 32 bit integer.
  - `real real_name = value`
    - Here, `value` is a 32 bit floating point value.
  - `num[] array_name = []`
    - Declaring an array results in `array_name` being associated with an empty list. The list can be populated with `nums` using operators and methods like `.append()` (see below).
  - `real[] array_name = []`
    - Declaring an array results in `array_name` being associated with an empty list. The list can be populated with `reals` using operators and methods like `.append()` (see below).
- RGB Images:
  - `img img_name<h, w>`
    - Here, `h` is the height of the image and `w` is the width of the image.
    - Declaring an image automatically allocates memory for the image, which is stored as a 3D array (height, width, 3). Each element is initialized to 0 (the image is initially black).
  - `img img_name<h, w, hex_code>`
    - This declaration is similar to the previous one, except for the hex-code. The format of the hex-code is `'#RRGGBB'`, where `RR`, `GG`, and `BB` are hexadecimal numbers representing the red, green, and blue components of the color respectively.
  - `img img_name<'./img.bmp'>`
    - Here, `'./img.bmp'` is the path to the image file.
    - Declaring an image automatically allocates memory for the image, which is stored as a 3D array (height, width, 3). The corresponding RGB values of the image are stored.
- Grayscale Images: `grey_img img_name<h, w>` Grayscale images are stored as 2D arrays (height, width). The declaration is similar to RGB images.
  - `grey_img img_name<h, w>`
  - `grey_img img_name<'./img.bmp'>`
- RGB Videos (Image Arrays): `img[] vid_name<h, w, f>` or `img[] vid_name<h, w>`
  - Here, `h` is the height of each frame, `w` is the width of each frame, and `f` is the frame rate in frames per second (fps). It is optional to specify the frame rate, and the default value is 30.
  - Declaring a video results in `vid_name` being associated with an empty list. The list can be populated with images using operators and methods like `.append()` (see below).

- Grayscale Videos (Grayscale Image Arrays): `grey_img[] vid_name<h, w, f>` or `grey_img[] vid_name<h, w>`
  - This is identical to the declaration of RGB videos, except that each frame is stored as a 2D array (height, width). As before, each element is initialized to 0.

5.2 Expressions

```
# a,b,c are images
a = b + c
b = (a + c)/2
a = a @ b * !c

# a,b are real numbers
a = !a or a and b
b = a++
a = a >= b

```

5.3 Loops

We have implemented only one type of spiral that incorporates both `for` and `while` loops. The syntax is as follows :-

Type 1

```
# Similar to for loops in C++
spiral (initialization expression; condition expression; update expression)
{
    <body of the loop>
}

# Example
spiral (num i = 0; i < 10; i++)
{
    <body of the loop>
}
```

Type 2

```
spiral (predicate)
{
    statements
}

# Example
spiral (i < 10)
{
    statements
}
```

5.4 Conditionals

Conditional statements will follow the following syntax :-

```
presuming (expression)
{
    statements
}
otherwise presuming (expression)
{
    statements
}
otherwise
{
    statements
}
```

The elif and else parts of the conditional statement are optional.

6 Programming Constructs

6.1 Functions

6.1.1 Image Manipulation

Method	Example	Description
`blur()`	`a.blur()`	Adds blur to the image (or blurs every frame of the video)
`noise()`	`a.noise()`	Adds random gaussian noise to the image (or adds noise to every frame of the video)
`grey()`	`a.grey()`	Converts the image to greyscale and changes the shape (or convert the video to greyscale)
`vflip()`, `hflip()`	`a.vflip()` or `a.hflip()`	Flips the image vertically or horizontally (or every frame of the video)
`get()`, `set()`	`a.get(x, y, c)` or `a.set(x, y, color_hex)`	Gets the pixel value at (x, y, c) or sets the pixel value at (x, y) to the specified color

6.1.2 Displaying Images and Videos

Method	Example	Description
`paint()`	`a.paint()`	Displays the image `a` in the terminal
`frame()`	`a.frame('img.bmp')`	Saves the image `a` to the specified path (only .bmp)
`play()`	`a.play()`	Plays the video `a` in the terminal (resolution might be lowered)

6.1.3 Other Methods

Method	Example	Description
`len()`	`a.len()`	Returns the number of frames in video `a`
`append()`	`a.append(b)`	Appends image `b` or video `b` to the video `a`. The types should match-up
`height()`	`a.height()`	Returns the height of an image or the images in video `a`
`width()`	`a.height()`	Returns the width of an image or the images in video `a`

