A Language for Interactive LED Visualization

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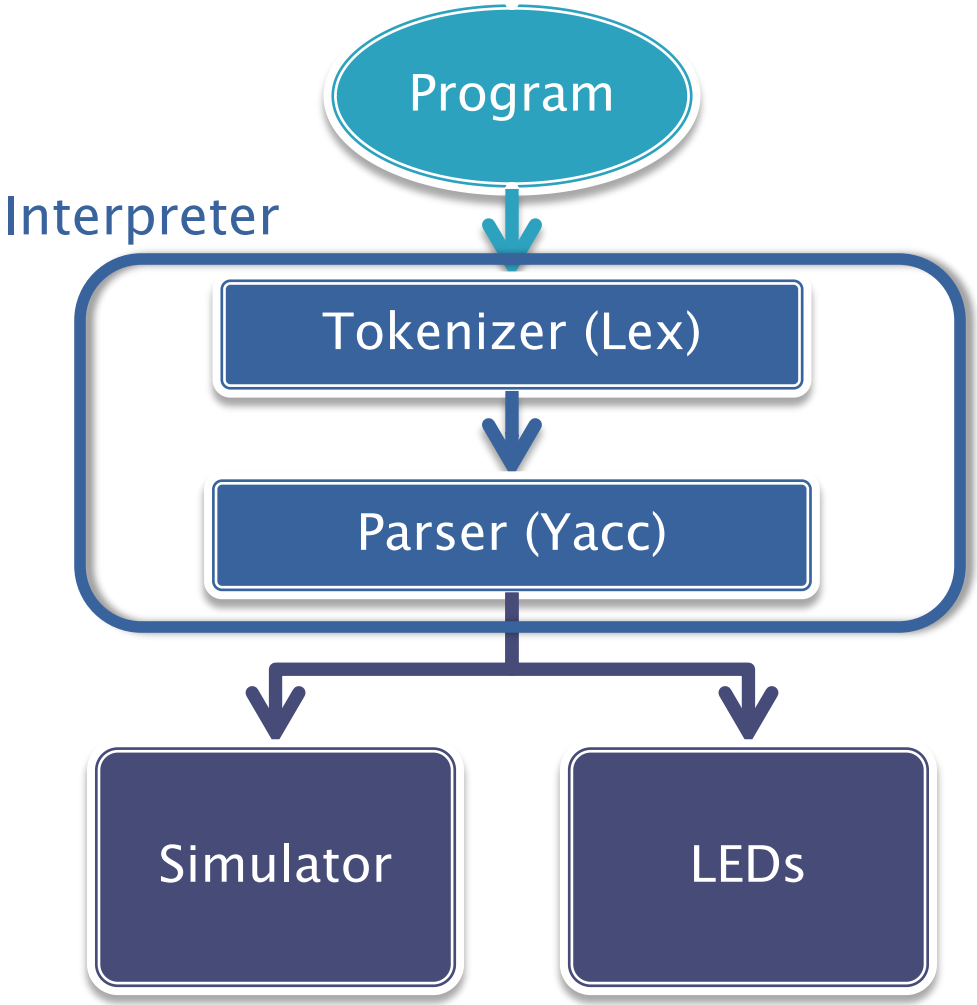
Motivation and Goals

- Create language to control LED displays
- Simple to use
- Enable interactive experience

Components

- Interpreter
  - Parser
  - Language design:
    - Encapsulation of LED display
    - Types
    - Functions
- Simulator
- Hardware interface
  - Components
  - Communication protocol
  - Signal converting

Components


Program
Interpreter
Tokenizer (Lex)
Parser (Yacc)
Simulator
LEDs

Parser

- PLY (Python Lex-Yacc)
  - Extensive error checking
  - Ambiguity resolution via precedence rules
- Output: array representing LED color channels
  - Analogous to skipping Assembly, straight to machine code

Language

- Nested brackets for all commands
  - No ambiguity as to order of operations
- RGB/HSV operations
  - Colorsys module
- Operations performed at current time for simplicity
- Functionality limited by resolution

