Wei-Hsuan Cheng

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OPTIONS

This is an experimental personal website for **Wei-Hsuan Cheng**, a MSc student at *department of biomechatronics engineering, national Taiwan university (NTU)*.

Wei-hsuan Cheng's research interest lies on `control` and `robotics`, and the application of `geometric algebra` in robotics.

Reach out if you're intereted in what I'm doing!

- **3 ways for making hyperlinks**
    1. https://bivector.net/ or clifford: Geometric Algebra for Python
    2. **Straightlinks and customlinks**
        - Straightlink: *Just logic*
        - *Customlink*
    3. Targetedlinks: */Justcode/Options*

Danger: Danger is red.

Caution: Caution is orange.

Tip: Tip is green.

Note: Note is blue.

- list item
- another item

Out of the admonition.

CHAPTER

ONE

JUST LOGIC

justlogic

1.1 Key goals

keygoals

1.1.1 Number list

1. one
2. two
3. three
4. four

1.1.2 Bulleted list

- **ONE**
  - a
  - b
- *TWO*
- THREE
- FOUR

1.2 Options

1.2.1 CodeMaster

1.2.2 Robot turtles

1.2.3 Primo/cubetto

CHAPTER

TWO

JUST CODE

2.1 Key goals

2.2 Options

Hi are you from the targetedlinks in homepage?

2.2.1 Scratch

2.2.2 KidsRuby

2.2.3 Python

Here is some Python code for *GA* environment setup:

```
from clifford.g2c import *

point = up(2 * e1 + e2)
line = up(3 * e1 + 2 * e2) ^ up(3 * e1 - 2 * e2) ^ einf
circle = up(e1) ^ up(-e1 + 2 * e2) ^ up(-e1 - 2 * e2)

# point and line reflected in the circle

point_refl = circle * point.gradeInvol() * ~circle
line_refl = circle * line.gradeInvol() * ~circle

# pyganja
from pyganja import GanjaScene, draw
import pyganja; pyganja.__version__

# GanjaScene: build scenes out of geometric objects, with attached labels and RGB colors:

sc = GanjaScene()
sc.add_object(point, color=(255, 0, 0), label='point')
sc.add_object(line, color=(0, 255, 0), label='line')
sc.add_object(circle, color=(0, 0, 255), label='circle')

sc_refl = GanjaScene()
```

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```
sc_refl.add_object(point_refl, color=(128, 0, 0), label='point_refl')
sc_refl.add_object(line_refl, color=(0, 128, 0), label='line_refl')

draw(sc, sig=layout.sig, scale=0.5)
draw(sc + sc_refl, sig=layout.sig, scale=0.5) # A cool feature of GanjaScene is the␣
↪ability to use "+" to draw both scenes together:

# mpl_toolkits.clifford

from matplotlib import pyplot as plt
plt.ioff()  # we'll ask for plotting when we want it

# if you're editing this locally, you'll get an interactive UI if you uncomment the␣
↪following
#
#    %matplotlib notebook

from mpl_toolkits.clifford import plot
import mpl_toolkits.clifford; mpl_toolkits.clifford.__version__

# standard matplotlib stuff - construct empty plots side-by-side, and set the scaling
fig, (ax_before, ax_both) = plt.subplots(1, 2, sharex=True, sharey=True)
ax_before.set(xlim=[-4, 4], ylim=[-4, 4], aspect='equal')
ax_both.set(xlim=[-4, 4], ylim=[-4, 4], aspect='equal')

# plot the objects before reflection on both plots
for ax in (ax_before, ax_both):
    plot(ax, [point], color='tab:blue', label='point', marker='x', linestyle=' ')
    plot(ax, [line], color='tab:green', label='line')
    plot(ax, [circle], color='tab:red', label='circle')

# plot the objects after reflection, with thicker lines
plot(ax_both, [point_refl], color='tab:blue', label='point_refl',  marker='x', linestyle=
↪' ', markeredgewidth=2)
plot(ax_both, [line_refl], color='tab:green', label='line_refl', linewidth=2)

fig.tight_layout()
ax_both.legend()

# show the figure
fig
```

And here is some C# code:

```
private static string GetMessageFromException(Exception ex)
{
    if (ex == null) return "";
    if (ex.InnerException != null)
    {
        return GetMessageFromException(ex.InnerException);
    }
    return ex.Message;
```

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```
}
```

2.2.4 Hopscotch

This is my cat,

This is GA study group icon

CHAPTER

THREE

CONTENT

Table 1: Making tables (*e.g.* csv-table)

Platform	Self-contained?	Cost	Flexibility
Raspberry Pi	No	$30	Limitless
Lego mindstorms	Yes	$350	Medium

3.1 Accepted content guidelines

3.2 Making suggestions

3.3 What to include

CHAPTER

FOUR

WORKFLOW

4.1 Overview

4.2 Key scenarios

4.2.1 Add new page(s)

4.2.2 Editing existing page(s)

2D and 3D CGA Practice

CHAPTER

FIVE

CONFORMAL GEOMETRIC ALGEBRA (CGA)