6.1.4 Drawing on Images

`draw()` is a method that can be used to draw shapes on images. It supports the following shapes :-

```
# Draws circle with center (x_c, y_c) and radius r on image 'a'
a.draw('circle', x_c, y_c, r, color_hex)

# Draws a line from (x1, y1) to (x2, y2) on image 'a'
a.draw('line', x1, y1, x2, y2, color_hex)

# Draws a rectangle with center (x_c, y_c) and dimensions h and w
a.draw('rectangle', x_center, y_center, h, w, color_hex)

# Draws a triangle with vertices (x1, y1), (x2, y2), (x3, y3)
a.draw('triangle', x1, y1, x2, y2, x3, y3, color_hex)

# Draws an ellipse with center (x_c, y_c) and radii a and b
a.draw('ellipse', x_center, y_center, a, b, color_hex)
```

6.1.5 User-defined Functions

The programmer must define a `def main()->void` function. All user defined functions must have a `return` statement in them. They must also only return an object of the declared return type.

```
def func_name (arguments)->return_type
{
    statements
}
```

6.2 Slicing

We allow the slicing of videos. This returns a new video with the specified frames. The syntax is as follows :-

```
a = b[1:10] # This returns a video with frames 1 to 9 of b
a = b[1:10:2] # This returns a video with frames 1, 3, 5, 7, 9 of b
a = b[1:] # This returns a video with frames 1 to the end of b

```

7 Sample Programs

```

def bar (img p, img q, img r)->img {
  img s
  int a = 2
  real b= 7.8

  if (a + b > 10) {
    s = p * (q + r)
  } elif (a + b == 10) {
    s = q * (p + r)
  } else {
    s = r * (p + q)
  }

  return s
}

```

```
def func(img i1, img i2, img i3)->img {
  int i

  loop (i = 0; i < 10; i++) {
    i1 = i1 + i2 * i3
  }

  return i1
}

def main()->void {
    img i1.load('./i1.bmp')
    img i2.load('./i2.bmp')
    img i3.load('./i3.bmp')

    i3 = func(bar(i1, i2, i3), i1, i2)

    i2.paint('rectangle', 50, 40, 50, 40, ff0000)
    i2.paint('triangle', 0, 0, 5, 5, 3, 4, 00ffff)

    i1.pai

    i3.frame('./i_mod.bmp')

    i3.paint()
    return
}
```

```
def bar (img p, img q, img r)->img {
  img s
  int a = 2
  real b= 7.8

  if (a + b > 10) {
    s = p * (q + r)
  } elif (a + b == 10) {
    s = q * (p + r)
  } else {
    s = r * (p + q)
  }

  return s
}

def func(img i1, img i2, img i3)->img {
  int i

  loop (i = 0; i < 10; i++) {
    i1 = i1 + i2 * i3
  }

  return i1
}

def foo(img a, img b, img c)->img {

 img res = a*b + c // This is doing conv(a, b) and then overlaying c
 return res
}
   def foo1(img a, img )->img {
    return b*a.blur(5)
```

```
}

def main()->void {
    img i1.load('./i1.bmp')
    img i2.load('./i2.bmp')
    img i3.load('./i3.bmp')

    i3 = foo1(foo(i1, i2, i3), i1)

    i2.paint('circle', 50, 40, 20)
    i2.paint('line', 0, 0, 2, 3)

    i2.paint()
    i2.frame('./i2_mod.bmp')

    i3.frame('./i_res.bmp')

    i3.paint()
    return
}
```

```
def bar(im)
def foo(img a, img b, img c)->img {
    img res = a*b + c // This is doing conv(a, b) and then overlaying c
    return res
}

def foo1(img a, img b)->img {
    return b*a.blur(5)
}

def main()->void {
    img i1 = load(./i1.bmp)
    img i2 = load(./i2.bmp)
    img i3 = load(./i3.bmp)

    i3 = foo1(foo(i1, i2, i3), i1)

    i3 = i3.boundary() // Another built in filter that gis us the image boundary.

    i2.draw('circle', 50, 40, 20)
    i2.draw('line', 0, 0, 2, 3)

    i2.print()
    i2.save(./i2_mod.bmp)

    i3.save(./i_res.bmp)

    i3.paint()
    return
}
```