LED Representation

- **4** : floors
- **70** : LEDs/floor
- **3** : color channels for defining colorspace
- **t** : visualization program length (default 250)
- **4 x 70 x 3 x t** array
  - Passed to simulator and/or hardware controller

- Encapsulated in Display(), along with the current time

Types

Type	Definition	Form(s)
Range	x- and y- pixels/ranges of LED array	int * int, (int * int) * (int * int)
Move	For looking to other LED pixels	int, neg
Timevar	Positive integer	int
Num	Float or positive integer	float, int
Int	Positive integer	int
Neg	Negative integer	neg
Float	Floating point	float
Signal	A wave with color	Numpy.array((3, n))
Wave	Length n vector defining how signal modulates; n is usually remaining time left in program	Numpy.array((1,n))
Colorspace	Color channels	(int * int * int)

Functions (incomplete list)

Function	Syntax
time	timevar -> null
shift	range * range * move * move * int -> null
wait	timevar -> null
set	range * range * signal -> null
decay	timevar * signal -> signal
add	signal * signal -> signal
merge	int * colorspace * wave -> signal
pulse	timevar -> wave
sin	num -> wave

Sample programs

- Rainbow:

```
[time 500]
[set (0 69) (0 3) [merge 0 (0.8 0.1 0.5) [sin 500]]]
```

- Bars:

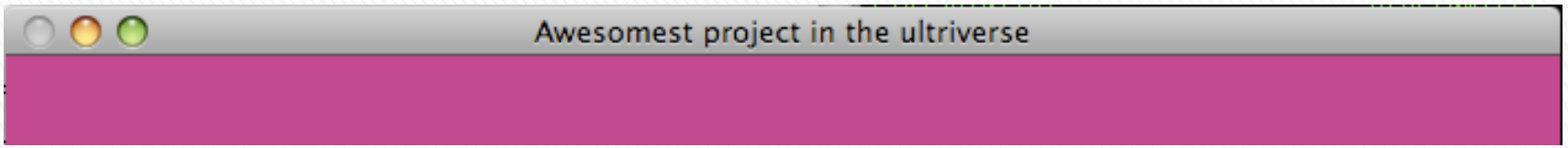
```
[time 130]
[set (0 69) 0 [decay end [merge 2 (0.01 0.5 0.9) [pulse end]]]]
[set (0 69) 1 [decay end [merge 2 (0.1 0.2 1) [pulse end]]]]
[set (0 69) 2 [decay end [merge 0 (0.3 0.2 0.8) [pulse end]]]]
[set (0 69) 3 [decay end [merge 0 (0.7 0.1 0.5) [pulse end]]]]
[wait 5]
[shift (0 69) 0 -1 0 70]
[wait 10]
[shift (0 69) 1 1 0 70]
[wait 15]
[shift (0 69) 2 -1 0 70]
[wait 5]
[shift (0 69) 3 1 0 70]
```

