Introduction Advancement in AR and Computer Graphics

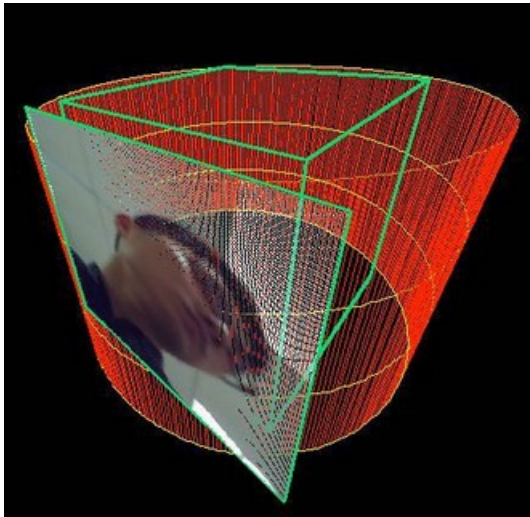**1** Pixel Graphics and Vector Graphics as the foundation

http://opencv.org/

www.opengl.org

2 https://xinreality.com/wiki/Input_Devices
IoT as a tool for better User Interface Experience, in 3D spaces

Accelerometer: senses the speed of the moving object in a particular direction. The accelerometer calculates the speed of the controller in the three axis

Intel realsense, Microsoft hololens etc , including gesture tracker

4 CUDA GPU as core processing engine

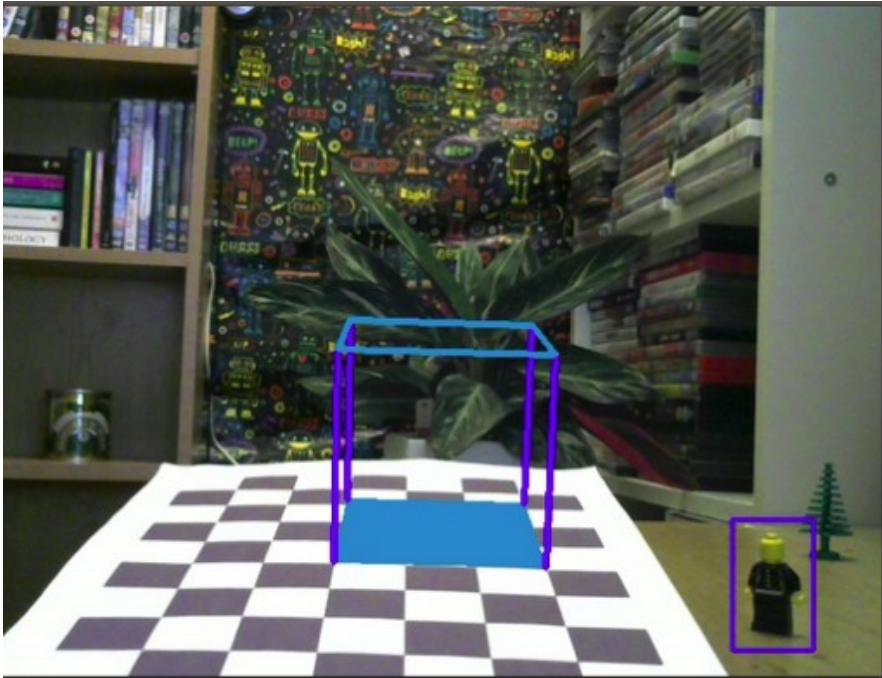Embedded GPU Tx2 or GPU for x86 platform

Tx2 NVDA

3 Smart phone becomes a popular deployment platform

https://www.marxentlabs.com/5-top-virtual-reality-augmented-reality-technology-trends-2017/

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Build OpenCV with OpenGL

https://docs.opencv.org/3.0-beta/modules/core/doc/opengl_interop.html

https://www.google.com/search?
q=opencv+plot+3d+points&tbm=isch&tbo=u&source=univ&s
a=X&ved=2ahUKEwid7c3s8YHdAhWZGTQIHWY3DVYQsA
R6BAgFEAE&biw=1301&bih=670#imgrc=ay8X4Woc_dbqB
M:

sudo apt-get install libgtkglext1-dev

OpenGL interoperability

To enable OpenGL, configure OpenCV CMake with WITH_OPENGL=ON . Currently OpenGL is supported only with WIN32, GTK and Qt backends on Windows and Linux (MacOS and Android are not supported). For GTK backend gtkglext-1.0 library is required.

use of the cmake flag

cmake -DWITH_OPENGL=ON ..

To use OpenGL functionality you should first create OpenGL context (window or frame buffer). You can do this with namedWindow() function or with other OpenGL toolkit (GLUT, for example).

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First OpenGL Program

OpenGL comes with Ubuntu preinstalled. However, you will have to install glut.h as follows

sudo apt-cache search glut

After you have installed package freeglut3-dev you can confirm it contains the needed GL files by issuing

dpkg -L freeglut3-dev

which will list contents of the package which include :

/usr/include/GL
/usr/include/GL/freeglut.h
/usr/include/GL/freeglut_ext.h
/usr/include/GL/freeglut_std.h
/usr/include/GL/glut.h
/usr/lib/x86_64-linux-gnu/libglut.a
...
/usr/lib/x86_64-linux-gnu/libglut.so

OpenGL For A Line Segment

```
/*****************************************************
 * Program: line.c   Coded by: Harry Li         *
 * Version: x1.0;    status: tested;            *
 * Compile and build:                           *
 * gcc main.cpp -o main.o -lGL -lGLU -lglut     *
 * Date: Jun 5, 2014                            *
 * Purpose: Graphics Demo.                      *
 ****************************************************/

#include<GL/glut.h>
#include<stdio.h>
void mydisplay()
{ //the window coordinates (-1.0, 1.0)
float p1x=1.0f,p1y=1.0f;
float p2x=-1.0f,p2y=-1.0f;
glClear(GL_COLOR_BUFFER_BIT);
glLoadIdentity();
glBegin(GL_LINES);
glVertex2f(p1x,p1y);
glVertex2f(p2x,p2y);
glEnd();
glFlush();
usleep(50);
}
```

```
int main(int argc, char** argv)
{
glutInit(&argc,argv);
glutCreateWindow("Harry: test");
glutDisplayFunc(mydisplay);
glutMainLoop();
}
```
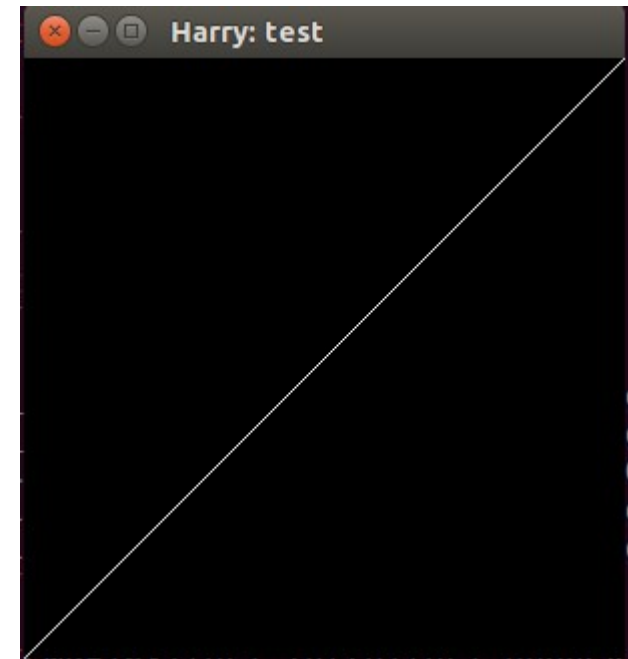
OpenGL Sample Code (1)

```c
/*****************************************************
 * Program: line.c   Coded by: Harry Li           *
 * Version: x1.0;    status: tested;              *
 * gcc main.cpp -o main.o -lGL -lGLU -lglut       *
 * Date: Jun 5, 2014                              *
 * Purpose: 2D grids demo                         *
 *****************************************************/
#include<GL/glut.h>
#include<stdio.h>
void mydisplay()
{ //define virtex for the square
float p1x=1.0f,p1y=1.0f;
float p2x=1.0f,p2y=0.0f;
float p3x=0.0f,p3y=0.0f;
float p4x=0.0f,p4y=1.0f;
int r, i;
float grid, float_r;
//define the x-y axis
float px1x=0.0f,px1y=0.5f, px2x=1.0f, px2y=0.5f;
float px3x=0.5f,px3y=0.0f, px4x=0.5f, px4y=1.0f;
glClear(GL_COLOR_BUFFER_BIT);
glLoadIdentity();
glTranslatef(-0.5f,-0.5f,0.0f);
```

```c
glFlush();
Sleep(1);
//-------draw square------------------//
glBegin(GL_LINES);
//draw square
glVertex2f(p1x,p1y);
glVertex2f(p2x,p2y);
glVertex2f(p2x,p2y);
glVertex2f(p3x,p3y);
glVertex2f(p3x,p3y);
glVertex2f(p4x,p4y);
glVertex2f(p4x,p4y);
glVertex2f(p1x,p1y);
glEnd();
```
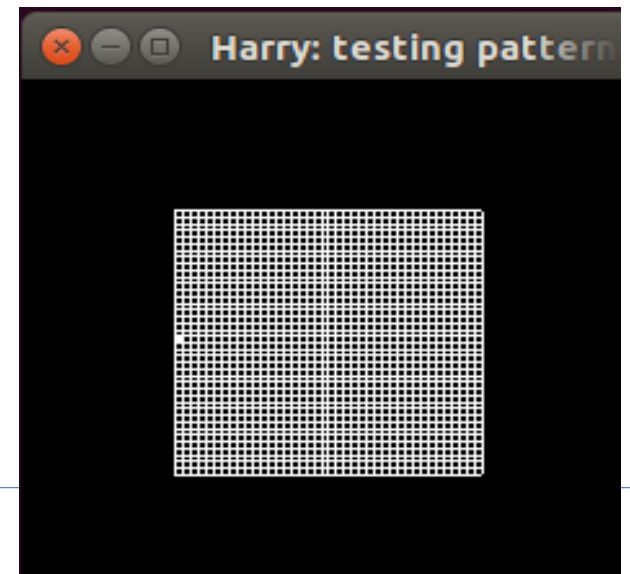
OpenGL Sample Code (2)

```
//-------draw x-y axis-----------------//
glBegin(GL_LINES);
glVertex2f(px1x,px1y);
glVertex2f(px2x,px2y);
glVertex2f(px3x,px3y);
glVertex2f(px4x,px4y);
glEnd();
//-------draw grids-----------------//
float_r = 20.0; r =  float_r;
grid = 1.0/(2*float_r);

glBegin(GL_LINES);
for (i=0; i < r; i++) {
glVertex2f(px1x,px1y+i*grid);  //x, upper half
glVertex2f(px2x,px2y+i*grid);
glVertex2f(px1x,px1y-i*grid);   //x, lower half
glVertex2f(px2x,px2y-i*grid);
glVertex2f(px3x+i*grid,px3y);  //y, right half
glVertex2f(px4x+i*grid,px4y);
glVertex2f(px3x-i*grid,px3y);   //y, left half
glVertex2f(px4x-i*grid,px4y);
}
glEnd();
```

```
//-------draw grid polygon---------------//
glBegin(GL_POLYGON);
glVertex2f(px1x, px1y);
//px1y = px1y + grid;
glVertex2f(px1x, px1y);
glVertex2f(px1x, px1y+grid);
glVertex2f(px1x+grid, px1y+grid);
glVertex2f(px1x+grid, px1y);
glEnd();
glFlush();
usleep(50);
}
```

```
int main(int argc, char** argv)
{
glutInit(&argc,argv);
glutCreateWindow("Harry: testing
pattern: square");
glutDisplayFunc(mydisplay);
glutMainLoop();
}
```

Vector Graphics 2D Rotating Square (1)

```
/****************************************************
 * Program: LinePattern.c                           *
 * Purpose: Rotation square based vectors           *
 * Compile and build:                               *
 *         gcc -lGU -lGLU -lglut                     *
 ***************************************************/
#include<GL/glut.h>
#include<stdio.h>
#define MAX_LEVEL 35
#define LAMBDA 0.1
void mydisplay()
{
float p1x=1.0f,p1y=1.0f,p2x=1.0f,p2y=0.0f;
float p3x=0.0f,p3y=0.0f,p4x=0.0f,p4y=1.0f;
int i=0;
glClear(GL_COLOR_BUFFER_BIT);
glLoadIdentity();
glTranslatef(-0.5f,-0.5f,0.0f);
glFlush();
sleep(1);
```


