Note: Define x_w-y_w-z_w.

```
//define the x-y-z world coordinate
world.X[0] = 0.0;    world.Y[0] =  0.0;   world.Z[0] =  0.0;    // origin
world.X[1] = 50.0;   world.Y[1] =  0.0;   world.Z[1] =  0.0;    // x-axis
world.X[2] = 0.0;    world.Y[2] =  50.0;  world.Z[2] =  0.0;    // y-axis
world.X[3] = 0.0;    world.Y[3] =  0.0;   world.Z[3] = 50.0;    // y-axis
```

Font Design

```
//----------letter--------------------*
letterL.X[0] = 10.0; letterL.Y[0] = 10.0;
letterL.X[1] = 20.0; letterL.Y[1] = 10.0;
letterL.X[2] = 20.0; letterL.Y[2] = 40.0;
letterL.X[3] = 40.0; letterL.Y[3] = 10.0;
letterL.X[4] = 50.0; letterL.Y[4] = 10.0;
letterL.X[5] = 30.0; letterL.Y[5] = 50.0;
```

For $\sin\theta$, $\cos\theta$, $\sin\phi$, $\cos\phi$ in the matrix of the transformation pipeline.

```
//sin and cosine computation for world-to-viewer
float sPheta = Ye / sqrt(pow(Xe,2) + pow(Ye,2));
float cPheta = Xe / sqrt(pow(Xe,2) + pow(Ye,2));
float sPhi = sqrt(pow(Xe,2) + pow(Ye,2)) / Rho;
float cPhi = Ze / Rho;
```

Note: Define $\vec{P_s}(x_s, y_s, z_s)$

```
world.X[45] = -200.0; world.Y[45] = 50.0; world.Z[45] = 200.0; // Ps (point source)
world.X[46] = 0; world.Y[46] = 0; world.Z[46] = 0; // arbitrary vector A on x-y plane
world.X[47] = 0; world.Y[47] = 0; world.Z[47] = 1; // normal vector for x-y plane
```

Define $\vec{a}$, $\vec{n}$ for $\vec{n} \cdot (\vec{v} - \vec{a}) = 0$

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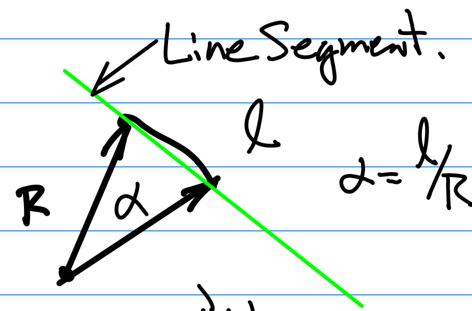
for $\vec{R}$ Ray Equation's

```
//----------lambda for Intersection pt on xw-yw plane---------
float temp = (world.X[47]*(world.X[46]-world.X[45]))
            +(world.Y[47]*(world.Y[46]-world.Y[45]))
            +(world.Z[47]*(world.Z[46]-world.Z[45]));
float lambda = temp / ((world.X[47]*(world.X[45]-world.X[7]))
                      +(world.Y[47]*(world.Y[45]-world.Y[7]))
                      +(world.Z[47]*(world.Z[45]-world.Z[7])));
float lambda_2 = temp / ((world.X[47]*(world.X[45]-world.X[6]))
                        +(world.Y[47]*(world.Y[45]-world.Y[6]))
                        +(world.Z[47]*(world.Z[45]-world.Z[6])));
```

Find the intersection Points.