Language Limitations

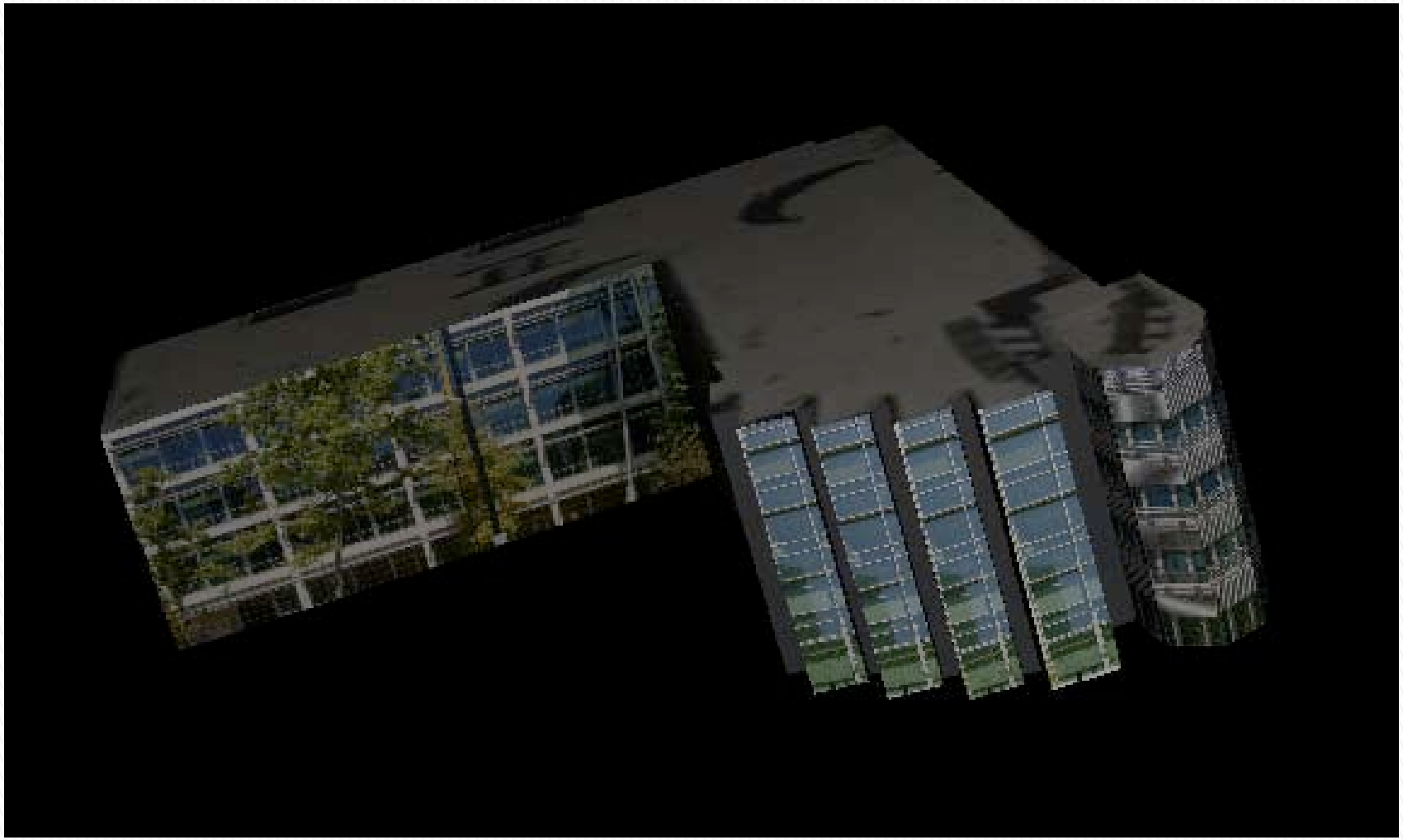
- Set-in-space not time
- Lack of variables (except end)
- Signals cannot be saved
- Color normalization
- Amplitude of signal ill-defined

Simulator

- Write pixel values to screen
- Cross Platform (Win/Linux/OSX)
- Draw pixels with OpenGL
- OpenGL's origin is different than array origin, for loops suck in Python so implementation reshuffles array data
- Need thorough verification because we are using it to make inferences about correctness



Simulator ‘99



Simulator 2000™ preview

Hardware

- 4D array to DMX signal converting
- Enttec DMX USB Pro
- Color Kinetics power supplies and fixtures