Harry: Vector Based Rotation S

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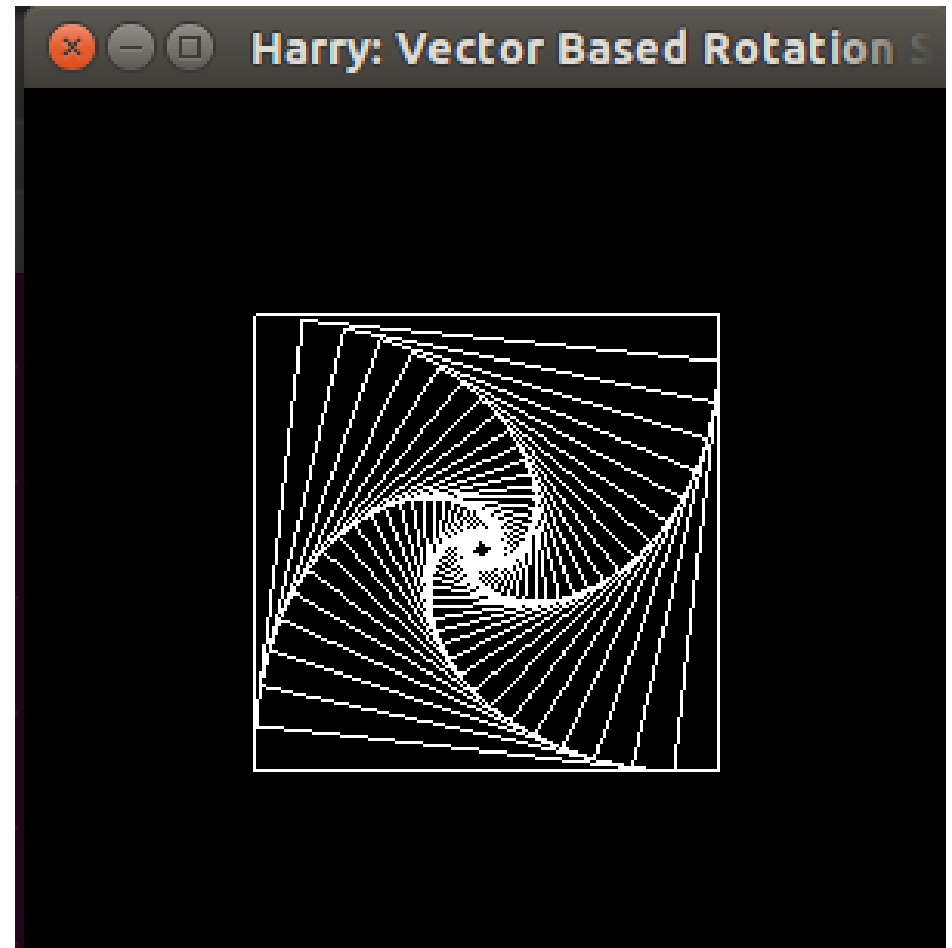
Vector Graphics 2D Rotating Square (2)

```
for(i=0;i<MAX_LEVEL;i++)
{ glBegin(GL_LINES);
 glVertex2f(p1x,p1y);
glVertex2f(p2x,p2y);
glVertex2f(p2x,p2y);
glVertex2f(p3x,p3y);
glVertex2f(p3x,p3y);
glVertex2f(p4x,p4y);
glVertex2f(p4x,p4y);
glVertex2f(p1x,p1y);

p1x=p1x + (LAMBDA * (p2x-p1x));
p1y=p1y + (LAMBDA * (p2y-p1y));
p2x=p2x + (LAMBDA * (p3x-p2x));
p2y=p2y + (LAMBDA * (p3y-p2y));
p3x=p3x + (LAMBDA * (p4x-p3x));
p3y=p3y + (LAMBDA * (p4y-p3y));
p4x=p4x + (LAMBDA * (p1x-p4x));
p4y=p4y + (LAMBDA * (p1y-p4y));
glEnd();
glFlush();
usleep(50000);
}
}
```

```
int main(int argc, char** argv)
{
glutInit(&argc,argv);
glutCreateWindow("Harry: Vector Square");
glutDisplayFunc(mydisplay);
glutMainLoop();
}
```