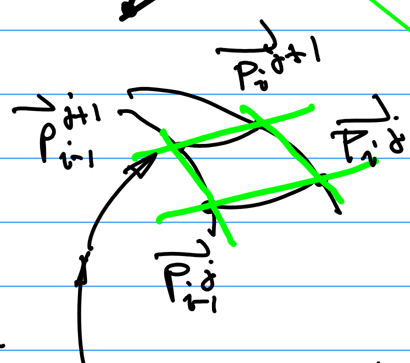
```
//-----------ray equation to find intersection pts------------*
world.X[48] = world.X[45] + lambda*(world.X[45] - world.X[7]); // Ir
world.Y[48] = world.Y[45] + lambda*(world.Y[45] - world.Y[7]); // Ir
world.Z[48] = 0.0;
```

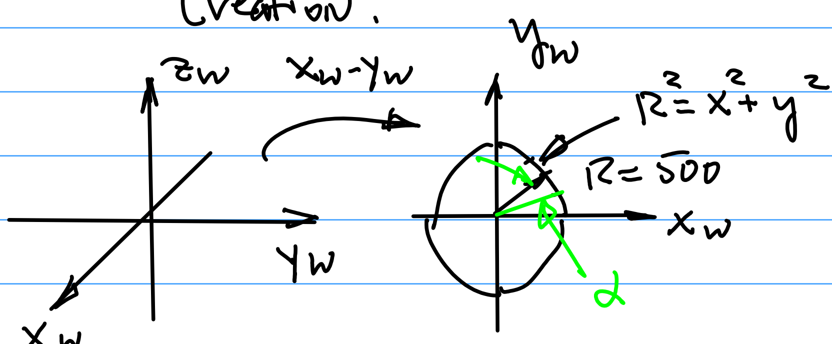


April 17 (Monday).

Note 1: Project in 3D is Due in 2 weeks. See the previous Announcement (CANVAS Posting By the end of the Day Today).

Q&A. Spherical Surface Creation.

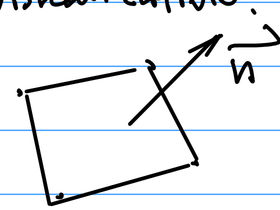




R Reduced By Predefined proportion. Make at least 10 Layers for Better Visualization.

Define incremental α

make smaller $\alpha \simeq 5°$



In Summary, we'll Create a Collection of Points

$$\{ \vec{P_i}(x_i, y_i, z_i) \Big|_{z_i = 0} ; i = 0, 1, \cdots N-1 \}$$

Example:

Ref: Previous Project

2018F-115-lab-DiffuseReflection-Ru...

2018F-116-11diffuse20181114.cpp

Sample code

Digital Differential Algorithm

2018F-117-12dda.cpp $y = ax + b$

2018F-118-13diffuseInterpolation20...

1. Definition.

Directions.

Fig.2

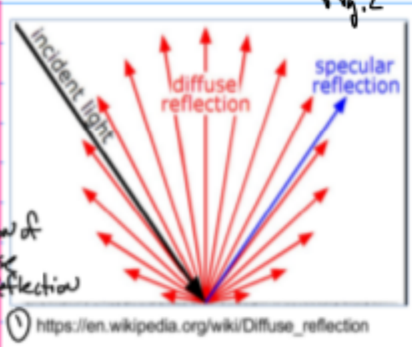


Illustration of Diffuse Reflection

2° Intensity of the Diffuse Reflection, The Intensity of

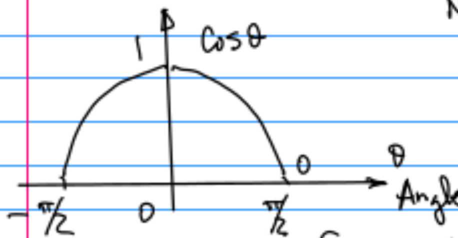
$$I(x, y) = (r(x,y), g(x,y), b(x,y))$$

red green Blue

depends on the incoming angle of the Ray Equation.