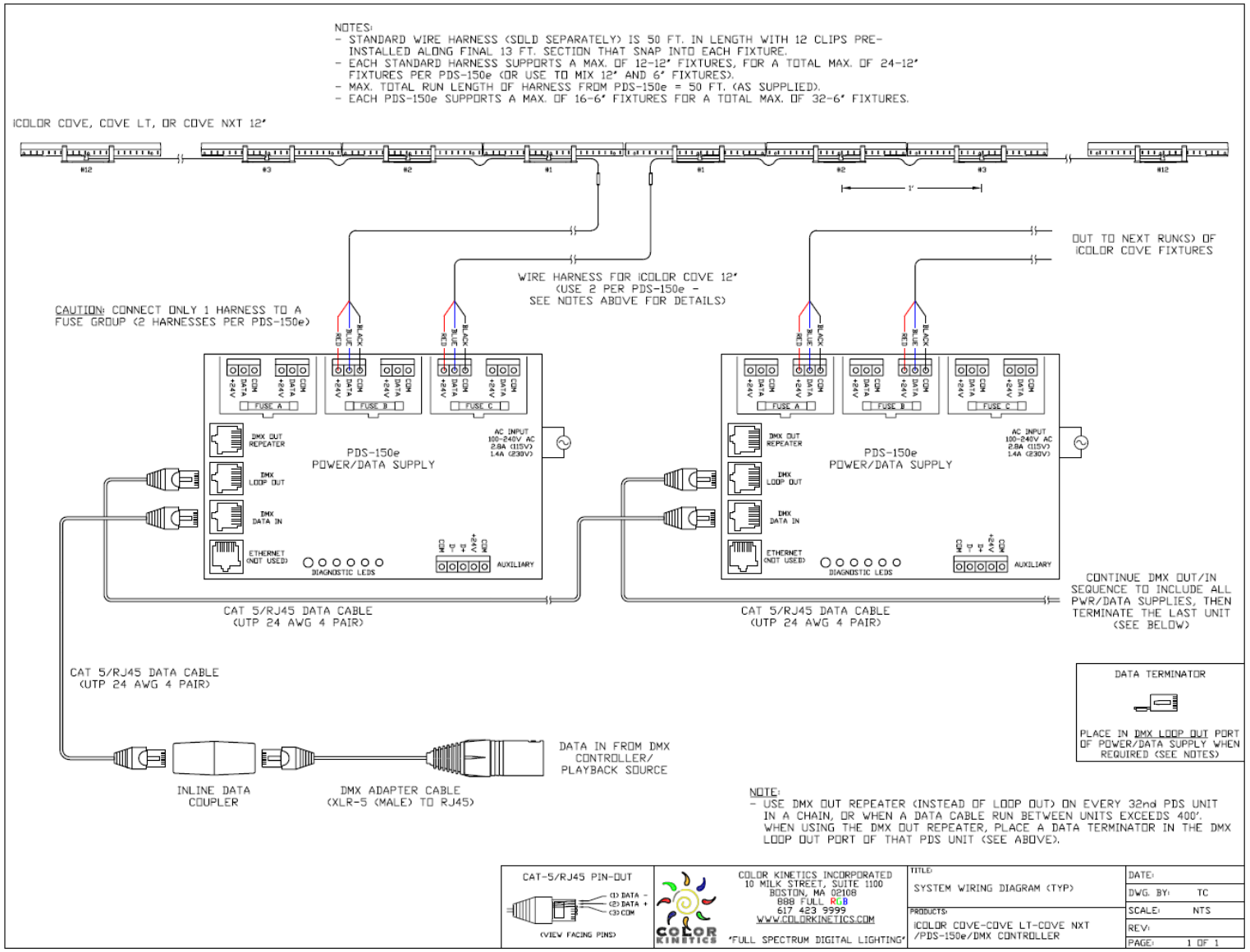
DMX512

- DMX512 is a standard for digital communication most commonly used for stage lighting
- 512 channels per universe
  - 1 byte per channel
  - 3 channels per fixture

Signal Converting

- Use DMX signaling convention to construct byte array at each time interval
- Transmit to USB Pro through serial USB port connection
- Signaling convention:

Size in Bytes	Description
1	Start of message delimiter, 0x7E
1	Label to identify type of message (0x06 for sending)
1	Data length LSB.
1	Data length MSB.
data_length	Data bytes.
1	End of message delimiter, 0xE7



Wiring Diagram

Hardware Limitations

- 512 channels limit us to 170 fixtures or just shy of 2.5 floors.
  - Possible to have multiple universes but requires additional hardware
- Not easy to translate from specific color to lighting configuration except basics
- Need to run Ethernet wires to connect the floors
  - May need to boost the signal along the way
- Floors were not configured properly to begin with so all fixtures will need to be readdressed.

Future Work

- Integrate optimization techniques
- More informative, language-specific error checking
- Added functionality of language:
  - set-in-time
  - Repeat a pattern
  - Randomizer
- Additional floors
- Simulator 2000

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Demo