- https://clifford.readthedocs.io/en/latest/tutorials/cga/index.html

[2]:
```
from numpy import pi,e
from clifford import Cl, conformalize

# demo of conformal in G2, prducing a CGA of G3,1

G2, blades_g2 = Cl(2)

blades_g2 # inspect the G2 blades

# now, conformalize it

G2c, blades_g2c, stuff = conformalize(G2)

blades_g2c   #inspect the CGA blades

stuff

locals().update(blades_g2c)
locals().update(stuff)

x = e1 + e2
X = up(x)
X
down(X)

##### Operations #####

# Versors purely in E0

a= 1 * e1 + 2 * e2
b= 3 * e1 + 4 * e2

# Inversions (reflections in ep)

assert(down(ep * up(a) * ep)  == a.inv())

# Involutions
```

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```
assert(down(E0 * up(a) * E0) == -a)

# Dilations
from numpy.random import rand
from numpy.lib.scimath import log



D = lambda alpha: e ** ((-log(alpha) / 2) * (E0))
alpha = rand()
assert(down( D(alpha) * up(a) * ~D(alpha)) == (alpha * a))


# Versors partly in E0

# Translations

T = lambda x: e ** (1 / 2 * (einf * x))
assert(down( T(a) * up(b) * ~T(a)) == b + a)

# Transversions

V = ep * T(a) * ep
assert ( V == 1 + (eo * a))

K = lambda x: 1 + (eo * a)

B = up(b)
assert( down(K(a) * B * ~K(a)) == 1 / (a + 1 / b) )

# Versors out of E0

m = 5 * e1 + 6 * e2
n = 7 * e1 + 8 * e2

# Reflections

assert(down(m * up(a) * m) == -m * a * m.inv())

# Rotations

R = lambda theta: e ** ((-.5*theta) * (e12))
theta = pi / 2
assert(down( R(theta) * up(a) * ~R(theta)) == R(theta) * a * ~R(theta))

##### Combinations of Operations #####

# Simple Example

A = up(a)
V = T(e1) * E0 * D(2)
B = V * A * ~V
```

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```
assert(down(B) == (-2 * a) + e1 ) # combination operations of translation,scaling, and␣
↪inversion.

# Transversion

A = up(a)
V = ep * T(b) * ep
C = V * A * ~V
assert(down(C) ==1 / (1 / a + b)) # A transversion may be built from a inversion,␣
↪translation, and inversion.

##### Testing #####
```

CHAPTER

SIX

G2C

[3]:
```
from clifford.g2c import *

point = up(2 * e1 + e2)
line = up(3 * e1 + 2 * e2) ^ up(3 * e1 - 2 * e2) ^ einf
circle = up(e1) ^ up(-e1 + 2 * e2) ^ up(-e1 - 2 * e2)

# point and line reflected in the circle

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sc.add_object(circle, color=(0, 0, 255), label='circle')

sc_refl = GanjaScene()
sc_refl.add_object(point_refl, color=(128, 0, 0), label='point_refl')
sc_refl.add_object(line_refl, color=(0, 128, 0), label='line_refl')

draw(sc, sig=layout.sig, scale=0.5)
draw(sc + sc_refl, sig=layout.sig, scale=0.5) # A cool feature of GanjaScene is the␣
↪ability to use "+" to draw both scenes together:

# mpl_toolkits.clifford

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↪following
#
#    %matplotlib notebook
```

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```
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import mpl_toolkits.clifford; mpl_toolkits.clifford.__version__

# standard matplotlib stuff - construct empty plots side-by-side, and set the scaling
fig, (ax_before, ax_both) = plt.subplots(1, 2, sharex=True, sharey=True)
ax_before.set(xlim=[-4, 4], ylim=[-4, 4], aspect='equal')
ax_both.set(xlim=[-4, 4], ylim=[-4, 4], aspect='equal')

# plot the objects before reflection on both plots
for ax in (ax_before, ax_both):
    plot(ax, [point], color='tab:blue', label='point', marker='x', linestyle=' ')
    plot(ax, [line], color='tab:green', label='line')
    plot(ax, [circle], color='tab:red', label='circle')

# plot the objects after reflection, with thicker lines
plot(ax_both, [point_refl], color='tab:blue', label='point_refl',  marker='x', linestyle=
↪' ', markeredgewidth=2)
plot(ax_both, [line_refl], color='tab:green', label='line_refl', linewidth=2)

fig.tight_layout()
ax_both.legend()