From Ref

Nov. 21, 22



(Ray Eqn. & Normal Vector)

Fig.3

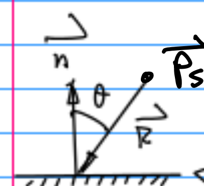


Fig.4

3° Intensity $\sim \frac{1}{(\text{distance})^2}$

Note: $\vec{n}$ Normal Vector of the Surface

$\vec{R}$ Ray Equation from the light Source $\vec{P_s}(x_s, y_s, z_s)$ to the point of Interests

From pp. 48

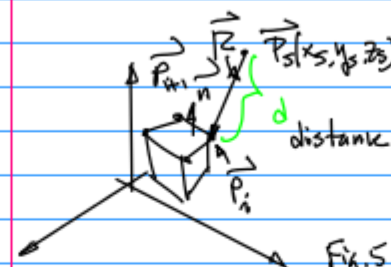


Fig.5

Note: Ray Equations:

$\vec{r_i}$ from $\vec{P_s}, \vec{P_i}$

$\vec{r_{i+1}}$ " $\vec{P_s}, \vec{P_{i+1}}$

$\vdots$

$\vec{r_{i+3}}$ ... $\vec{P_s}, \vec{P_{i+3}}$

From the Ray Equation.

$$\vec{r} = \vec{P_i} + \lambda(\vec{P_s} - \vec{P_i}) \quad \cdots (1)$$

PP57.

$$\vec{n}\cdot\vec{r} = \|\vec{n}\|\|\vec{r}\|\cos\theta \quad \ldots (2)$$

$$\therefore \cos\theta = \frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|} \quad \ldots (3)$$

$I_{diff}(x,y)$ OR $I_d(x,y,z)$

"World"

$$I_d(x,y,z) \hat{\approx} \cos\theta = \frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|} \quad \ldots (4)$$

Next, Consider the distance (Squared)

$$\|\vec{r}\|_2^2 = (x_s - x_i)^2 + (y_s - y_i)^2 + (z_s - z_i)^2$$

mode

then, update Eqn(4),

$$I_d(x,y,z) \hat{\approx} \frac{1}{\|\vec{r}\|_2^2} \frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|} \quad \ldots (5)$$

Now, Let's Consider Reflectivity.

$$\text{Reflectivity } \vec{K_d} = (K_{dr}, K_{dg}, K_{db}) \quad \ldots (6)$$

Red Green Blue

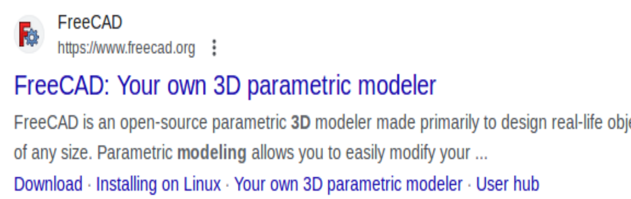
Update Eqn(5) with Reflectivity.
with Simplification, for Each Primitive Color.

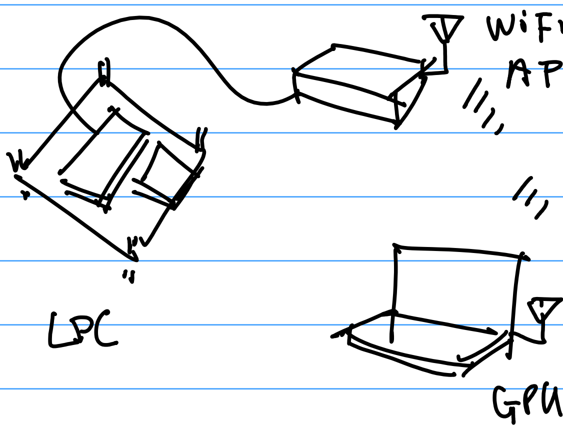
$$\vec{I}_{dr}(x,y) = K_{dr} \frac{1}{\|\vec{r}\|^2} \frac{\vec{r}\cdot\vec{n}}{\|\vec{r}\|\|\vec{n}\|} \quad \ldots (7)$$

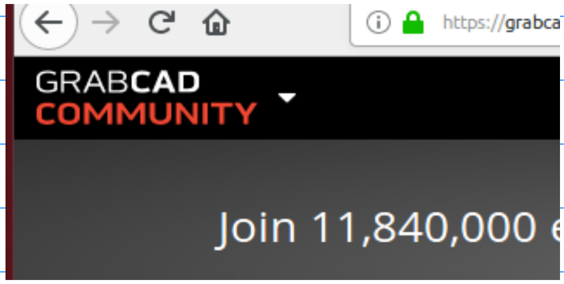
April 12 (Wed).

Note 1. Project Assignment is posted on CANVAS.

2. 5% Bonus for Using/Importing Real 3D CAD Data.







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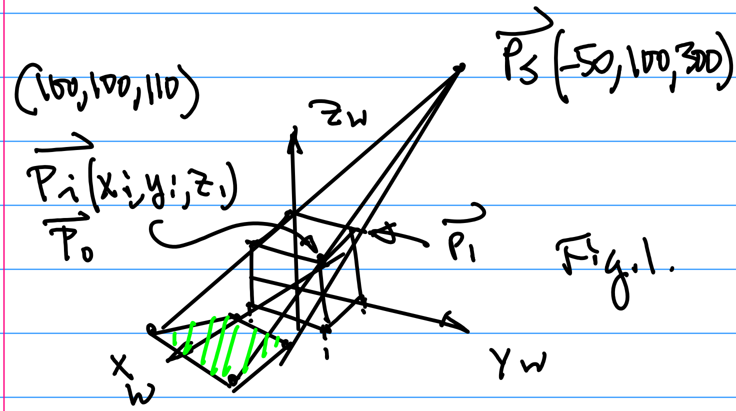


Fig. 1.

$$\|\vec{r}\|^2 = (x_s - x_i)^2 + (y_s - y_i)^2 + (z_s - z_i)^2$$

$$= 150^2 + 0^2 + 190^2$$

Hence, $\frac{1}{\|\vec{r}\|^2} \ll \delta$ ...(1)

which makes $\vec{I_d}(x_0, y_0) \ll \delta$

Therefore, Suppose 8 bits per pixel

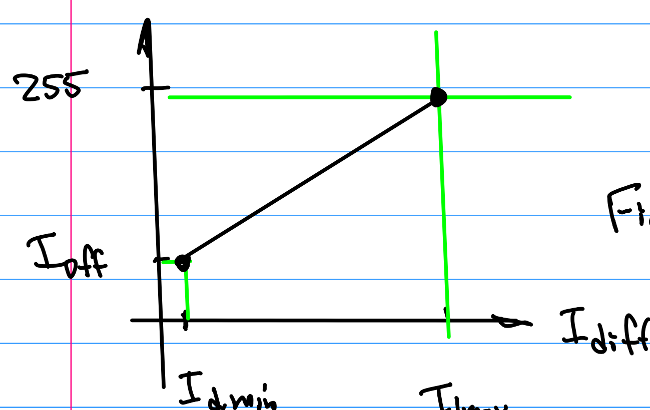


Fig. 2

Where $I_{off} = 20$.

$(I_{d\text{-}min}, I_{off})$ is a point on Fig. 2.

$(I_{dmax}, 255)$ is the other point

Let's define a Linear mapping function

Let

$$(I_{d\text{-}min}, I_{off}) = (x_1, y_1) \quad \ldots (2a)$$

$$(I_{dmax}, 255) = (x_2, y_2) \quad \ldots (2b)$$

then,

$$\frac{y_2 - y_1}{x_2 - x_1} = \frac{y - y_1}{x - x_1} \quad \ldots (3)$$

$$y = bx + c \quad \ldots (4)$$

Now, Suppose we want to display diffuse Reflection for a pixel location (x_i, y_i)

Step 1. Use Eqn (7), pp 39, to find $I_{diff}(x_i, y_i)$

Step 2. Substitute $I_{diff}(x_i, y_i)$ into this Eqn (4)

$$y = bx + c \Big|_{x = I_{diff}(x_i, y_i)}$$

$$= b \cdot I_{diff}(x_i, y_i) + c$$

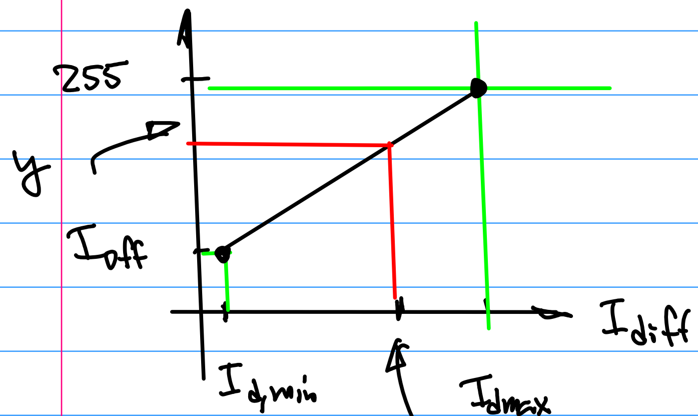


Fig.3

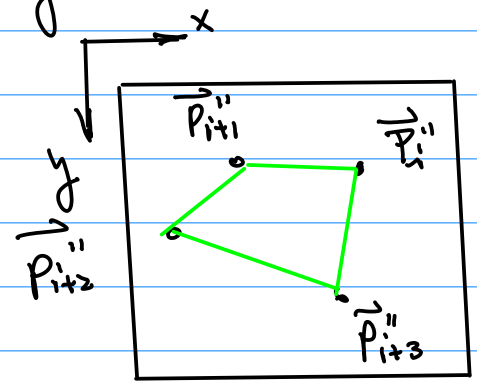


Fig 5

Find Diffuse Reflection on the Boundary Lines (Green).

April 17 (Monday).

Note 1. Check CANVAS for the Last Project Announcement.

y is the final intensity Level for the color.

Sample code Reading for Diffuse Reflection Computing.

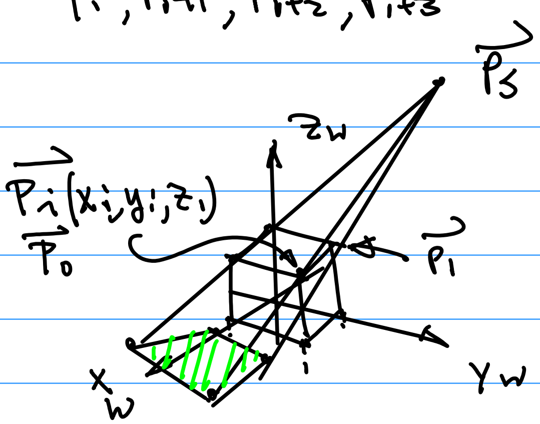
2018F-116-11diffuse20181114.cpp

Now, we have 4 vertices with Diffuse Reflection Result.

$\vec{P}_i, \vec{P}_{i+1}, \vec{P}_{i+2}, \vec{P}_{i+3}$

Example.

Preliminary 1. Intersection Pts. from the Ray Equations



Now, After Perspective Project

Fig.4

```
//------------ray equation to find intersection pts-----------*
world.X[48] = world.X[45] + lambda*(world.X[45] - world.X[7]);
world.Y[48] = world.Y[45] + lambda*(world.Y[45] - world.Y[7]);
world.Z[48] = 0.0;
```

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Note: 1. Define Reflectivity,

```
//------------diffuse reflection----------*
pt_diffuse  diffuse;   //diffuse.r[3]

//-------reflectivity coefficient----------*
#define     Kdr     0.8
#define     Kdg     0.0
#define     Kdb     0.0
```

for Red color.

Note 2. Distance. To Speed up the Computation, No. Sqrt Needed.

```
//--------compute distance----------------*
float distance[UpperBD];
for (int i=48; i<=49; i++) {
distance[i] = sqrt(pow((world.X[i]-world.X[45]),2)+
                    pow((world.Y[i]-world.Y[45]),2)+
                    pow((world.X[i]-world.X[45]),2) );
//std::cout << "distance[i]  " << distance[i] << std::
```

Note 3. Compute cosθ for Diffuse Reflection.

```
tmp_dotProd[i] = world.Z[i]-world.Z[45];
std::cout << " tmp_dotProd[i]  " <<  tmp_dotProd[i] << std::endl;

tmp_mag_dotProd[i] = sqrt(pow((world.X[i]-world.X[45]),2)+          /
                    pow((world.Y[i]-world.Y[45]),2)+
                    pow((world.Z[i]-world.Z[45]),2) );
std::cout << " tmp_mag_dotProd[i]  1 " <<  tmp_mag_dotProd[i] << std

angle[i] = tmp_dotProd[i]/ tmp_mag_dotProd[i];
std::cout << "angle[i]  " << angle[i] << std::endl;
```

Note 4. Theoretical Part of the Diffuse Reflection. The Result is Very Small

```
diffuse.r[i] = Kdr *  angle[i] / pow(distance[i],2) ;
diffuse.g[i] = Kdg *  angle[i] / pow(distance[i],2) ;
diffuse.b[i] = Kdb *  angle[i] / pow(distance[i],2) ;
}
```

Very Big Distance

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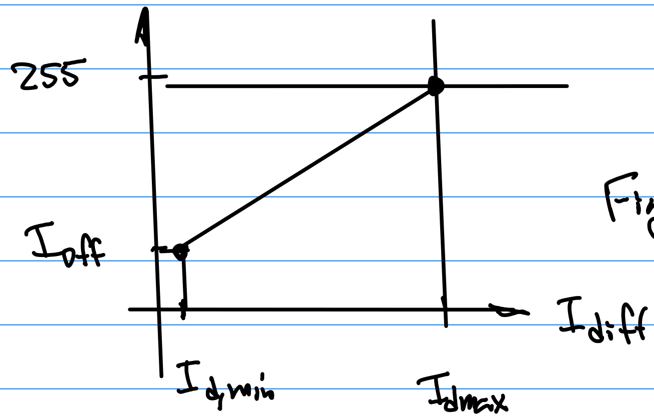

Fig.2

Sample code for the post Processing:

- Add offset = 20
- Map the diffuse Reflection [offset, 255]

CMPE240-Adv-Microprocessors / 2018F / 2022S-101-notes2-cmpe240-2022-04-18.pdf.pdf.20.pdf

```
float r, g, b;
r = display_scaling*diffuse.r[i]+display_shifting;
//r = display_scaling*diffuse.r[i];
g = diffuse.g[i]; b = diffuse.b[i] ;
glColor3f(r, g, b);
```

Post Processing function, PP13

$$\frac{x - x_2}{y - y_2} = \frac{x_1 - x_2}{y_1 - y_2} \quad \cdots (5)$$

Example: Bi-Linear Interpolation of Diffuse Reflection.

From Eqn (5), PP.14.

$$\frac{x - x_2}{y - y_2} = \frac{x_1 - x_2}{y_1 - y_2}$$

$$\frac{y_1 - y_2}{x_1 - x_2} = \frac{y - y_2}{x - x_2}$$

$$y = y_2 + \frac{y_2 - y_1}{x_2 - x_1}(x - x_2) \qquad y = b'x + c'$$

$$\boxed{y = \frac{y_2 - y_1}{x_2 - x_1} x - \frac{y_2 - y_1}{x_2 - x_1} x_2 + y_2} \quad \cdots (1)$$

$$a y = b x + c, \quad y = \frac{b}{a} x + \frac{c}{a} \quad \cdots (2)$$

$$\frac{b}{a} = \frac{y_2 - y_1}{x_2 - x_1} \quad \cdots (2\text{-}b)$$

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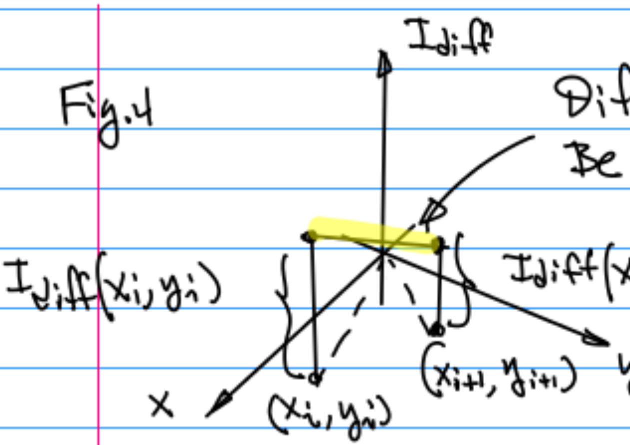
~~$I_{diff}(x_i, y_i)$.~~

/ 2018F / 2020S-APL29-BilinearDiff1.jpg

PP15.

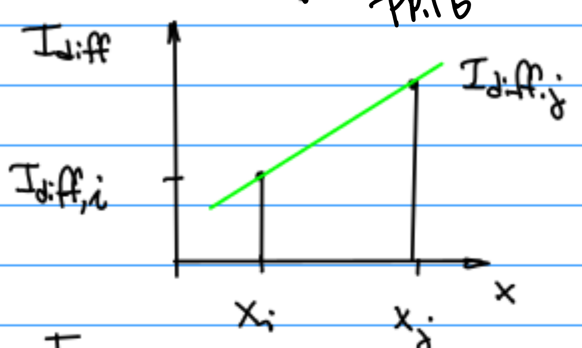
Fig.4



Diffuse Reflection to Be Computed, on the Bounding line with $\vec{P_i}(I_{diff,i})$ and $P_{i+1}(I_{diff,i+1})$ as Starting & Ending point.

x, y are from the Display Device

PP.16



Fig(1.c)

then, derived the following Equations

$$\boxed{y = \frac{y_2 - y_1}{x_2 - x_1} x - \frac{y_2 - y_1}{x_2 - x_1} x_2 + y_2} \quad \cdots (1)$$

$$a\,y = b\,x + c, \quad y = \frac{b}{a} x + \frac{c}{a} \quad \cdots (2)$$

$$\frac{b}{a} = \frac{y_2 - y_1}{x_2 - x_1} \quad \cdots (2\text{-}b)$$

$$\frac{c}{a} = -\frac{y_2 - y_1}{x_2 - x_1} x_2 + y_2 \quad \cdots (2\text{-}c)$$

From,

$$\frac{x - x_2}{y - y_2} = \frac{x_1 - x_2}{y_1 - y_2} \quad \cdots (5)$$

PP.17.

Therefore, 2020S-APL29-BilinearDiff2.jpg

$$I_{diff,x} = \frac{I_{diff,j} - I_{diff,i}}{x_j - x_i} x - \frac{I_{diff,j} - I_{diff,i}}{x_j - x_i} x_j + I_{diff,j} \quad \cdots (3)$$

For Idiff w.r.t y. we have (Symmetric)

$$I_{diff,y} = \frac{I_{diff,j} - I_{diff,i}}{y_j - y_i} y - \frac{I_{diff,j} - I_{diff,i}}{y_j - y_i} y_j + I_{diff,j} \quad \cdots (4)$$

Hence,

$$I_{diff} = \frac{1}{2}\left[I_{diff,x} + I_{diff,y}\right] \quad \ldots (5)$$