# show the figure
fig
```
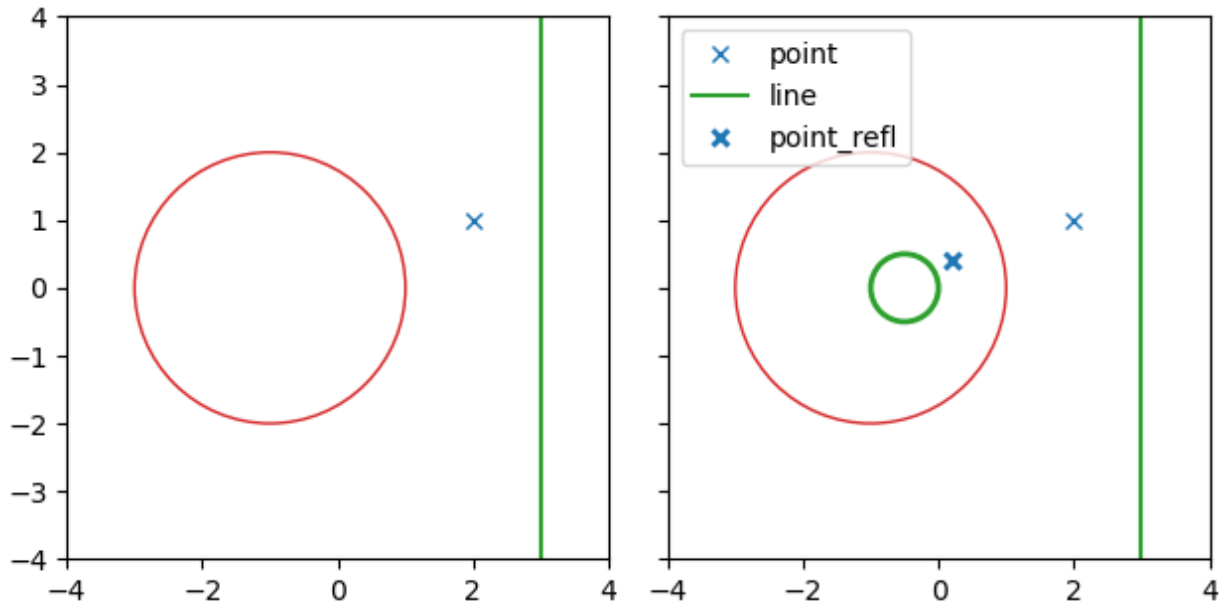

```
c:\Users\RMML05\anaconda3\lib\site-packages\pyganja\__init__.py:2: UserWarning: Failed␣
↪to import cef_gui, cef functions will be unavailable
  from .script_api import *
```

```
<IPython.core.display.Javascript object>
```

```
<IPython.core.display.Javascript object>
```

[3]:



CHAPTER

SEVEN

G3C

[4]:
```
from clifford.g3c import *

point = up(2 * e1 + e2)
line = up(3 * e1 + 2 * e2) ^ up(3 * e1 - 2 * e2) ^ einf
circle = up(e1) ^ up(-e1 + 1.6 * e2 + 1.2 * e3) ^ up(-e1 - 1.6 * e2 - 1.2 * e3)
sphere = up(3 * e1) ^ up(e1) ^ up(2 * e1 + e2) ^ up(2 * e1 + e3)

# note that due to floating point rounding, we need to truncate back to a single grade␣
↪here, with ``(grade)``
point_refl = homo((circle * point.gradeInvol() * ~circle)(1))
line_refl = (circle * line.gradeInvol() * ~circle)(3)
sphere_refl = (circle * sphere.gradeInvol() * ~circle)(4)

# pyganja

sc = GanjaScene()
sc.add_object(point, color=(255, 0, 0), label='point')
sc.add_object(line, color=(0, 255, 0), label='line')
sc.add_object(circle, color=(0, 0, 255), label='circle')
sc.add_object(sphere, color=(0, 255, 255), label='sphere')

sc_refl = GanjaScene()
sc_refl.add_object(point_refl, color=(128, 0, 0), label='point_refl')
sc_refl.add_object(line_refl.normal(), color=(0, 128, 0), label='line_refl')
sc_refl.add_object(sphere_refl.normal(), color=(0, 128, 128), label='sphere_refl')

draw(sc + sc_refl, scale=0.5)

# mpl_toolkits.clifford

# standard matplotlib stuff - construct empty plots side-by-side, and set the scaling
fig, (ax_before, ax_both) = plt.subplots(1, 2, subplot_kw=dict(projection='3d'),␣
↪figsize=(8, 4))
ax_before.set(xlim=[-4, 4], ylim=[-4, 4], zlim=[-4, 4])
ax_both.set(xlim=[-4, 4], ylim=[-4, 4], zlim=[-4, 4])

# plot the objects before reflection on both plots
for ax in (ax_before, ax_both):
    plot(ax, [point], color='tab:red', label='point', marker='x', linestyle=' ')
    plot(ax, [line], color='tab:green', label='line')
```

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```
    plot(ax, [circle], color='tab:blue', label='circle')
    plot(ax, [sphere], color='tab:cyan')  # labels do not work for spheres: pygae/mpl_
↪toolkits.clifford#5

# plot the objects after reflection
plot(ax_both, [point_refl], color='tab:red', label='point_refl', marker='x', linestyle='
↪', markeredgewidth=2)
plot(ax_both, [line_refl.normal()], color='tab:green', label='line_refl', linewidth=2)
plot(ax_both, [sphere_refl], color='tab:cyan')

fig.tight_layout()
ax_both.legend()

# show the figure
fig
```

```
<IPython.core.display.Javascript object>
```

[4]: