

1059 Mod A = 2

$\zeta(2) = 60$

Rotate = 60

$\cos(1) = 0.5$

$\sin(1) = 0.866$

| | | Y | 0 | 1 |
|---|---|---|---|---|
| X | 0 | 3 | 4 | |
| | 1 | 6 | 7 | |

$x' = x\cos - y\sin$

$y' = x\sin + y\cos$

59011059 5775 6672MS:7A

FORWARD
MAPPING

| | | | |
|----|---|---|---|
| -1 | 0 | 1 | 2 |
| -2 | 0 | 0 | 0 |
| -1 | 0 | 4 | 0 |
| 0 | 0 | 3 | 6 |
| 1 | 0 | 0 | 7 |
| 2 | 0 | 0 | 0 |

BACKWARD
MAPPING

| | | | | |
|----|---|---|---|---|
| -2 | 0 | 0 | 1 | 2 |
| -1 | 0 | 2 | 1 | 0 |
| 0 | 1 | 3 | 4 | 5 |
| 1 | 0 | 4 | 2 | 0 |
| 2 | 0 | 0 | 0 | 0 |

| x' | y' | x | y | x0 | y0 | x1 | y1 | f(x0,y0) | f(x1,y0) | f(x0,y1) | f(x1,y1) | dx | dy | f(A) | f(B) | f(C) | g(x'y') |
|----|----|--------|---------|----|----|----|----|----------|----------|----------|----------|-------|-------|--------|--------|--------|---------|
| -2 | -1 | -0.134 | -2.232 | -1 | -3 | 0 | -2 | 0 | 0 | 0 | 0 | 0.866 | 0.768 | 0 | 0 | 0 | 0 |
| -2 | 0 | -1 | -1.732 | -1 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.268 | 0 | 0 | 0 | 0 |
| -2 | 1 | -1.866 | -1.2305 | 2 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0.134 | 0.768 | 0 | 0 | 0 | 0 |
| -2 | 2 | -2.732 | -0.732 | -3 | -1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.268 | 0.268 | 0 | 0 | 0 | 0 |
| -1 | -1 | 0.366 | -1.366 | 0 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0.366 | 0.634 | 0 | 0 | 0 | 0 |
| -1 | 0 | -0.5 | -0.866 | -1 | -1 | 0 | 0 | 0 | 0 | 3 | 4 | 0.5 | 0.134 | 1.5 | 0 | 0.067 | 1.567 |
| -1 | 1 | -1.366 | -0.366 | -2 | -1 | -1 | 0 | 0 | 0 | 4 | 0 | 0.634 | 0.634 | 2.536 | 0 | -1.608 | 0.928 |
| -1 | 2 | -2.232 | -0.134 | -3 | 0 | -2 | 1 | 0 | 0 | 0 | 0 | 0.768 | 0.134 | 0 | 0 | 0 | 0 |
| 0 | -1 | 0.866 | -0.5 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 3 | 0.866 | 0.5 | 0 | 0 | 1.299 | 1.299 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 6 | 7 | 0 | 0 | 0 | 0 | 0 | 3 |
| 0 | 1 | -0.866 | 0.5 | -1 | 0 | 0 | 1 | 3 | 4 | 6 | 7 | 0.134 | 0.5 | 0.402 | 0.5 | 0 | 3.902 |
| 0 | 2 | -1.732 | 1 | -2 | 1 | -1 | 1 | 7 | 0 | 0 | 0 | 0.366 | 0.366 | 0 | 0 | 0 | 5.124 |
| 1 | -1 | 1.366 | 0.366 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 6 | 0.5 | 0.866 | 0 | 2.598 | 1.299 | 3.897 |
| 1 | 0 | 0.5 | 0.866 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 7 | 0.634 | 0.366 | -3.804 | 0.366 | -0.232 | 2.330 |
| 1 | 1 | -0.366 | 1.366 | -1 | 1 | 0 | 2 | 6 | 7 | 0 | 0 | 0.768 | 0.866 | -5.376 | -6.062 | 4.655 | 0.21762 |
| 1 | 2 | -1.232 | 1.066 | -2 | 1 | -1 | 2 | 7 | 0 | 0 | 0 | 0.866 | 0.268 | 0 | 0 | 0 | 0 |
| 2 | -1 | 1.866 | 1.232 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0.732 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1.732 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0.134 | 0.268 | 0 | 0 | 0 | 0 |
| 2 | 1 | 0.134 | 2.232 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.268 | 0.732 | 0 | 0 | 0 | 0 |
| 2 | 2 | -0.732 | 2.732 | 1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

$$\therefore f(A) = [f(x_1, y_1) - f(x_0, y_0)] * dx \quad f(c) = [f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$$

$$f(B) = [f(x_0, y_1) - f(x_0, y_0)] * dy \quad g(x'y') \in (f(x_0, y_0), f(A), f(B), f(C))$$

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 4 | 5 |
| x=1 | 6 | 7 |

| Seta | RADIEN |
|------|--------|
| 60 | 1.0472 |

| | y'=-1 | y'=0 | y'=1 | y'=2 |
|-------|-------|------|------|------|
| x'=-2 | 0 | 0 | 0 | 0 |
| x'=-1 | 0 | 0 | 5 | 0 |
| x'=0 | 0 | 4 | 7 | 0 |
| x'=1 | 0 | 0 | 6 | 0 |
| x'=2 | 0 | 0 | 0 | 0 |

| Forward Mapping | | | | | | |
|-----------------|---|--------|----------------|----------------|-----------|-----------|
| x | y | f(x,y) | x'=x*cos-y*sin | y'=x*sin+y*cos | round(x') | round(y') |
| 0 | 0 | 4 | 0.000000 | 0.000000 | 0 | 0 |
| 0 | 1 | 5 | -0.866025 | 0.500000 | -1 | 1 |
| 1 | 0 | 6 | 0.500000 | 0.866025 | 1 | 1 |
| 1 | 1 | 7 | -0.366025 | 1.366025 | 0 | 1 |

| x' | y' | x=x'cos+y'sin | y=-x'sin-y'cos | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0) - f(x0,y0)] * dx |
|----|----|---------------|----------------|----|----|----------|----------|----------|----------|-------------|-------------|----------------------------|
| -2 | -1 | -1.866025404 | 1.232050808 | -2 | 1 | 0 | 0 | 0 | 0 | 0.133974596 | 0.232050808 | 0 |
| -2 | 0 | -1 | 1.732050808 | -1 | 1 | 0 | 0 | 5 | 0 | 0 | 0.732050808 | 0 |
| -2 | 1 | -0.133974596 | 2.232050808 | -1 | 2 | 0 | 0 | 0 | 0 | 0.866025404 | 0.232050808 | 0 |
| -2 | 2 | 0.732050808 | 2.732050808 | 0 | 2 | 0 | 0 | 0 | 0 | 0.732050808 | 0.732050808 | 0 |
| -1 | -1 | -1.366025404 | 0.366025404 | -2 | 0 | 0 | 0 | 0 | 0 | 0.633974596 | 0.366025404 | 0 |
| -1 | 0 | -0.5 | 0.866025404 | -1 | 0 | 0 | 0 | 4 | 5 | 0.5 | 0.866025404 | 2 |
| -1 | 1 | 0.366025404 | 1.366025404 | 0 | 1 | 5 | 0 | 7 | 0 | 0.366025404 | 0.366025404 | 0.732050808 |
| -1 | 2 | 1.232050808 | 1.866025404 | 1 | 1 | 7 | 0 | 0 | 0 | 0.232050808 | 0.866025404 | -1.624355653 |
| 0 | -1 | -0.866025404 | -0.5 | -1 | -1 | 0 | 0 | 0 | 4 | 0.133974596 | 0.5 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 6 | 7 | 0 | 0 | 0 |
| 0 | 1 | 0.866025404 | 0.5 | 0 | 0 | 4 | 5 | 6 | 7 | 0.866025404 | 0.5 | 1.732050808 |
| 0 | 2 | 1.732050808 | 1 | 1 | 1 | 7 | 0 | 0 | 0 | 0.732050808 | 0 | -5.124355653 |
| 1 | -1 | -0.366025404 | -1.366025404 | -1 | -2 | 0 | 0 | 0 | 0 | 0.633974596 | 0.633974596 | 0 |
| 1 | 0 | 0.5 | -0.866025404 | 0 | -1 | 0 | 4 | 0 | 6 | 0.5 | 0.133974596 | 0 |
| 1 | 1 | 1.366025404 | -0.366025404 | 1 | -1 | 0 | 6 | 0 | 0 | 0.366025404 | 0.633974596 | 0 |
| 1 | 2 | 2.232050808 | 0.133974596 | 2 | 0 | 0 | 0 | 0 | 0 | 0.232050808 | 0.133974596 | 0 |
| 2 | -1 | 0.133974596 | -2.232050808 | 0 | -3 | 0 | 0 | 0 | 0 | 0.133974596 | 0.767949192 | 0 |
| 2 | 0 | 1 | -1.732050808 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.267949192 | 0 |
| 2 | 1 | 1.866025404 | -1.232050808 | 1 | -2 | 0 | 0 | 0 | 0 | 0.866025404 | 0.767949192 | 0 |
| 2 | 2 | 2.732050808 | -0.732050808 | 2 | -1 | 0 | 0 | 0 | 0 | 0.732050808 | 0.267949192 | 0 |

| $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx$ | $g(x', y')$ |
|------------------------------------|--|-------------|
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0.433012702 | 2.433012702 |
| -1.830127019 | -0.267949192 | 3.633974596 |
| -6.062177826 | 1.40673326 | 0.720199781 |
| 0 | 0.267949192 | 0.267949192 |
| 0 | 0 | 4 |
| 0.5 | 0 | 6.232050808 |
| 0 | 0 | 1.875644347 |
| 0 | 0 | 0 |
| 0.535898385 | 0.133974596 | 0.669872981 |
| 3.803847577 | -1.392304845 | 2.411542732 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |

| | y=0 | y=1 | | y=-1 | y=0 | y=1 | y=2 |
|--------|----------|-----|------|------|-----|-----|-----|
| x=0 | 5 | 6 | x=-2 | 0 | 0 | 0 | 0 |
| x=1 | 7 | 6 | x=-1 | 0 | 0 | 6 | 0 |
| | | | x=0 | 0 | 5 | 6 | 0 |
| | | | x=1 | 0 | 0 | 7 | 0 |
| Rotate | 60 | | x=2 | 0 | 0 | 0 | 0 |
| cos() | 0.5 | | | | | | |
| sin() | 0.866025 | | | | | | |

| Forward Mapping | | | | | | | |
|-----------------|---|--------|------------------|------------------|-----------|-----------|--|
| x | y | f(x,y) | x' = xcos - ysin | y' = xsin + ycos | round(x') | round(y') | |
| 0 | 0 | 5 | 0 | 0 | 0 | 0 | |
| 0 | 1 | 6 | -0.866025404 | 0.5 | -1 | 1 | |
| 1 | 0 | 7 | 0.5 | 0.8660254 | 1 | 1 | |
| 1 | 1 | 6 | -0.366025404 | 1.3660254 | 0 | 1 | |

| min | -0.866025404 | 0 | -1 | 0 |
|-----|--------------|-----------|----|---|
| max | 0.5 | 1.3660254 | 1 | 1 |

| x' | y' | x=x'cos+y'sin | y=-x'sin+y'cos | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) |
|----|----|---------------|----------------|----|----|----------|----------|----------|----------|
| -2 | -1 | -1.866025404 | 1.232050808 | -2 | 1 | 0 | 0 | 0 | 0 |
| -2 | 0 | -1 | 1.732050808 | -1 | 1 | 0 | 0 | 6 | 0 |
| -2 | 1 | -0.133974596 | 2.232050808 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 2 | 0.732050808 | 2.732050808 | 0 | 2 | 0 | 0 | 0 | 0 |
| -1 | -1 | -1.366025404 | 0.366025404 | -2 | 0 | 0 | 0 | 0 | 0 |
| -1 | 0 | -0.5 | 0.866025404 | -1 | 0 | 0 | 0 | 5 | 6 |
| -1 | 1 | 0.366025404 | 1.366025404 | 0 | 1 | 6 | 0 | 6 | 0 |
| -1 | 2 | 1.232050808 | 1.866025404 | 1 | 1 | 6 | 0 | 0 | 0 |
| 0 | -1 | -0.866025404 | -0.5 | -1 | -1 | 0 | 0 | 0 | 5 |
| 0 | 0 | 0 | 0 | 0 | 0 | 5 | 6 | 7 | 6 |
| 0 | 1 | 0.866025404 | 0.5 | 0 | 0 | 5 | 6 | 7 | 6 |
| 0 | 2 | 1.732050808 | 1 | 1 | 1 | 6 | 0 | 0 | 0 |
| 1 | -1 | -0.366025404 | -1.366025404 | -1 | -2 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0.5 | -0.866025404 | 0 | -1 | 0 | 5 | 0 | 7 |
| 1 | 1 | 1.366025404 | -0.366025404 | 1 | -1 | 0 | 7 | 0 | 0 |
| 1 | 2 | 2.232050808 | 0.133974596 | 2 | 0 | 0 | 0 | 0 | 0 |
| 2 | -1 | 0.133974596 | -2.232050808 | 0 | -3 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1 | -1.732050808 | 1 | -2 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1.866025404 | -1.232050808 | 1 | -2 | 0 | 0 | 0 | 0 |
| 2 | 2 | 2.732050808 | -0.732050808 | 2 | -1 | 0 | 0 | 0 | 0 |

| dx | dy | [f(x1,y0) - f(x0,y0)] * dx | [f(x0,y1) - f(x0,y0)] * dy | [...] * dx * dy | g(x',y') |
|----------|----------|----------------------------|----------------------------|-----------------|----------|
| 0.133975 | 0.232051 | 0 | 0 | 0 | 0 |
| 0 | 0.732051 | 0 | 0 | 0 | 0 |
| 0.866025 | 0.232051 | 0 | 0 | 0 | 0 |
| 0.732051 | 0.732051 | 0 | 0 | 0 | 0 |
| 0.633975 | 0.366025 | 0 | 0 | 0 | 0 |
| 0.5 | 0.866025 | 2.5 | 0 | 0.4330127 | 2.933013 |
| 0.366025 | 0.366025 | 0 | -2.196152423 | 0 | 3.803848 |
| 0.232051 | 0.866025 | -1.392304845 | -5.196152423 | 1.2057714 | 0.617314 |
| 0.133975 | 0.5 | 0 | 0 | 0.3349365 | 0.334936 |
| 0 | 0 | 0 | 0 | 0 | 5 |
| 0.866025 | 0.5 | 1.732050808 | 0.5 | -0.866025 | 6.366025 |
| 0.732051 | 0 | -4.392304845 | 0 | 0 | 1.607695 |
| 0.633975 | 0.633975 | 0 | 0 | 0 | 0 |
| 0.5 | 0.133975 | 0 | 0.669872981 | 0.1339746 | 0.803848 |
| 0.366025 | 0.633975 | 0 | 4.437822174 | -1.624356 | 2.813467 |
| 0.232051 | 0.133975 | 0 | 0 | 0 | 0 |
| 0.133975 | 0.767949 | 0 | 0 | 0 | 0 |
| 0 | 0.267949 | 0 | 0 | 0 | 0 |
| 0.866025 | 0.767949 | 0 | 0 | 0 | 0 |
| 0.732051 | 0.267949 | 0 | 0 | 0 | 0 |

Bilinear Interpolation (Image Processing) 59011098

| | |
|--------|---------|
| Rotate | 120 |
| cos() | -0.5000 |
| sin() | 0.8660 |

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 7 | 6 |
| x=1 | 3 | 4 |

| x' | y' | x=x'cos+y'sin | y=-x'sin+y'cos | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [...]*dx | [...]*dy | [...]*dx*dy | g(x',y') | |
|----|----|---------------|----------------|----|----|----------|----------|----------|----------|--------|--------|----------|----------|-------------|----------|--------|
| -2 | -1 | 0.1340 | 2.2321 | 0 | 2 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -2 | 0 | 1.0000 | 1.7321 | 1 | 1 | 4 | 0 | 0 | 0 | 0.0000 | 0.7321 | 0.0000 | -2.9284 | 0.0000 | -2.9284 | |
| -2 | 1 | 1.8660 | 1.2321 | 1 | 1 | 4 | 0 | 0 | 0 | 0.8660 | 0.2321 | -3.4640 | -0.9284 | 0.8040 | -3.5884 | |
| -2 | 2 | 2.7321 | 0.7321 | 2 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -1 | -1 | -0.3660 | 1.3660 | -1 | 1 | 0 | 0 | 6 | 0 | 0.6340 | 0.3660 | 3.8040 | 0.0000 | -1.3923 | 2.4117 | |
| -1 | 0 | 0.5000 | 0.8660 | 0 | 0 | 7 | 6 | 3 | 4 | 0.5000 | 0.8660 | -2.0000 | -0.8660 | 0.8660 | -2.0000 | |
| -1 | 1 | 1.3660 | 0.3660 | 1 | 0 | 3 | 4 | 0 | 0 | 0.3660 | 0.3660 | -1.0980 | 0.3660 | -0.1340 | -0.8660 | |
| -1 | 2 | 2.2321 | -0.1340 | 2 | -1 | 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 0 | -1 | -0.8660 | 0.5000 | -1 | 0 | 0 | 0 | 7 | 6 | 0.1340 | 0.5000 | 0.9380 | 0.0000 | -0.0670 | 0.8710 | |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 7 | 6 | 3 | 4 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | |
| 0 | 1 | 0.8660 | -0.5000 | 0 | -1 | 0 | 7 | 0 | 3 | 0.8660 | 0.5000 | 0.0000 | 3.5000 | -1.7320 | 1.7680 | |
| 0 | 2 | 1.7321 | -1.0000 | 1 | -1 | 0 | 3 | 0 | 0 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 1 | -1 | -1.3660 | -0.3660 | -2 | -1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | -0.5000 | -0.8660 | -1 | -1 | 0 | 0 | 0 | 7 | 0.5000 | 0.1340 | 0.0000 | 0.0000 | 0.4690 | 0.4690 | |
| 1 | 1 | 0.3660 | -1.3660 | 0 | -2 | 0 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 1 | 2 | 1.2321 | -1.8660 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | -1 | -1.8660 | -1.2321 | -2 | -2 | 0 | 0 | 0 | 0 | 0 | 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0 | -1.0000 | -1.7321 | -1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 1 | -0.1340 | -2.2321 | -1 | -3 | 0 | 0 | 0 | 0 | 0 | 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 2 | 0.7321 | -2.7321 | 0 | -3 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y = -1 | y = 0 | y = 1 | y = 2 |
|--------|--------|---------|---------|--------|
| x = -2 | 0.0000 | -2.9284 | -3.5884 | 0.0000 |
| x = -1 | 2.4117 | -2.0000 | -0.8660 | 0.0000 |
| x = 0 | 0.8710 | 1.0000 | 1.7680 | 0.0000 |
| x = 1 | 0.0000 | 0.4690 | 0.0000 | 0.0000 |
| x = 2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y = -1 | y = 0 | y = 1 | y = 2 |
|--------|--------|-------|-------|-------|
| x = -2 | 0 | -3 | -4 | 0 |
| x = -1 | 2 | -2 | -1 | 0 |
| x = 0 | 0 | 1 | 1 | 0 |
| x = 1 | 0 | 0 | 0 | 0 |
| x = 2 | 0 | 0 | 0 | 0 |

สร้างภาพขนาด 2x2 พิกเซล random ระหว่าง 3-7

| x,y | 0 | 1 |
|-----|---|---|
| 0 | 6 | 5 |
| 1 | 7 | 4 |

หมุนด้วยองศา 120

| | |
|--------|-------------|
| 0874%4 | 2 |
| Rotate | 120 |
| cos() | -0.5 |
| sin() | 0.866025404 |

Forward Mapping

| x,y | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
|-----|----------------------|----------------------|---------------|---------------|
| 0,0 | 0 | 0 | 0 | 0 |
| 0,1 | -0.866025404 | -0.5 | -1 | -1 |
| 1,0 | -0.5 | 0.866025404 | -1 | 1 |
| 1,1 | -1.366025404 | 0.366025404 | -1 | 0 |

| min | -1.366025404 | -0.5 | -1 | -1 |
|-----|--------------|-------------|----|----|
| max | 0 | 0.866025404 | 0 | 1 |

Round

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|----|---|---|---|
| -2 | | | | | |
| -1 | | 5 | 4 | 7 | |
| 0 | | | 6 | | |
| 1 | | | | | |

Backward Mapping

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|-----------|-----------|-----------|---|
| -2 | 0 | 0.4115427 | 1.0717968 | 0 | 0 |
| -1 | 0 | 2.0096189 | 4.7679492 | 3.7416698 | 0 |
| 0 | 0 | 0.4019238 | 6 | 0.4019238 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|----|---|---|---|
| -2 | 0 | 0 | 1 | 0 | 0 |
| -1 | 0 | 2 | 5 | 4 | 0 |
| 0 | 0 | 0 | 6 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |

Backward Mapping

| x' | y' | x | y | x_0 | y_0 | $f(x_0,y_0)$ | $f(x_0,y_1)$ | $f(x_1,y_0)$ | $f(x_1,y_1)$ | dx | dy | $f(x_1,y_0)-f(x_0,y_0)$ | $f(x_0,y_1)-f(x_1,y_1)$ | $[...]*dx*dy$ | $g(x',y')$ |
|------|------|----------|----------|-------|-------|--------------|--------------|--------------|--------------|----------|----------|-------------------------|-------------------------|---------------|------------|
| 1 | -2 | -2.23205 | 0.13397 | -3 | 0 | 0 | 0 | 0 | 0 | 0.767949 | 0.133975 | 0 | 0 | 0 | 0 |
| -1 | -2 | -1.23205 | 1.86603 | -2 | 1 | 0 | 0 | 0 | 0 | 0.767949 | 0.866025 | 0 | 0 | 0 | 0 |
| 0 | -2 | -1.73205 | 1 | -2 | 1 | 0 | 0 | 0 | 0 | 0.267949 | 0 | 0 | 0 | 0 | 0 |
| 1 | -1 | -1.36603 | -0.36603 | -2 | -1 | 0 | 0 | 0 | 0 | 0.633975 | 0.633975 | 0 | 0 | 0 | 0 |
| -2 | -2 | -0.73205 | 2.73205 | -1 | 2 | 0 | 0 | 0 | 0 | 0.267949 | 0.732051 | 0 | 0 | 0 | 0 |
| -1 | -1 | -0.36603 | 1.36603 | -1 | 1 | 0 | 0 | 5 | 0 | 0.633975 | 0.366025 | 3.169873 | 0 | -1.16025 | 2.00962 |
| 0 | -1 | -0.86603 | 0.5 | -1 | 0 | 0 | 0 | 6 | 0 | 0.133975 | 0.5 | 0.803848 | 0 | -0.40192 | 0.40192 |
| 1 | 0 | -0.5 | -0.86603 | -1 | -1 | 0 | 0 | 0 | 0 | 0.5 | 0.133975 | 0 | 0 | 0 | 0 |
| -2 | -1 | 0.13397 | 2.23205 | 0 | 2 | 0 | 0 | 0 | 0 | 0.133975 | 0.232051 | 0 | 0 | 0 | 0 |
| -1 | 0 | 0.5 | 0.86603 | 0 | 0 | 6 | 5 | 7 | 4 | 0.5 | 0.866025 | 0.5 | -0.86603 | -0.86603 | 4.76795 |
| 0 | 0 | 0 | 0 | 0 | 0 | 6 | 5 | 7 | 4 | 0 | 0 | 0 | 0 | 0 | 6 |
| 0 | 1 | 0.86603 | -0.5 | 0 | -1 | 0 | 6 | 0 | 0 | 0.866025 | 0.5 | 0 | 3 | -2.59808 | 0.40192 |
| 1 | 1 | 0.36603 | -1.36603 | 0 | -2 | 0 | 0 | 0 | 0 | 0.366025 | 0.633975 | 0 | 0 | 0 | 0 |
| -2 | 0 | 1 | 1.73205 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 0.732051 | 0 | -2.9282 | 0 | 1.0718 |
| -2 | 1 | 1.86603 | 1.23205 | 1 | 1 | 4 | 0 | 0 | 0 | 0.866025 | 0.232051 | -3.4641 | -0.9282 | 0.80385 | 0.41154 |
| -1 | 1 | 1.36603 | 0.36603 | 1 | 0 | 7 | 4 | 0 | 0 | 0.366025 | 0.366025 | -2.56218 | -1.09808 | 0.40192 | 3.74167 |
| 0 | 2 | 1.73205 | -1 | 1 | -1 | 0 | 7 | 0 | 0 | 0.732051 | 0 | 0 | 0 | 0 | 0 |
| 1 | 2 | 1.23205 | -1.86603 | 1 | -2 | 0 | 0 | 0 | 0 | 0.232051 | 0.133975 | 0 | 0 | 0 | 0 |
| -2 | 2 | 2.73205 | 0.73205 | 2 | 0 | 0 | 0 | 0 | 0 | 0.732051 | 0.732051 | 0 | 0 | 0 | 0 |
| -1 | 2 | 2.23205 | -0.13397 | 2 | -1 | 0 | 0 | 0 | 0 | 0.232051 | 0.866025 | 0 | 0 | 0 | 0 |

สร้างภาพขนาด 2x2 พิกเซล random ระหว่าง 3-7

| | | |
|-----|---|---|
| x,y | 0 | 1 |
| 0 | 6 | 5 |
| 1 | 7 | 4 |

หมุนด้วยองศา 60

| | |
|--------|-------------|
| 1189 | 3 |
| Rotate | 60 |
| cos() | 0.5 |
| sin() | 0.866025404 |

Forward Mapping

| x,y | x' | y' | round(x') | round(y') |
|-----|--------------|-------------|-----------|-----------|
| 0,0 | 0 | 0 | 0 | 0 |
| 0,1 | -0.866025404 | -0.5 | -1 | -1 |
| 1,0 | -0.5 | 0.866025404 | -1 | 1 |
| 1,1 | -1.366025404 | 0.366025404 | -1 | 0 |

Round

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|----|---|---|---|
| -2 | 0 | 0 | 1 | 0 | 0 |
| -1 | 0 | 2 | 5 | 4 | 0 |
| 0 | 0 | 0 | 6 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |

| | | | | |
|-----|--------------|-------------|----|----|
| min | -1.366025404 | -0.5 | -1 | -1 |
| max | 0 | 0.866025404 | 0 | 1 |

Backward Mapping

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|-----------|-----------|-----------|---|
| -2 | 0 | 0.4115427 | 1.0717968 | 0 | 0 |
| -1 | 0 | 2.0096189 | 4.7679492 | 3.7416698 | 0 |
| 0 | 0 | 0.4019238 | 6 | 0.4019238 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|----|---|---|---|
| -2 | | | | | |
| -1 | | 5 | 4 | 7 | |
| 0 | | | 6 | | |
| 1 | | | | | |

Backward Mapping

| x' | y' | x | y | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | f(x1,y0)-f(x) | f(x0,y1)-f(x) | [...]*dx*dy | g(x',y') |
|----|----|-----------|-----------|----|----|----------|----------|----------|----------|------------|------------|---------------|---------------|-------------|-----------|
| -2 | -1 | -1.866025 | 1.2320508 | -2 | 1 | 0 | 0 | 0 | 0 | 0.1339746 | 0.23205081 | 0 | 0 | 0 | 0 |
| -1 | -1 | -1.366025 | 0.3660254 | -2 | 0 | 0 | 0 | 0 | 0 | 0.6339746 | 0.3660254 | 0 | 0 | 0 | 0 |
| -2 | 0 | -1 | 1.7320508 | -1 | 1 | 0 | 0 | 5 | 0 | 0 | 0.73205081 | 0 | 0 | 0 | 0 |
| -2 | 1 | -0.133975 | 2.2320508 | -1 | 2 | 0 | 0 | 0 | 0 | 0.8660254 | 0.23205081 | 0 | 0 | 0 | 0 |
| -1 | 0 | -0.5 | 0.8660254 | -1 | 0 | 0 | 0 | 4 | 5 | 0.5 | 0.8660254 | 2 | 0 | 0.4330127 | 2.4330127 |
| 0 | -1 | -0.866025 | -0.5 | -1 | -1 | 0 | 0 | 0 | 4 | 0.1339746 | 0.5 | 0 | 0 | 0.2679492 | 0.2679492 |
| 1 | -1 | -0.366025 | -1.366025 | -1 | -2 | 0 | 0 | 0 | 0 | 0.6339746 | 0.6339746 | 0 | 0 | 0 | 0 |
| -2 | 2 | 0.7320508 | 2.7320508 | 0 | 2 | 0 | 0 | 0 | 0 | 0.73205081 | 0.73205081 | 0 | 0 | 0 | 0 |
| -1 | 1 | 0.3660254 | 1.3660254 | 0 | 1 | 5 | 0 | 6 | 0 | 0.3660254 | 0.3660254 | 0.3660254 | -1.830127 | -0.133975 | 3.4019238 |
| 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 7 | 6 | 0 | 0 | 0 | 0 | 0 | 4 |
| 0 | 1 | 0.8660254 | 0.5 | 0 | 0 | 4 | 5 | 7 | 6 | 0.8660254 | 0.5 | 2.5980762 | 0.5 | -0.866025 | 6.2320508 |
| 1 | 0 | 0.5 | -0.866025 | 0 | -1 | 0 | 4 | 0 | 7 | 0.5 | 0.1339746 | 0 | 0.5358984 | 0.2009619 | 0.7368603 |
| 2 | -1 | 0.1339746 | -2.232051 | 0 | -3 | 0 | 0 | 0 | 0 | 0.1339746 | 0.76794919 | 0 | 0 | 0 | 0 |
| -1 | 2 | 1.2320508 | 1.8660254 | 1 | 1 | 6 | 0 | 0 | 0 | 0.23205081 | 0.8660254 | -1.392305 | -5.196152 | 1.2057714 | 0.6173141 |
| 0 | 2 | 1.7320508 | 1 | 1 | 1 | 6 | 0 | 0 | 0 | 0.73205081 | 0 | -4.392305 | 0 | 0 | 1.6076952 |
| 1 | 1 | 1.3660254 | -0.366025 | 1 | -1 | 0 | 7 | 0 | 0 | 0.3660254 | 0.6339746 | 0 | 4.4378222 | -1.624356 | 2.8134665 |
| 2 | 0 | 1 | -1.732051 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.26794919 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1.8660254 | -1.232051 | 1 | -2 | 0 | 0 | 0 | 0 | 0.8660254 | 0.76794919 | 0 | 0 | 0 | 0 |
| 1 | 2 | 2.2320508 | 0.1339746 | 2 | 0 | 0 | 0 | 0 | 0 | 0.23205081 | 0.1339746 | 0 | 0 | 0 | 0 |
| 2 | 2 | 2.7320508 | -0.732051 | 2 | -1 | 0 | 0 | 0 | 0 | 0.73205081 | 0.26794919 | 0 | 0 | 0 | 0 |

นายธนิก จันทร์ดี 59010615

| | y=0 | y=1 |
|---------|-----|------------|
| x=0 | 5 | 3 |
| x=1 | 3 | 7 |
| 0615%4= | 3 | $\zeta(3)$ |

150

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 3 | 0 |
| x=0 | 0 | 5 | 7 | 0 |
| x=1 | 0 | 0 | 3 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

หมุนภาพด้วยเทคนิค Backward mapping

Rotation Transform

$$\begin{array}{c|cc|c} & \text{Transform} \\ \hline x & 0.699250806 & -0.71487643 & x' \\ y & 0.71487643 & 0.699250806 & y' \end{array}$$

| | |
|--------------|----------|
| Rotate | 2.617994 |
| <u>cos()</u> | -0.86603 |
| <u>sin()</u> | 0.5 |

Forward mapping

| x | y | f(x,y) | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
|---|---|--------|----------------------|----------------------|-----------|-----------|
| 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| 0 | 1 | 3 | -0.5 | -0.8660254 | -1 | -1 |
| 1 | 0 | 3 | -0.8660254 | 0.5 | -1 | 1 |
| 1 | 1 | 7 | -1.3660254 | -0.3660254 | -1 | 0 |

$$\begin{array}{llllll} \min & & -1.3660254 & -0.8660254 & -1 & -1 \\ \max & & 0 & 0.5 & 0 & 1 \end{array}$$

| | | +y'sin | +y'cos | | | | | | | | | | f(x0,y0)]*dx | f(x0,y0)]*dy | f(x0,y1)-f(x1,y0)]*dx*dy | | |
|----|----|---------|---------|----|----|----|----|---|---|---|---|--------|--------------|--------------|--------------------------|---------|--------|
| -2 | -1 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 7 | 0 | 0 | 0 | 0.2321 | 0.8660 | -1.6244 | -6.0622 | 1.4067 | 0.7202 |
| -2 | 0 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 7 | 7 | 0 | 0 | 0.7321 | 0.0000 | -5.1244 | 0.0000 | 0.0000 | 1.8756 |
| -2 | 1 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 3 | 0 | 7 | 0 | 0.3660 | 0.3660 | 1.4641 | -1.0981 | -0.5359 | 2.8301 |
| -1 | 0 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 5 | 3 | 3 | 7 | 0.8660 | 0.5000 | -1.7321 | -1.0000 | 2.5981 | 4.8660 |
| -1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 3 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 1.9019 | -0.6962 | 1.2058 |
| -1 | 2 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -1 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 5 | 3 | 0.5000 | 0.8660 | 2.5000 | 0.0000 | -0.8660 | 1.6340 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0000 |
| 0 | 1 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 5 | 0 | 3 | 0.5000 | 0.1340 | 0.0000 | 0.6699 | -0.1340 | 0.5359 |
| 0 | 2 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 5 | 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.3349 | 0.3349 |
| 1 | 1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 2 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 | 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | -1 | -2.2321 | -0.1340 | -3 | -1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.7679 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0 | -1.7321 | -1.0000 | -2 | -1 | -1 | -1 | 0 | 0 | 0 | 0 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 1 | -1.2321 | -1.8660 | -2 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0.7679 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 2 | -0.7321 | -2.7321 | -1 | -3 | 0 | -2 | 0 | 0 | 0 | 0 | 0.2679 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|
| x=-2 | 0.7202 | 1.8756 | 0.0000 | 0.0000 |
| x=-1 | 2.8301 | 4.8660 | 1.2058 | 0.0000 |
| x=0 | 1.6340 | 5.0000 | 0.5359 | 0.0000 |
| x=1 | 0.0000 | 0.3349 | 0.0000 | 0.0000 |
| x=2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

floor

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 1 | 0 | 0 |
| x=-1 | 2 | 4 | 1 | 0 |
| x=0 | 1 | 5 | 0 | 0 |
| x=1 | 0 | 0 | 0 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

| | y=1 | y=0 | y=1 | y=2 |
|------|-----|-----|-----|-----|
| x=-2 | 1 | 2 | 0 | 0 |
| x=-1 | 3 | 5 | 2 | 0 |
| x=0 | 2 | 5 | 1 | 0 |
| x=1 | 0 | 1 | 0 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

$y = 0$ $y = 1$

| | | |
|---------|---|---|
| $x = 0$ | 4 | 3 |
| $x = 1$ | 7 | 5 |

นายอภิรัตน์ เชาว์เครือ 59011497

| | |
|----------|----------|
| Rotate | 150 |
| $\cos()$ | -0.86603 |
| $\sin()$ | 0.50 |

| | $y = -2$ | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $x = -2$ | 0 | 0 | 0 | 0 | 0 |
| $x = -1$ | 0 | 3 | 5 | 7 | 0 |
| $x = 0$ | 0 | 0 | 4 | 0 | 0 |
| $x = 1$ | 0 | 0 | 0 | 0 | 0 |

Forward mapping

| x | y | f(x,y) | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
|---|---|--------|----------------------|----------------------|---------------|---------------|
| 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| 0 | 1 | 3 | -0.5 | -0.86603 | -1 | -1 |
| 1 | 0 | 7 | -0.86603 | 0.5 | -1 | 1 |
| 1 | 1 | 5 | -1.36603 | -0.36603 | -1 | 0 |

| | | | | |
|-----|----------|----------|----|----|
| min | -1.36603 | -0.86603 | -1 | -1 |
| max | 0 | 0.5 | 0 | 1 |

| x' | y' | $x = x'\cos + y\sin$ | $y = -x\sin + y\cos$ | x_0 | y_0 | x_1 | y_1 |
|------|------|----------------------|----------------------|-------|-------|-------|-------|
| -2 | -2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 |
| -2 | -1 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 |
| -2 | 0 | 1.7321 | 1.0000 | 1 | 1 | 2 | 2 |
| -2 | 1 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 |
| -2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 |
| -1 | -2 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 |
| -1 | -1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 |
| -1 | 0 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 |
| -1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 |
| -1 | 2 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 |
| 0 | -2 | -1.0000 | 1.7321 | -1 | 1 | 0 | 2 |
| 0 | -1 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 1 | 1 |
| 0 | 1 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 |
| 0 | 2 | 1.0000 | -1.7321 | 1 | -2 | 2 | -1 |
| 1 | -2 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 |
| 1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 |
| 1 | 0 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 |
| 1 | 1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 |
| 1 | 2 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 |

| $f(x_0, y_0)$ | $f(x_0, y_1)$ | $f(x_1, y_0)$ | $f(x_1, y_1)$ | dx | dy | $[x_1, y_0] - f(x_0, y_0)]dx$ | $[y_1, f(x_0, y_0)]dy$ | $[0] - f(x_1, y_0)]dxdy$ | $g(x', y')$ |
|---------------|---------------|---------------|---------------|--------|--------|-------------------------------|------------------------|--------------------------|-------------|
| 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | 0 | 0 | 0 | 0.2321 | 0.8660 | -1.1603 | -4.3301 | 1.0048 | 0.5144 |
| 5 | 0 | 0 | 0 | 0.7321 | 0.0000 | -3.6603 | 0.0000 | 0.0000 | 1.3397 |
| 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3 | 0 | 5 | 0 | 0.3660 | 0.3660 | 0.7321 | -1.0981 | -0.2679 | 2.3660 |
| 4 | 3 | 7 | 5 | 0.8660 | 0.5000 | 2.5981 | -0.5000 | -0.4330 | 5.6651 |
| 0 | 7 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 4.4378 | -1.6244 | 2.8135 |
| 0 | 0 | 0 | 0 | 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 3 | 0 | 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 4 | 3 | 0.5000 | 0.8660 | 2.0000 | 0.0000 | -0.4330 | 1.5670 |
| 4 | 3 | 7 | 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.0000 |
| 0 | 4 | 0 | 7 | 0.5000 | 0.1340 | 0.0000 | 0.5359 | 0.2010 | 0.7369 |
| 0 | 0 | 0 | 0 | 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 4 | 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.2679 | 0.2679 |
| 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | $y = -2$ | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|---------|----------|---------|
| $x = -2$ | 0 | 0.514428 | 1.33975 | 0 | 0 |
| $x = -1$ | 0 | 2.366025 | 5.66506 | 2.813467 | 0 |
| $x = 0$ | 0 | 1.566987 | 4 | 0.73686 | 0 |
| $x = 1$ | 0 | 0 | 0.26795 | 0 | 0 |

| | $y = -2$ | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $x = -2$ | 0 | 1 | 1 | 0 | 0 |
| $x = -1$ | 0 | 2 | 6 | 3 | 0 |
| $x = 0$ | 0 | 2 | 4 | 1 | 0 |
| $x = 1$ | 0 | 0 | 0 | 0 | 0 |

Homework (Image Processing) Karn noppawing 59010099

| | |
|--------|---------|
| Rotate | 150 |
| cos() | -0.8660 |
| sin() | 0.5000 |

| | | |
|-----|-----|-----|
| | y=0 | y=1 |
| x=0 | 5 | 6 |
| x=1 | 3 | 4 |

| x' | y' | $x = x' \cos + y' \sin$ | $y = -x' \sin + y' \cos$ | x0 | y0 | x1 | y1 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) |
|----|----|-------------------------|--------------------------|----|----|----|----|----------|----------|----------|----------|
| -2 | -1 | 1.2321 | 1.8660 | -2 | 1 | 2 | 2 | 0 | 0 | 0 | 0 |
| -2 | 0 | 1.7321 | 1.0000 | -1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 |
| -2 | 1 | 2.2321 | 0.1340 | -1 | 2 | 3 | 1 | 0 | 0 | 0 | 0 |
| -2 | 2 | 2.7321 | -0.7321 | 0 | 2 | 3 | 0 | 5 | 0 | 0 | 0 |
| -1 | -1 | 0.3660 | 1.3660 | -2 | 0 | 1 | 2 | 0 | 3 | 0 | 0 |
| -1 | 0 | 0.8660 | 0.5000 | -1 | 0 | 1 | 1 | 6 | 0 | 3 | 0 |
| -1 | 1 | 1.3660 | -0.3660 | 0 | 1 | 2 | 0 | 6 | 5 | 0 | 0 |
| -1 | 2 | 1.8660 | -1.2321 | 1 | 1 | 2 | -1 | 0 | 0 | 0 | 0 |
| 0 | -1 | -0.5000 | 0.8660 | -1 | -1 | 0 | 1 | 0 | 0 | 0 | 4 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 |
| 0 | 1 | 0.5000 | -0.8660 | 0 | 0 | 1 | 0 | 5 | 3 | 5 | 3 |
| 0 | 2 | 1.0000 | -1.7321 | 1 | 1 | 1 | -1 | 4 | 4 | 0 | 0 |
| 1 | -1 | -1.3660 | 0.3660 | -1 | -2 | -1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | -0.8660 | -0.5000 | 0 | -1 | 0 | 0 | 0 | 5 | 0 | 5 |
| 1 | 1 | -0.3660 | -1.3660 | 1 | -1 | 0 | -1 | 0 | 0 | 0 | 0 |
| 1 | 2 | 0.1340 | -2.2321 | 2 | 0 | 1 | -2 | 0 | 0 | 3 | 0 |
| 2 | -1 | -2.2321 | -0.1340 | 0 | -3 | -2 | 0 | 0 | 5 | 0 | 0 |
| 2 | 0 | -1.7321 | -1.0000 | 1 | -2 | -1 | -1 | 0 | 0 | 0 | 0 |
| 2 | 1 | -1.2321 | -1.8660 | 1 | -2 | -1 | -1 | 0 | 0 | 0 | 0 |
| 2 | 2 | -0.7321 | -2.7321 | 2 | -1 | 0 | -2 | 0 | 0 | 0 | 0 |

| | y=-1 | y=0 | y=1 | y=2 | |
|---------|---------|----------|----------|-------------|----------|
| x=-2 | 0 | 0 | 0 | -37.3219 | |
| x=-1 | -5.5979 | -5.799 | -8.696 | 0 | |
| x=0 | 3.732 | 1 | 1.732 | 0 | |
| x=1 | 0 | 2.5 | 0 | -18.0933 | |
| x=2 | 46.316 | 0 | 0 | 0 | |
| dx | dy | [...]*dx | [...]*dy | [...]*dx*dy | g(x',y') |
| 3.2321 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3.2321 | -1.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2.7321 | -2.7321 | -13.6605 | 13.6605 | -37.3219 | -37.3219 |
| 2.3660 | 1.3660 | 0.0000 | 4.0980 | -9.6959 | -5.5979 |
| 1.8660 | 0.5000 | -5.5980 | -3.0000 | 2.7990 | -5.7990 |
| 1.3660 | -1.3660 | -8.1960 | 1.3660 | -1.8660 | -8.6960 |
| 0.8660 | -2.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 1.8660 | 0.0000 | 0.0000 | 3.7320 | 3.7320 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| 0.5000 | -0.8660 | 0.0000 | 1.7320 | 0.0000 | 1.7320 |
| 0.0000 | -2.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -0.3660 | 2.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -0.8660 | 0.5000 | 0.0000 | 2.5000 | 0.0000 | 2.5000 |
| -1.3660 | -0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1.8660 | -2.2321 | -5.5980 | 0.0000 | -12.4953 | -18.0933 |
| -2.2321 | 2.8660 | 0.0000 | 14.3300 | 31.9860 | 46.3160 |
| -2.7321 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2.7321 | -1.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Random pixel

| | |
|---|---|
| 5 | 3 |
| 4 | 6 |

$\zeta(3) = 150$

| | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|----------|----------|
| $x = 2$ | 0 | 0 | 0 | 0 |
| $x = 1$ | 0 | 2.721134 | 5.538675 | 0.588314 |
| $x = -0$ | 0.022081 | 5 | 2.721134 | 0.029703 |
| $x = -1$ | 0 | 0.022521 | 0 | 0 |
| $x = -2$ | 0 | 0 | 0 | 0 |

| | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|---------|---------|---------|
| $x = 2$ | 0 | 0 | 0 | 0 |
| $x = 1$ | 0 | 3 | 6 | 1 |
| $x = -0$ | 0 | 5 | 3 | 0 |
| $x = -1$ | 0 | 0 | 0 | 0 |
| $x = -2$ | 0 | 0 | 0 | 0 |

| x' | y' | $x = x' \cos + y' \sin$ | $y = x' \sin + y' \cos$ | x_0 | y_0 | $f(x_0, y_0)$ |
|------|------|-------------------------|-------------------------|-------|-------|---------------|
| -2 | -1 | -0.803960862 | -1.895092367 | -1 | -2 | 0 |
| -2 | 0 | 0.191447096 | -1.990815916 | 0 | -2 | 0 |
| -2 | 1 | 1.186855054 | -2.086539464 | 1 | -3 | 0 |
| -2 | 2 | 2.182263012 | -2.182263012 | 2 | -3 | 0 |
| -1 | -1 | -0.89968441 | -0.89968441 | -1 | -1 | 0 |
| -1 | 0 | 0.095723548 | -0.995407958 | 0 | -1 | 0 |
| -1 | 1 | 1.091131506 | -1.091131506 | 1 | -2 | 0 |
| -1 | 2 | 2.086539464 | -1.186855054 | 2 | -2 | 0 |
| 0 | -1 | -0.995407958 | 0.095723548 | -1 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 0 | 1 | 0.995407958 | -0.095723548 | 0 | -1 | 0 |
| 0 | 2 | 1.990815916 | -0.191447096 | 1 | -1 | 0 |
| 1 | -1 | -1.091131506 | 1.091131506 | -2 | 1 | 0 |
| 1 | 0 | -0.095723548 | 0.995407958 | -1 | 0 | 0 |
| 1 | 1 | 0.89968441 | 0.89968441 | 0 | 0 | 5 |
| 1 | 2 | 1.895092367 | 0.803960862 | 1 | 0 | 4 |
| 2 | -1 | -1.186855054 | 2.086539464 | -2 | 2 | 0 |
| 2 | 0 | -0.191447096 | 1.990815916 | -1 | 1 | 0 |
| 2 | 1 | 0.803960862 | 1.895092367 | 0 | 1 | 0 |
| 2 | 2 | 1.799368819 | 1.799368819 | 1 | 1 | 0 |

เจษฎา อังไพบูลย์ 59010237

| $f(x_0, y_1)$ | $f(x_1, y_0)$ | $f(x_1, y_1)$ | dx | dy | $[f(x_1, y_0) - f(x_0, y_0)] * dx$ | $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[...] * dx * dy$ | $g(x', y')$ |
|---------------|---------------|---------------|----------|----------|------------------------------------|------------------------------------|-------------------|-------------|
| 0 | 0 | 0 | 0.196039 | 0.104908 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.191447 | 0.009184 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.186855 | 0.913461 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.182263 | 0.817737 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.100316 | 0.100316 | 0 | 0 | 0 | 0 |
| 5 | 0 | 4 | 0.095724 | 0.004592 | 0 | 0.022960211 | -0.00043957 | 0.022521 |
| 0 | 0 | 0 | 0.091132 | 0.908868 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.086539 | 0.813145 | 0 | 0 | 0 | 0 |
| 0 | 5 | 3 | 0.004592 | 0.095724 | 0.022960211 | 0 | -0.00087913 | 0.022081 |
| 3 | 4 | 6 | 0 | 0 | 0 | 0 | 0 | 5 |
| 5 | 0 | 3 | 0.995408 | 0.904276 | 0 | 4.52138226 | -1.80024795 | 2.721134 |
| 4 | 0 | 0 | 0.990816 | 0.808553 | 0 | 3.234211616 | -3.20450834 | 0.029703 |
| 0 | 0 | 0 | 0.908868 | 0.091132 | 0 | 0 | 0 | 0 |
| 0 | 5 | 3 | 0.904276 | 0.995408 | 4.52138226 | 0 | -1.80024795 | 2.721134 |
| 3 | 4 | 6 | 0.899684 | 0.899684 | -0.89968441 | -1.799368819 | 3.23772815 | 5.538675 |
| 6 | 0 | 0 | 0.895092 | 0.803961 | -3.58036947 | 1.607921723 | -1.43923846 | 0.588314 |
| 0 | 0 | 0 | 0.813145 | 0.086539 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.808553 | 0.990816 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.803961 | 0.895092 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.799369 | 0.799369 | 0 | 0 | 0 | 0 |

Rotation using Bilinear Interpolation

งานวิจัย อนิเวตกลชัย

59011061

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 6 | 6 |
| x=1 | 5 | 6 |

$$1061 \bmod 4 = 1 \text{ ได้ } \mu_m zeta(1) = 60$$

| Rotation | | Transform | | | | | |
|----------|--|-------------|--------------|----|--|--------|----------|
| x | | -0.95241298 | -0.304810621 | x' | | Rotate | 1.047198 |
| y | | 0.304810621 | -0.95241298 | y' | | cos() | 0.5 |

| | |
|-------|----------|
| sin() | 0.866025 |
|-------|----------|

| Forward mapping | | | | | | |
|-----------------|---|--------|------------------|------------------|-----------|-----------|
| x | y | f(x,y) | x' = xcos - ysin | y' = xsin + ycos | round(x') | round(y') |
| 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| 0 | 1 | 6 | -0.866025404 | 0.5 | -1 | 1 |
| 1 | 0 | 5 | 0.5 | 0.866025404 | 1 | 1 |
| 1 | 1 | 6 | -0.366025404 | 1.366025404 | 0 | 1 |

| | | | | |
|-----|--------------|-------------|----|---|
| min | -0.866025404 | 0 | -1 | 0 |
| max | 0.5 | 1.366025404 | 1 | 1 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 6 | 0 |
| x=0 | 0 | 6 | 6 | 0 |
| x=1 | 0 | 0 | 5 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

Backward Mapping (Bilinear Interpolation)

| x' | y' | $x = x' \cos + y' \sin$ | $y = -x' \sin + y' \cos$ | x_0 | y_0 | x_1 | y_1 | $f(x_0, y_0)$ | $f(x_0, y_1)$ | $f(x_1, y_0)$ | $f(x_1, y_1)$ |
|------|------|-------------------------|--------------------------|-------|-------|-------|-------|---------------|---------------|---------------|---------------|
| -2 | -1 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 0 | -1.0000 | 1.7321 | -1 | 1 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 1 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 |
| -2 | 2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 |
| -1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 |
| -1 | 0 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 6 | 6 |
| -1 | 1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 6 | 0 | 6 | 0 |
| -1 | 2 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 6 | 0 | 0 | 0 |
| 0 | -1 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 6 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 6 | 6 | 6 | 6 |
| 0 | 1 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 6 | 6 | 5 | 6 |
| 0 | 2 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 6 | 6 | 0 | 0 |
| 1 | -1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 6 | 0 | 5 |
| 1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 5 | 0 | 0 |
| 1 | 2 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 |
| 2 | -1 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 |
| 2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 |

| dx | dy | $[f(x_1, y_0) - f(x_0, y_0)] * dx$ | $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$ | $g(x', y')$ |
|--------|--------|------------------------------------|------------------------------------|---|-------------|
| 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 0.8660 | 3.0000 | 0.0000 | 0.0000 | 3.0000 |
| 0.3660 | 0.3660 | 0.0000 | -2.1962 | 0.0000 | 3.8038 |
| 0.2321 | 0.8660 | -1.3923 | -5.1962 | 1.2058 | 0.6173 |
| 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.4019 | 0.4019 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.0000 |
| 0.8660 | 0.5000 | -0.8660 | 0.0000 | 0.4330 | 5.5670 |
| 0.7321 | 0.0000 | -4.3923 | 0.0000 | 0.0000 | 1.6077 |
| 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 0.1340 | 0.0000 | 0.8038 | -0.0670 | 0.7369 |
| 0.3660 | 0.6340 | 0.0000 | 3.1699 | -1.1603 | 2.0096 |
| 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| x=-1 | 0.0000 | 3.0000 | 3.8038 | 0.6173 |
| x=0 | 0.4019 | 6.0000 | 5.5670 | 1.6077 |
| x=1 | 0.0000 | 0.7369 | 2.0096 | 0.0000 |
| x=2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

floor

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 3 | 3 | 0 |
| x=0 | 0 | 6 | 5 | 1 |
| x=1 | 0 | 0 | 2 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

ceiling

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 3 | 4 | 1 |
| x=0 | 1 | 6 | 6 | 2 |
| x=1 | 0 | 1 | 3 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

| | $y=0$ | $y=1$ |
|-------|-------|-------|
| $x=0$ | 3 | 7 |
| $x=1$ | 7 | 5 |

| | $y = -2$ | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $x = -2$ | 0 | 0 | 0 | 0 | 0 |
| $x = -1$ | 0 | 7 | 5 | 7 | 0 |
| $x = 0$ | 0 | 0 | 3 | 0 | 0 |
| $x = 1$ | 0 | 0 | 0 | 0 | 0 |

$$1511 \% 4 = \quad 3 \quad \zeta(3) \quad 150$$

หมุนภาพด้วยเทคนิค Backward mapping
การคำนวณค่าระดับความเข้มแสงผลลัพธ์ด้วยเทคนิค bilinear interpolation

| Rotation | Transform | |
|----------|-------------|-------------|
| x | 0.699250806 | -0.71487643 |
| y | 0.71487643 | 0.699250806 |

| | |
|--------|----------|
| Rotate | 2.617994 |
| cos() | -0.86603 |
| sin() | 0.5 |

Forward mapping

| Forward mapping | | | | | | |
|-----------------|---|--------|-----------------|----------------|-----------|-----------|
| x | y | f(x,y) | x' = xcos-y sin | y' = xsin+ycos | round(x') | round(y') |
| 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| 0 | 1 | 7 | -0.5 | -0.866025404 | -1 | -1 |
| 1 | 0 | 7 | -0.8660254 | 0.5 | -1 | 1 |
| 1 | 1 | 5 | -1.3660254 | -0.366025404 | -1 | 0 |

| | | | | |
|-----|------------|--------------|----|----|
| min | -1.3660254 | -0.866025404 | -1 | -1 |
| max | 0 | 0.5 | 0 | 1 |

| x' | y' | $x = x' \cos y + y' \sin y$ | $y = -x' \sin y + y' \cos y$ | x_0 | y_0 | x_1 | y_1 | $f(x_0, y_0)$ | $f(x_0, y_1)$ | $f(x_1, y_0)$ | $f(x_1, y_1)$ | dx | dy | $[f(x_1, y_0) - f(x_0, y_0)] * dx$ | $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$ | $g(x', y')$ |
|------|------|-----------------------------|------------------------------|-------|-------|-------|-------|---------------|---------------|---------------|---------------|--------|--------|------------------------------------|------------------------------------|---|-------------|
| -2 | -2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | -1 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 5 | 0 | 0 | 0 | 0.2321 | 0.8660 | -1.1603 | -4.3301 | 1.0048 | 0.5144 |
| -2 | 0 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 5 | 5 | 0 | 0 | 0.7321 | 0.0000 | -3.6603 | 0.0000 | 0.0000 | 1.3397 |
| -2 | 1 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -2 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 7 | 0 | 5 | 0 | 0.3660 | 0.3660 | -0.7321 | -2.5622 | 0.2679 | 3.9737 |
| -1 | 0 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 3 | 7 | 7 | 5 | 0.8660 | 0.5000 | 3.4641 | 2.0000 | -2.5981 | 5.8660 |
| -1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 7 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 4.4378 | -1.6244 | 2.8135 |
| -1 | 2 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -2 | -1.0000 | 1.7321 | -1 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -1 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 3 | 7 | 0.5000 | 0.8660 | 1.5000 | 0.0000 | 1.7321 | 3.2321 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.0000 |
| 0 | 1 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 3 | 0 | 7 | 0.5000 | 0.1340 | 0.0000 | 0.4019 | 0.2679 | 0.6699 |
| 0 | 2 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | -2 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 3 | 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.2010 | 0.2010 |
| 1 | 1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 2 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 | 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | $y = -2$ | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $x = -2$ | 0.0000 | 0.5144 | 1.3397 | 0.0000 | 0.0000 |
| $x = -1$ | 0.0000 | 3.9737 | 5.8660 | 2.8135 | 0.0000 |
| $x = 0$ | 0.0000 | 3.2321 | 3.0000 | 0.6699 | 0.0000 |
| $x = 1$ | 0.0000 | 0.0000 | 0.2010 | 0.0000 | 0.0000 |

floor

| | $y = -2$ | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $x = -2$ | 0 | 0 | 1 | 0 | 0 |
| $x = -1$ | 0 | 3 | 5 | 2 | 0 |
| $x = 0$ | 0 | 3 | 3 | 0 | 0 |
| $x = 1$ | 0 | 0 | 0 | 0 | 0 |

ceiling

| | $y = -2$ | $y = -1$ | $y = 0$ | $y = 1$ | $y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $x = -2$ | 0 | 1 | 2 | 0 | 0 |
| $x = -1$ | 0 | 4 | 6 | 3 | 0 |
| $x = 0$ | 0 | 4 | 3 | 1 | 0 |
| $x = 1$ | 0 | 0 | 1 | 0 | 0 |

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 4 | 5 |
| x=1 | 4 | 6 |

| | y=-2 | y=-1 | y=0 | y=1 | y=2 |
|------|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 5 | 6 | 4 | 0 |
| x=0 | 0 | 0 | 4 | 0 | 0 |
| x=1 | 0 | 0 | 0 | 0 | 0 |

| | |
|--------|--------------|
| Rotate | 2.617993878 |
| cos() | -0.866025404 |
| sin() | 0.5 |

1371%4= 3 zeta(3) 150

หน้าจอคำนวณ Backward mapping
การกำหนดค่าระดับความเร็วและสัมประสิทธิ์ของเส้น bilinear interpolation

| Rotation | Transform |
|----------|--|
| x y | $\begin{vmatrix} 0.699250806 & -0.71487643 \\ 0.71487643 & 0.69925081 \end{vmatrix}$ |

| Forward mapping | | | | | | |
|-----------------|---|--------|----------------------|----------------------|-----------|-----------|
| x | y | f(x,y) | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
| 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| 0 | 1 | 5 | -0.5 | -0.866025404 | -1 | -1 |
| 1 | 0 | 4 | -0.86603 | 0.5 | -1 | 1 |
| 1 | 1 | 6 | -1.36603 | -0.366025404 | -1 | 0 |

min -1.36603 -0.866025404 -1 -1
max 0 0.5 0 1

| x' | y' | x=x'cos+y'sin | y=x'sin+y'cos | x0 | y0 | x1 | y1 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0)-f(x0,y0)]*dx | [f(x0,y1)-f(x0,y0)]*dy | [f(x1,y1)+f(x0,y0)-f(x0,y1)-f(x1,y0)]*dx*dy | g(x',y') |
|----|----|---------------|---------------|----|----|----|----|----------|----------|----------|----------|--------|--------|------------------------|------------------------|---|----------|
| -2 | -2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | -1 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 6 | 0 | 0 | 0 | 0.2321 | 0.8660 | -1.3923 | -5.1962 | 1.2058 | 0.6173 |
| -2 | 0 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 6 | 6 | 0 | 0 | 0.7321 | 0.0000 | -4.3923 | 0.0000 | 0.0000 | 1.6077 |
| -2 | 1 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -2 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 5 | 0 | 6 | 0 | 0.3660 | 0.3660 | -1.8301 | -0.1340 | 3.4019 | |
| -1 | 0 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 4 | 5 | 4 | 6 | 0.8660 | 0.5000 | 0.0000 | 0.5000 | 0.4330 | 4.9330 |
| -1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 4 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 2.5359 | -0.9282 | 1.6077 |
| -1 | 2 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -2 | -1.0000 | 1.7321 | -1 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -1 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 4 | 5 | 0.5000 | 0.8660 | 2.0000 | 0.0000 | 0.4330 | 2.4330 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 4 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.0000 |
| 0 | 1 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 4 | 0 | 4 | 0.5000 | 0.1340 | 0.0000 | 0.5359 | 0.0000 | 0.5359 |
| 0 | 2 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | -2 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | -0.8660 | -0.5000 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.2679 | 0.2679 |
| 1 | 1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 2 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 | 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-2 | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.6173 | 1.6077 | 0.0000 | 0.0000 |
| x=-1 | 0.0000 | 3.4019 | 4.9330 | 1.6077 | 0.0000 |
| x=0 | 0.0000 | 2.4330 | 4.0000 | 0.5359 | 0.0000 |
| x=1 | 0.0000 | 0.0000 | 0.2679 | 0.0000 | 0.0000 |

| floor | x=-2 | y=-2 | y=-1 | y=0 | y=1 | y=2 |
|-------|------|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 1 | 0 | 0 | 0 |
| x=-1 | 0 | 3 | 4 | 1 | 0 | 0 |
| x=0 | 0 | 2 | 4 | 0 | 0 | 0 |
| x=1 | 0 | 0 | 0 | 0 | 0 | 0 |

| ceiling | x=-2 | y=-2 | y=-1 | y=0 | y=1 | y=2 |
|---------|------|------|------|-----|-----|-----|
| x=-2 | 0 | 1 | 2 | 0 | 0 | 0 |
| x=-1 | 0 | 4 | 5 | 2 | 0 | 0 |
| x=0 | 0 | 3 | 4 | 1 | 0 | 0 |
| x=1 | 0 | 0 | 1 | 0 | 0 | 0 |

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 3 | 3 |
| x=1 | 6 | 5 |

1194%4= 0 zeta(0) 30

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 3 | 0 |
| x=0 | 0 | 3 | 5 | 0 |
| x=1 | 0 | 0 | 6 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

นายวิทธิชัย สัมพันธ์กิจ รหัส 590111194

ท่าการหมุนภาพตัวย่อ Backward mapping

การกำหนดค่าระดับความเข้มแสงผลลัพธ์ตัวย่อ technique bilinear interpolation

| Rotation | Transform |
|----------|---|
| x | 0.15425145 -0.98803162 0.988031624 0.15425145 |
| y | x' |

| | |
|--------|----------|
| Rotate | 0.523599 |
| cos() | 0.866025 |
| sin() | 0.5 |

Forward mapping

| x | y | f(x,y) | x'=x*cos-y*sin | y'=x*sin+y*cos | round(x') | round(y') |
|---|---|--------|----------------|----------------|-----------|-----------|
| 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| 0 | 1 | 3 | -0.5 | 0.866025404 | -1 | 1 |
| 1 | 0 | 6 | 0.866025404 | 0.5 | 1 | 1 |
| 1 | 1 | 5 | 0.366025404 | 1.366025404 | 0 | 1 |

min -0.5 0 -1 0
max 0.866025404 1.366025404 1 1

| x' | y' | x=x'*cos+y'*sin | y=-x'*sin+y'*cos | x0 | y0 | x1 | y1 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0)-f(x0,y0)]*dx | [f(x0,y1)-f(x0,y0)]*dy | [f(x1,y1)+f(x0,y0)-f(x0,y1)-f(x1,y0)]*dx*dy | g(x',y') |
|----|----|-----------------|------------------|----|----|----|----|----------|----------|----------|----------|--------|--------|------------------------|------------------------|---|----------|
| -2 | -1 | -2.2321 | 0.1340 | -3 | 0 | -2 | 1 | 0 | 0 | 0 | 0 | 0.7679 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 0 | -1.7321 | 1.0000 | -2 | 1 | -1 | 1 | 0 | 0 | 0 | 0 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 1 | -1.2321 | 1.8660 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.7679 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 2 | -0.7321 | 2.7321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0.2679 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -1 | -1.3660 | -0.3660 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | 0 | -0.8660 | 0.5000 | -1 | 0 | 0 | 1 | 0 | 0 | 3 | 3 | 0.1340 | 0.5000 | 0.4019 | 0.0000 | 0.0000 | 0.4019 |
| -1 | 1 | -0.3660 | 1.3660 | -1 | 1 | 0 | 2 | 0 | 0 | 3 | 0 | 0.6340 | 0.3660 | 1.9019 | 0.0000 | -0.6962 | 1.2058 |
| -1 | 2 | 0.1340 | 2.2321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -1 | -0.5000 | -0.8660 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 3 | 0.5000 | 0.1340 | 0.0000 | 0.0000 | 0.2010 | 0.2010 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 3 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 3.0000 |
| 0 | 1 | 0.5000 | 0.8660 | 0 | 0 | 1 | 1 | 3 | 3 | 6 | 5 | 0.5000 | 0.8660 | 1.5000 | 0.0000 | -0.4330 | 4.0670 |
| 0 | 2 | 1.0000 | 1.7321 | 1 | 1 | 1 | 2 | 5 | 0 | 5 | 0 | 0.0000 | 0.7321 | -3.6603 | 0.0000 | 0.0000 | 1.3397 |
| 1 | -1 | 0.3660 | -1.3660 | 0 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | 0.8660 | -0.5000 | 0 | -1 | 1 | 0 | 0 | 3 | 0 | 6 | 0.8660 | 0.5000 | 0.0000 | 1.5000 | 1.2990 | 2.7990 |
| 1 | 1 | 1.3660 | 0.3660 | 1 | 0 | 2 | 1 | 6 | 5 | 0 | 0 | 0.3660 | 0.3660 | -2.1962 | -0.3660 | 0.1340 | 3.5718 |
| 1 | 2 | 1.8660 | 1.2321 | 1 | 1 | 2 | 2 | 5 | 0 | 0 | 0 | 0.8660 | 0.2321 | -4.3301 | -1.1603 | 1.0048 | 0.5144 |
| 2 | -1 | 1.2321 | -1.8660 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0 | 1.7321 | -1.0000 | 1 | -1 | 2 | -1 | 0 | 0 | 0 | 0 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 1 | 2.2321 | -0.1340 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 2 | 2.7321 | 0.7321 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| x=-1 | 0.0000 | 0.4019 | 1.2058 | 0.0000 |
| x=0 | 0.2010 | 3.0000 | 4.0670 | 1.3397 |
| x=1 | 0.0000 | 2.7990 | 3.5718 | 0.5144 |
| x=2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

floor

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 1 | 0 |
| x=0 | 0 | 3 | 4 | 1 |
| x=1 | 0 | 2 | 3 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

ceiling

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 1 | 2 | 0 |
| x=0 | 1 | 3 | 5 | 2 |
| x=1 | 0 | 3 | 4 | 1 |
| x=2 | 0 | 0 | 0 | 0 |

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 4 | 6 |
| x=1 | 7 | 3 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 6 | 0 |
| x=0 | 0 | 4 | 3 | 0 |
| x=1 | 0 | 0 | 7 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

1325%4= 1 zeta(1) 60

អង្គភាពតាមលទ្ធផល Backward mapping
ការការណ៍គរាយបុគ្គលិក bilinear interpolation

Rotation Transform

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} -0.95241298 & -0.30481062 \\ 0.30481062 & -0.95241298 \end{pmatrix} \begin{pmatrix} x' \\ y' \end{pmatrix}$$

| | |
|--------|----------|
| Rotate | 1.047198 |
| cos() | 0.5 |
| sin() | 0.866025 |

Forward mapping

| x | y | f(x,y) | x'cos+y'sin | y'xsin+y'cos | round(x') | round(y') |
|---|---|--------|-------------|--------------|-----------|-----------|
| 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| 0 | 1 | 6 | -0.8660254 | 0.5 | -1 | 1 |
| 1 | 0 | 7 | 0.5 | 0.866025404 | 1 | 1 |
| 1 | 1 | 3 | -0.3660254 | 1.366025404 | 0 | 1 |

min -0.8660254 0 -1 0
max 0.5 1.366025404 1 1

| x' | y' | xx'cos+y'sin | yx'-x'sin+y'cos | x0 | y0 | x1 | y1 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | $\int [f(x1,y0)-f(x0,y0)]*dx$ | $\int [f(x0,y1)-f(x0,y0)]*dy$ | $\int [f(x1,y1)+f(x0,y0)-f(x0,y1)-f(x1,y0)]*dx*dy$ | g(x',y') | |
|----|----|--------------|-----------------|----|----|----|----|----------|----------|----------|----------|--------|--------|-------------------------------|-------------------------------|--|----------|--------|
| -2 | -1 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -2 | 0 | -1.0000 | 1.7321 | -1 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -2 | 1 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -2 | 2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | 0 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 4 | 6 | 0.5000 | 0.8660 | 2.0000 | 0.0000 | 0.8660 | 2.8660 | |
| -1 | 1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 6 | 0 | 3 | 0 | 0.3660 | 0.3660 | -1.0981 | -2.1962 | 0.4019 | 3.1077 | |
| -1 | 2 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 3 | 0 | 0 | 0 | 0.2321 | 0.8660 | -0.6962 | -2.5981 | 0.6029 | 0.3087 | |
| 0 | -1 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 4 | 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.2679 | 0.2679 | |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 4 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 4.0000 | 4.0000 | |
| 0 | 1 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 4 | 6 | 7 | 3 | 0.8660 | 0.5000 | 2.5981 | 1.0000 | -2.5981 | 5.0000 | |
| 0 | 2 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 3 | 3 | 0 | 0 | 0.7321 | 0.0000 | -2.1962 | 0.0000 | 0.8038 | 0.8038 | |
| 1 | -1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 4 | 4 | 0 | 7 | 0.5000 | 0.1340 | 0.0000 | 0.5359 | 0.2010 | 0.7369 |
| 1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 7 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 4.4378 | -1.6244 | 2.8135 |
| 1 | 2 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0.2521 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | -1 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 1 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0 | 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| x=-1 | 0.0000 | 2.8660 | 3.1077 | 0.3087 |
| x=0 | 0.2679 | 4.0000 | 5.0000 | 0.8088 |
| x=1 | 0.0000 | 0.7369 | 2.8185 | 0.0000 |
| x=2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 2 | 3 | 0 |
| x=0 | 0 | 4 | 5 | 0 |
| x=1 | 0 | 0 | 2 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 3 | 4 | 1 |
| x=0 | 1 | 4 | 5 | 1 |
| x=1 | 0 | 1 | 3 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

ପ୍ରକଳ୍ପ ନିର୍ମାଣ

59010759

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 3 | 4 |
| x=1 | 6 | 7 |

| Seta | RADIEN |
|------|--------|
| 60 | 1.0472 |

| | y'=-1 | y'=0 | y'=1 | y'=2 |
|-------|-------|------|------|------|
| x'=-2 | 0 | 0 | 0 | 0 |
| x'=-1 | 0 | 0 | 4 | 0 |
| x'=0 | 0 | 3 | 7 | 0 |
| x'=1 | 0 | 0 | 6 | 0 |
| x'=2 | 0 | 0 | 0 | 0 |

| Forward Mapping | | | | | | |
|-----------------|---|--------|------------------|------------------|-----------|-----------|
| x | y | f(x,y) | x' = xcos - ysin | y' = xsin + ycos | round(x') | round(y') |
| 0 | 0 | 3 | 0.000000 | 0.000000 | 0 | 0 |
| 0 | 1 | 4 | -0.866025 | 0.500000 | -1 | 1 |
| 1 | 0 | 6 | 0.500000 | 0.866025 | 1 | 1 |
| 1 | 1 | 7 | -0.366025 | 1.366025 | 0 | 1 |

| x' | y' | x=x'cos+y'sin | y=-x'sin-y'cos | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0) - f(x0,y0)] * dx |
|----|----|---------------|----------------|----|----|----------|----------|----------|----------|-------------|-------------|----------------------------|
| -2 | -1 | -1.866025404 | 1.232050808 | -2 | 1 | 0 | 0 | 0 | 0 | 0.133974596 | 0.232050808 | 0 |
| -2 | 0 | -1 | 1.732050808 | -1 | 1 | 0 | 0 | 4 | 0 | 0 | 0.732050808 | 0 |
| -2 | 1 | -0.133974596 | 2.232050808 | -1 | 2 | 0 | 0 | 0 | 0 | 0.866025404 | 0.232050808 | 0 |
| -2 | 2 | 0.732050808 | 2.732050808 | 0 | 2 | 0 | 0 | 0 | 0 | 0.732050808 | 0.732050808 | 0 |
| -1 | -1 | -1.366025404 | 0.366025404 | -2 | 0 | 0 | 0 | 0 | 0 | 0.633974596 | 0.366025404 | 0 |
| -1 | 0 | -0.5 | 0.866025404 | -1 | 0 | 0 | 0 | 3 | 4 | 0.5 | 0.866025404 | 1.5 |
| -1 | 1 | 0.366025404 | 1.366025404 | 0 | 1 | 4 | 0 | 7 | 0 | 0.366025404 | 0.366025404 | 1.098076211 |
| -1 | 2 | 1.232050808 | 1.866025404 | 1 | 1 | 7 | 0 | 0 | 0 | 0.232050808 | 0.866025404 | -1.624355653 |
| 0 | -1 | -0.866025404 | -0.5 | -1 | -1 | 0 | 0 | 0 | 3 | 0.133974596 | 0.5 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 6 | 7 | 0 | 0 | 0 |
| 0 | 1 | 0.866025404 | 0.5 | 0 | 0 | 3 | 4 | 6 | 7 | 0.866025404 | 0.5 | 2.598076211 |
| 0 | 2 | 1.732050808 | 1 | 1 | 1 | 7 | 0 | 0 | 0 | 0.732050808 | 0 | -5.124355653 |
| 1 | -1 | -0.366025404 | -1.366025404 | -1 | -2 | 0 | 0 | 0 | 0 | 0.633974596 | 0.633974596 | 0 |
| 1 | 0 | 0.5 | -0.866025404 | 0 | -1 | 0 | 3 | 0 | 6 | 0.5 | 0.133974596 | 0 |
| 1 | 1 | 1.366025404 | -0.366025404 | 1 | -1 | 0 | 6 | 0 | 0 | 0.366025404 | 0.633974596 | 0 |
| 1 | 2 | 2.232050808 | 0.133974596 | 2 | 0 | 0 | 0 | 0 | 0 | 0.232050808 | 0.133974596 | 0 |
| 2 | -1 | 0.133974596 | -2.232050808 | 0 | -3 | 0 | 0 | 0 | 0 | 0.133974596 | 0.767949192 | 0 |
| 2 | 0 | 1 | -1.732050808 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.267949192 | 0 |
| 2 | 1 | 1.866025404 | -1.232050808 | 1 | -2 | 0 | 0 | 0 | 0 | 0.866025404 | 0.767949192 | 0 |
| 2 | 2 | 2.732050808 | -0.732050808 | 2 | -1 | 0 | 0 | 0 | 0 | 0.732050808 | 0.267949192 | 0 |

| $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$ | $g(x', y')$ |
|------------------------------------|---|-------------|
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0.433012702 | 1.933012702 |
| -1.464101615 | -0.401923789 | 3.232050808 |
| -6.062177826 | 1.40673326 | 0.720199781 |
| 0 | 0.200961894 | 0.200961894 |
| 0 | 0 | 3 |
| 0.5 | 0 | 6.098076211 |
| 0 | 0 | 1.875644347 |
| 0 | 0 | 0 |
| 0.401923789 | 0.200961894 | 0.602885683 |
| 3.803847577 | -1.392304845 | 2.411542732 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |

| | y_0 | y_1 |
|-------|-------|-------|
| x_0 | 2 | 3 |
| x_1 | 4 | 5 |

| Rotate | 150 |
|----------|-----------|
| $\cos()$ | -0.866025 |
| $\sin()$ | 0.5 |

Forward Mapping

| x | y | $f(x, y)$ | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
|-----|-----|-----------|----------------------|----------------------|---------------|---------------|
| 0 | 0 | x | 0 | 0 | 0 | 0 |
| 0 | 1 | 3 | -0.5 | -0.8660254 | -1 | -1 |
| 1 | 0 | 4 | -0.866025404 | 0.5 | -1 | 1 |
| 1 | 1 | 5 | -1.366025404 | -0.3660254 | -1 | 0 |

| min | | -1.366025404 | -0.8660254 | -1 | -1 |
|-----|--|--------------|------------|----|----|
| max | | 0 | 0.5 | 0 | 1 |

Zero padding

| | $y=-3$ | $y=-2$ | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 0 | 0 | 0 | 0 | 0 |
| $x=0$ | 0 | 0 | 0 | 2 | 3 | 0 |
| $x=1$ | 0 | 0 | 0 | 4 | 5 | 0 |
| $x=2$ | 0 | 0 | 0 | 0 | 0 | 0 |

ROTATION CENTERED AT THE POINT

| x' | y' | $x' = x\cos + y'\sin$ | $y' = x'\sin + y\cos$ | x_0 | y_0 | x_1 | y_1 | $f(x_0, y_0)$ | $f(x_0, y_1)$ | $f(x_1, y_0)$ | $f(x_1, y_1)$ |
|------|------|-----------------------|-----------------------|-------|-------|-------|-------|---------------|---------------|---------------|---------------|
| -2 | -2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 |
| -2 | -1 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 5 | 0 | 0 | 0 |
| -2 | 0 | 1.7321 | 1.0000 | 1 | 1 | 2 | 2 | 5 | 0 | 0 | 0 |
| -2 | 1 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 |
| -2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 |
| -1 | -2 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 |
| -1 | -1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 3 | 0 | 5 | 0 |
| -1 | 0 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 5 |
| -1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 4 | 0 | 0 |
| -1 | 2 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 |
| 0 | -2 | -1.0000 | 1.7321 | -1 | 1 | 0 | 2 | 0 | 0 | 3 | 0 |
| 0 | -1 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 2 | 3 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 5 |
| 0 | 1 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 2 | 0 | 4 |
| 0 | 2 | 1.0000 | -1.7321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 |
| 1 | -2 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 |
| 1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 2 |
| 1 | 1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 |
| 1 | 2 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 |

| dx | dy | $[f(x_1, y_0) - f(x_0, y_0)] * dx$ | $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[...] * dx * dy$ | $g(x', y')$ |
|--------|--------|------------------------------------|------------------------------------|-------------------|-------------|
| 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.2321 | 0.8660 | -1.1603 | -4.3301 | 1.0048 | 0.5144 |
| 0.7321 | 0.0000 | -3.6603 | 0.0000 | 0.0000 | 1.3397 |
| 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.3660 | 0.3660 | 0.7321 | -1.0981 | -0.2679 | 2.3660 |

| | | | | | |
|--------|--------|--------|--------|---------|--------|
| 0.8660 | 0.5000 | 1.7321 | 0.5000 | 0.0000 | 4.2321 |
| 0.3660 | 0.6340 | 0.0000 | 2.5359 | -0.9282 | 1.6077 |
| 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 0.8660 | 1.0000 | 0.0000 | 0.4330 | 1.4330 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.0000 | 0.0000 |
| 0.5000 | 0.1340 | 0.0000 | 0.2679 | 0.1340 | 0.4019 |
| 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.1340 | 0.1340 |
| 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-2 | y=-1 | y=0 | y=-1 | y=-2 |
|------|--------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.5144 | 1.3397 | 0.0000 | 0.0000 |
| x=-1 | 0.0000 | 2.3660 | 4.2321 | 1.6077 | 0.0000 |
| x=0 | 0.0000 | 1.4330 | 2.0000 | 0.4019 | 0.0000 |
| x=1 | 0.0000 | 0.0000 | 0.1340 | 0.0000 | 0.0000 |

| | y=-2 | y=-1 | y=0 | y=-1 | y=-2 |
|------|------|------|-----|------|------|
| x=-2 | 0 | 1 | 1 | 0 | 0 |
| x=-1 | 0 | 2 | 4 | 2 | 0 |
| x=0 | 0 | 1 | 2 | 0 | 0 |
| x=1 | 0 | 0 | 0 | 0 | 0 |

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| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 | 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 | 271 | 272 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 | 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | 331 | 332 | 333 | 334 | 335 | 336 | 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 | 353 | 354 | 355 | 356 | 357 | 358 | 359 | 360 | 361 | 362 | 363 | 364 | 365 | 366 | 367 | 368 | 369 | 370 | 371 | 372 | 373 | 374 | 375 | 376 | 377 | 378 | 379 | 380 | 381 | 382 | 383 | 384 | 385 | 386 | 387 | 388 | 389 | 390 | 391 | 392 | 393 | 394 | 395 | 396 | 397 | 398 | 399 | 400 | 401 | 402 | 403 | 404 | 405 | 406 | 407 | 408 | 409 | 410 | 411 | 412 | 413 | 414 | 415 | 416 | 417 | 418 | 419 | 420 | 421 | 422 | 423 | 424 | 425 | 426 | 427 | 428 | 429 | 430 | 431 | 432 | 433 | 434 | 435 | 436 | 437 | 438 | 439 | 440 | 441 | 442 | 443 | 444 | 445 | 446 | 447 | 448 | 449 | 450 | 451 | 452 | 453 | 454 | 455 | 456 | 457 | 458 | 459 | 460 | 461 | 462 | 463 | 464 | 465 | 466 | 467 | 468 | 469 | 470 | 471 | 472 | 473 | 474 | 475 | 476 | 477 | 478 | 479 | 480 | 481 | 482 | 483 | 484 | 485 | 486 | 487 | 488 | 489 | 490 | 491 | 492 | 493 | 494 | 495 | 496 | 497 | 498 | 499 | 500 | 501 | 502 | 503 | 504 | 505 | 506 | 507 | 508 | 509 | 510 | 511 | 512 | 513 | 514 | 515 | 516 | 517 | 518 | 519 | 520 | 521 | 522 | 523 | 524 | 525 | 526 | 527 | 528 | 529 | 530 | 531 | 532 | 533 | 534 | 535 | 536 | 537 | 538 | 539 | 540 | 541 | 542 | 543 | 544 | 545 | 546 | 547 | 548 | 549 | 550 | 551 | 552 | 553 | 554 | 555 | 556 | 557 | 558 | 559 | 560 | 561 | 562 | 563 | 564 | 565 | 566 | 567 | 568 | 569 | 570 | 571 | 572 | 573 | 574 | 575 | 576 | 577 | 578 | 579 | 580 | 581 | 582 | 583 | 584 | 585 | 586 | 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 | 597 | 598 | 599 | 600 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | 611 | 612 | 613 | 614 | 615 | 616 | 617 | 618 | 619 | 620 | 621 | 622 | 623 | 624 | 625 | 626 | 627 | 628 | 629 | 630 | 631 | 632 | 633 | 634 | 635 | 636 | 637 | 638 | 639 | 640 | 641 | 642 | 643 | 644 | 645 | 646 | 647 | 648 | 649 | 650 | 651 | 652 | 653 | 654 | 655 | 656 | 657 | 658 | 659 | 660 | 661 | 662 | 663 | 664 | 665 | 666 | 667 | 668 | 669 | 670 | 671 | 672 | 673 | 674 | 675 | 676 | 677 | 678 | 679 | 680 | 681 | 682 | 683 | 684 | 685 | 686 | 687 | 688 | 689 | 690 | 691 | 692 | 693 | 694 | 695 | 696 | 697 | 698 | 699 | 700 | 701 | 702 | 703 | 704 | 705 | 706 | 707 | 708 | 709 | 710 | 711 | 712 | 713 | 714 | 715 | 716 | 717 | 718 | 719 | 720 | 721 | 722 | 723 | 724 | 725 | 726 | 727 | 728 | 729 | 730 | 731 | 732 | 733 | 734 | 735 | 736 | 737 | 738 | 739 | 740 | 741 | 742 | 743 | 744 | 745 | 746 | 747 | 748 | 749 | 750 | 751 | 752 | 753 | 754 | 755 | 756 | 757 | 758 | 759 | 760 | 761 | 762 | 763 | 764 | 765 | 766 | 767 | 768 | 769 | 770 | 771 | 772 | 773 | 774 | 775 | 776 | 777 | 778 | 779 | 780 | 781 | 782 | 783 | 784 | 785 | 786 | 787 | 788 | 789 | 790 | 791 | 792 | 793 | 794 | 795 | 796 | 797 | 798 | 799 | 800 | 801 | 802 | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | 811 | 812 | 813 | 814 | 815 | 816 | 817 | 818 | 819 | 820 | 821 | 822 | 823 | 824 | 825 | 826 | 827 | 828 | 829 | 830 | 831 | 832 | 833 | 834 | 835 | 836 | 837 | 838 | 839 | 840 | 841 | 842 | 843 | 844 | 845 | 846 | 847 | 848 | 849 | 850 | 851 | 852 | 853 | 854 | 855 | 856 | 857 | 858 | 859 | 860 | 861 | 862 | 863 | 864 | 865 | 866 | 867 | 868 | 869 | 870 | 871 | 872 | 873 | 874 | 875 | 876 | 877 | 878 | 879 | 880 | 881 | 882 | 883 | 884 | 885 | 886 | 887 | 888 | 889 | 890 | 891 | 892 | 893 | 894 | 895 | 896 | 897 | 898 | 899 | 900 | 901 | 902 | 903 | 904 | 905 | 906 | 907 | 908 | 909 | 910 | 911 | 912 | 913 | 914 | 915 | 916 | 917 | 918 | 919 | 920 | 921 | 922 | 923 | 924 | 925 | 926 | 927 | 928 | 929 | 930 | 931 | 932 | 933 | 934 | 935 | 936 | 937 | 938 | 939 | 940 | 941 | 942 | 943 | 944 | 945 | 946 | 947 | 948 | 949 | 950 | 951 | 952 | 953 | 954 | 955 | 956 | 957 | 958 | 959 | 960 | 961 | 962 | 963 | 964 | 965 | 966 | 967 | 968 | 969 | 970 | 971 | 972 | 973 | 974 | 975 | 976 | 977 | 978 | 979 | 980 | 981 | 982 | 983 | 984 | 985 | 986 | 987 | 988 | 989 | 990 | 991 | 992 | 993 | 994 | 995 | 996 | 997 | 998 | 999 | 1000 | 1001 | 1002 | 1003 | 1004 | 1005 | 1006 | 1007 | 1008 | 1009 | 10010 | 10011 | 10012 | 10013 | 10014 | 10015 | 10016 | 10017 | 10018 | 10019 | 10020 | 10021 | 10022 | 10023 | 10024 | 10025 | 10026 | 10027 | 10028 | 10029 | 10030 | 10031 | 10032 | 10033 | 10034 | 10035 | 10036 | 10037 | 10038 | 10039 | 10040 | 10041 | 10042 | 10043 | 10044 | 10045 | 10046 | 10047 | 10048 | 10049 | 10050 | 10051 | 10052 | 10053 | 10054 | 10055 | 10056 | 10057 | 10058 | 10059 | 10060 | 10061 | 10062 | 10063 | 10064 | 10065 | 10066 | 10067 | 10068 | 10069 | 10070 | 10071 | 10072 | 10073 | 10074 | 10075 | 10076 | 10077 | 10078 | 10079 | 10080 | 10081 | 10082 | 10083 | 10084 | 10085 | 10086 | 10087 | 10088 | 10089 | 10 |
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କଣ୍ଠାନ୍ଦୁ

59011345

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 3 | 4 |
| x=1 | 5 | 6 |

| | |
|--------|---------|
| Rotate | 60 |
| cos() | 0.5 |
| sin() | 0.86603 |

| x' | y' | x=x'cos+y'sin | y=-x'sin-y'cos | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) |
|----|----|---------------|----------------|----|----|----------|----------|----------|----------|
| -2 | -1 | -1.8660254 | 1.232050808 | -2 | 1 | 0 | 0 | 0 | 0 |
| -2 | 0 | -1 | 1.732050808 | -1 | 1 | 0 | 0 | 4 | 0 |
| -2 | 1 | -0.1339746 | 2.232050808 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 2 | 0.73205081 | 2.732050808 | 0 | 2 | 0 | 0 | 0 | 0 |
| -1 | -1 | -1.3660254 | 0.366025404 | -2 | 0 | 0 | 0 | 0 | 0 |
| -1 | 0 | -0.5 | 0.866025404 | -1 | 0 | 0 | 0 | 3 | 4 |
| -1 | 1 | 0.3660254 | 1.366025404 | 0 | 1 | 4 | 0 | 6 | 0 |
| -1 | 2 | 1.23205081 | 1.866025404 | 1 | 1 | 6 | 0 | 0 | 0 |
| 0 | -1 | -0.8660254 | -0.5 | -1 | -1 | 0 | 0 | 0 | 3 |
| 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 5 | 6 |
| 0 | 1 | 0.8660254 | 0.5 | 0 | 0 | 3 | 4 | 5 | 6 |
| 0 | 2 | 1.73205081 | 1 | 1 | 1 | 6 | 0 | 0 | 0 |
| 1 | -1 | -0.3660254 | -1.3660254 | -1 | -2 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0.5 | -0.8660254 | 0 | -1 | 0 | 3 | 0 | 5 |
| 1 | 1 | 1.3660254 | -0.3660254 | 1 | -1 | 0 | 5 | 0 | 0 |
| 1 | 2 | 2.23205081 | 0.133974596 | 2 | 0 | 0 | 0 | 0 | 0 |
| 2 | -1 | 0.1339746 | -2.23205081 | 0 | -3 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1 | -1.73205081 | 1 | -2 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1.8660254 | -1.23205081 | 1 | -2 | 0 | 0 | 0 | 0 |
| 2 | 2 | 2.73205081 | -0.73205081 | 2 | -1 | 0 | 0 | 0 | 0 |

| dx | dy | $[f(x_1, y_0) - f(x_0, y_0)] * dx$ | $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$ | $g(x', y')$ |
|----------|----------|------------------------------------|------------------------------------|---|--------------|
| 0.133975 | 0.232051 | 0 | 0 | 0 | 0 |
| 0 | 0.732051 | 0 | 0 | 0 | 0 |
| 0.866025 | 0.232051 | 0 | 0 | 0 | 0 |
| 0.732051 | 0.732051 | 0 | 0 | 0 | 0 |
| 0.633975 | 0.366025 | 0 | 0 | 0 | 0 |
| 0.5 | 0.866025 | 1.5 | 0 | 0.433012702 | 1.933012702 |
| 0.366025 | 0.366025 | 0.732050808 | -1.464101615 | -0.267949192 | -1 |
| 0.232051 | 0.866025 | -1.392304845 | -5.196152423 | 1.205771366 | -5.382685902 |
| 0.133975 | 0.5 | 0 | 0 | 0.200961894 | 0.200961894 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0.866025 | 0.5 | 1.732050808 | 0.5 | 0 | 2.232050808 |
| 0.732051 | 0 | -4.392304845 | 0 | 0 | -4.392304845 |
| 0.633975 | 0.633975 | 0 | 0 | 0 | 0 |
| 0.5 | 0.133975 | 0 | 0.401923789 | 0.133974596 | 0.535898385 |
| 0.366025 | 0.633975 | 0 | 3.169872981 | -1.160254038 | 2.009618943 |
| 0.232051 | 0.133975 | 0 | 0 | 0 | 0 |
| 0.133975 | 0.767949 | 0 | 0 | 0 | 0 |
| 0 | 0.267949 | 0 | 0 | 0 | 0 |
| 0.866025 | 0.767949 | 0 | 0 | 0 | 0 |
| 0.732051 | 0.267949 | 0 | 0 | 0 | 0 |

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 4 | 5 |
| x=1 | 6 | 3 |

0829%4= 1 zeta(1) 60

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 5 | 0 |
| x=0 | 0 | 4 | 3 | 0 |
| x=1 | 0 | 0 | 6 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

អង្គភាពគិតវិធីការពិនិត្យការមានបំផុតនូវបណ្តុះបណ្តុះទិន្នន័យ bilinear interpolation

| Rotation | Transform |
|----------|-------------------------|
| x | -0.95241298 -0.30481062 |
| y | 0.304810621 -0.95241298 |

| | |
|--------|----------|
| Rotate | 1.047198 |
| cos() | 0.5 |
| sin() | 0.866025 |

Forward mapping

| x | y | f(x,y) | x' = x * cos + y * sin | y' = x * sin + y * cos | round(x') | round(y') |
|---|---|--------|------------------------|------------------------|-----------|-----------|
| 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| 0 | 1 | 5 | -0.8660254 | 0.5 | -1 | 1 |
| 1 | 0 | 6 | 0.5 | 0.866025404 | 1 | 1 |
| 1 | 1 | 3 | -0.3660254 | 1.366025404 | 0 | 1 |

min -0.8660254 0 -1 0
max 0.5 1.366025404 1 1

| x' | y' | x=x'cos+y'sin | y=y'sin+x'cos | x0 | y0 | x1 | y1 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0)-f(x0,y0)]*dx | [f(x0,y1)-f(x0,y0)]*dy | [f(x1,y1)-f(x0,y0)-f(x0,y1)]*dx*dy | g(x',y') |
|----|----|---------------|---------------|----|----|----|----|----------|----------|----------|----------|----|--------|------------------------|------------------------|------------------------------------|----------|
| -2 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 2 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | |
| -2 | 0 | -1.0000 | 1.7321 | -1 | 0 | -1 | 2 | 0 | 0 | 0 | 0 | 0 | 0.0000 | 0.7321 | 0.0000 | 0.0000 | |
| -2 | 1 | -0.1340 | 2.3231 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0.8660 | 0.2321 | 0.0000 | 0.0000 | |
| -2 | 2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | |
| -1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.3660 | 0.0000 | 0.0000 | |
| -1 | 0 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 4 | 5 | 0 | 0.5000 | 0.8660 | 2.0000 | 0.4330 | |
| -1 | 1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 5 | 0 | 3 | 0 | 0 | 0.3660 | 0.3660 | -0.7321 | 2.4330 | |
| -1 | 2 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | -0.6962 | 2.7058 | |
| 0 | -1 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0.1340 | 0.5000 | 0.0000 | 0.6029 | |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 0 | 0.0000 | 0.0000 | 0.0000 | 0.2679 | |
| 0 | 1 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 4 | 5 | 6 | 3 | 0 | 0.8660 | 0.5000 | 1.7321 | 4.0000 | |
| 0 | 2 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.7321 | 0.0000 | -2.1962 | 4.5000 | |
| 1 | -1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | |
| 1 | 0 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 4 | 0 | 6 | 0 | 0.5000 | 0.1340 | 0.5359 | 0.6699 | |
| 1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 6 | 0 | 0 | 0 | 0.3660 | 0.6340 | 3.8038 | -1.3923 | |
| 1 | 2 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 2.4115 | |
| 2 | -1 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.1340 | 0.7679 | 0.0000 | 0.0000 | |
| 2 | 0 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.0000 | 0.2679 | 0.0000 | 0.0000 | |
| 2 | 1 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0 | 0.8660 | 0.7679 | 0.0000 | 0.0000 | |
| 2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.2679 | 0.0000 | 0.0000 | |

| | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| x=-1 | 0.0000 | 2.4330 | 2.7058 | 0.3087 |
| x=0 | 0.2679 | 4.0000 | 4.5000 | 0.8038 |
| x=1 | 0.0000 | 0.6699 | 2.4115 | 0.0000 |
| x=2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 2 | 2 | 0 |
| x=0 | 0 | 4 | 4 | 0 |
| x=1 | 0 | 0 | 2 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 3 | 3 | 1 |
| x=0 | 1 | 4 | 5 | 1 |
| x=1 | 0 | 1 | 3 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

| x=0 | y=0 | y=1 |
|-----|-----|-----|
| x=1 | 5 | 4 |
| x=2 | 0 | 0 |

| x=-2 | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-1 | 0 | 0 | 0 | 0 |
| x=0 | 0 | 5 | 4 | 0 |
| x=1 | 0 | 0 | 5 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

0484%4= 0 zeta(0) 30

មុនភាពគំរែងហេដិច Backward mapping

ការការណែនការរួមគូតាមប្រព័ន្ធនឹងបណ្តុះបណ្តាល

| | | |
|----------|------------------------|----|
| Rotation | Transform | |
| x | 0.15425145 -0.98803162 | x' |
| y | 0.988031624 0.15425145 | y' |

| | |
|--------|----------|
| Rotate | 0.523599 |
| cos() | 0.866025 |
| sin() | 0.5 |

Forward mapping

| x | y | f(x,y) | x'=x*cos-y*sin | y'=x*sin+y*cos | round(x') | round(y') |
|---|---|--------|----------------|----------------|-----------|-----------|
| 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| 0 | 1 | 5 | -0.5 | 0.866025404 | -1 | 1 |
| 1 | 0 | 5 | 0.866025404 | 0.5 | 1 | 1 |
| 1 | 1 | 4 | 0.566025404 | 1.366025404 | 0 | 1 |

| | | | | |
|-----|-------------|-------------|----|---|
| min | -0.5 | 0 | -1 | 0 |
| max | 0.866025404 | 1.366025404 | 1 | 1 |

| x' | y' | x*x'cos+y'*sin | y=-x'*sin+y'*cos | x0 | y0 | x1 | y1 | f(x,y0) | f(x,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0)-f(x0,y0)]*dx | [f(x0,y1)-f(x0,y0)]*dy | [f(x1,y1)+f(x0,y0)-f(x0,y1)]*dx*dy | g(x',y') | |
|----|----|----------------|------------------|----|----|----|----|---------|---------|----------|----------|--------|--------|------------------------|------------------------|------------------------------------|----------|--------|
| -2 | -1 | -2.2321 | 0.1340 | -3 | 0 | -2 | 1 | 0 | 0 | 0 | 0 | 0.7679 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -2 | 0 | -1.7321 | 1.0000 | -2 | 1 | -1 | 1 | 0 | 0 | 0 | 0 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -2 | 1 | -1.2321 | 1.8660 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.7679 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -2 | 2 | -0.7321 | 2.7321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0.2679 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -1 | -1 | -1.3660 | -0.3660 | -2 | -1 | 1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| -1 | 0 | -0.8660 | 0.5000 | -1 | 0 | 0 | 1 | 0 | 0 | 5 | 5 | 0.1340 | 0.5000 | 0.6699 | 0.0000 | 0.0000 | 0.6699 | |
| -1 | 1 | -0.3660 | 1.3660 | -1 | 1 | 0 | 2 | 0 | 0 | 5 | 5 | 0 | 0.3660 | 0.3660 | 3.1699 | 0.0000 | -1.1603 | 2.0096 |
| -1 | 2 | 0.1340 | 2.2321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -1 | -0.5000 | -0.8660 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 5 | 0.5000 | 0.1340 | 0.0000 | 0.0000 | 0.3349 | 0.3349 | |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 | 5 | 0.0000 | 0.0000 | 0.0000 | 5.0000 | 5.0000 | |
| 0 | 1 | 0.5000 | 0.8660 | 0 | 0 | 1 | 1 | 5 | 5 | 5 | 5 | 4 | 0.5000 | 0.8660 | 0.0000 | -0.4330 | 4.5670 | 4.5670 |
| 0 | 2 | 1.0000 | 1.7321 | 1 | 1 | 1 | 2 | 4 | 0 | 4 | 0 | 0 | 0.0000 | 0.7321 | 0.0000 | 0.0000 | 1.0718 | 0.0000 |
| 1 | -1 | 0.3660 | -1.3660 | 0 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | 0.8660 | -0.5000 | 0 | -1 | 1 | 0 | 0 | 5 | 5 | 5 | 5 | 0.8660 | 0.5000 | 0.0000 | 2.5000 | 0.0000 | 2.5000 |
| 1 | 1 | 1.3660 | 0.3660 | 1 | 0 | 2 | 1 | 5 | 4 | 0 | 0 | 0 | 0.3660 | 0.3660 | -1.8301 | -0.3660 | 0.1340 | 2.9378 |
| 1 | 2 | 1.8660 | 1.2321 | 1 | 1 | 2 | 2 | 4 | 0 | 0 | 0 | 0 | 0.8660 | 0.2321 | -3.4641 | -0.9282 | 0.8038 | 0.4115 |
| 2 | -1 | 1.2321 | -1.8660 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0 | 1.7321 | -1.0000 | 1 | -1 | 2 | -1 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 1 | 2.2321 | -0.1340 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 2 | 2.7321 | 0.7321 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| x=-2 | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|
| x=-1 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| x=0 | 0.3349 | 5.0000 | 4.5670 | 1.0718 |
| x=1 | 0.0000 | 2.5000 | 2.9378 | 0.4115 |
| x=2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| x=-2 | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-1 | 0 | 0 | 2 | 0 |
| x=0 | 0 | 5 | 4 | 1 |
| x=1 | 0 | 2 | 2 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

| x=-2 | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-1 | 0 | 0 | 0 | 0 |
| x=0 | 1 | 5 | 5 | 2 |
| x=1 | 0 | 3 | 3 | 1 |
| x=2 | 0 | 0 | 0 | 0 |

ceiling

floor

| | y_0 | y_1 | | | | | | | | | | | | | | | |
|-------|-------|-------------------|--------------------|-------|-------|-------|-------|--------------|--------------|--------------|--------------|----------|----------|------------------------------|------------------------------|---------------|------------|
| x_0 | 7 | 3 | | | | | | | | | | | | | | | |
| x_0 | 4 | 4 | | | | | | | | | | | | | | | |
| x' | y' | $x=x'\cos+y'\sin$ | $y=-x'\sin+y'\cos$ | x_0 | y_0 | x_1 | y_1 | $f(x_0,y_0)$ | $f(x_0,y_1)$ | $f(x_1,y_0)$ | $f(x_1,y_1)$ | dx | dy | $(f(x_1,y_0)-f(x_0,y_0))*dx$ | $(f(x_0,y_1)-f(x_0,y_0))*dy$ | $[...]*dx*dy$ | $g(x',y')$ |
| -2 | -1 | 1.231906726 | 0.779513011 | 1 | 0 | 2 | 1 | 4 | 0 | 0 | 0 | 0.231907 | 0.779513 | -0.927626902 | -3.118052043 | 0.72309724 | -3.3225817 |
| -2 | 0 | 1.731973591 | 1.000133731 | 1 | 1 | 2 | 2 | 4 | 4 | 0 | 0 | 0.731974 | 0.000134 | -2.927894364 | 0 | 0 | -2.9278944 |
| -2 | 1 | 2.232040457 | 1.220754451 | 2 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 0.23204 | 0.220754 | 0 | 0 | 0 | 0 |
| -2 | 2 | 2.732107322 | 1.441375171 | 2 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 0.732107 | 0.441375 | 0 | 0 | 0 | 0 |
| -1 | -1 | 0.36591993 | 0.279446145 | 0 | 0 | 1 | 1 | 3 | 0 | 4 | 0 | 0.36592 | 0.279446 | 0.36591993 | -0.838338436 | -0.10225491 | -0.5746734 |
| -1 | 0 | 0.865986796 | 0.500066865 | 0 | 0 | 1 | 1 | 7 | 3 | 0 | 4 | 0.865987 | 0.500067 | -6.061907569 | -2.000267462 | 3.46441042 | -4.5977646 |
| -1 | 1 | 1.366053661 | 0.720687586 | 1 | 0 | 2 | 1 | 0 | 4 | 0 | 0 | 0.366054 | 0.720688 | 0 | 2.882750343 | -1.05524132 | 1.827509 |
| -1 | 2 | 1.866120526 | 0.941308306 | 1 | 0 | 2 | 1 | 0 | 0 | 3 | 0 | 0.866121 | 0.941308 | 2.598361579 | 0 | -2.44585934 | 0.1525022 |
| 0 | -1 | -0.500066865 | -0.22062072 | -1 | -1 | 0 | 0 | 0 | 0 | 7 | 3 | 0.499933 | 0.779379 | 3.499531942 | 0 | -1.55855011 | 1.9409818 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 7 | 7 | 4 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0.500066865 | 0.22062072 | 0 | 0 | 1 | 1 | 0 | 7 | 0 | 4 | 0.500067 | 0.220621 | 0 | 1.544345041 | -0.33097534 | 1.2133697 |
| 0 | 2 | 1.000133731 | 0.44124144 | 1 | 0 | 2 | 1 | 0 | 3 | 0 | 0 | 0.000134 | 0.441241 | 0 | 1.323724321 | -0.00017702 | 1.3235473 |
| 1 | -1 | -1.366053661 | -0.720687586 | -2 | -1 | -1 | 0 | 0 | 0 | 7 | 0 | 0.633946 | 0.279312 | 4.437624373 | 0 | -1.23948358 | 3.1981408 |
| 1 | 0 | -0.865986796 | -0.500066865 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 7 | 0.134013 | 0.499933 | 0 | 0 | 0.46898349 | 0.4689835 |
| 1 | 2 | 0.134146935 | -0.058825425 | 0 | -1 | 1 | 0 | 0 | 0 | 0 | 0 | 0.134147 | 0.941175 | 0 | 0 | 0 | 0 |
| 1 | -1 | -1.366053661 | -0.720687586 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.633946 | 0.279312 | 0 | 0 | 0 | 0 |
| 2 | -1 | -2.232040457 | -1.220754451 | -3 | -2 | -2 | -1 | 0 | 0 | 0 | 0 | 0.76796 | 0.779246 | 0 | 0 | 0 | 0 |
| 2 | 0 | -1.731973591 | -1.000133731 | -2 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0.268026 | 0.999866 | 0 | 0 | 0 | 0 |
| 2 | 1 | -1.231906726 | -0.779513011 | -2 | -1 | -1 | -1 | 0 | 0 | 0 | 0 | 0.768093 | 0.220487 | 0 | 0 | 0 | 0 |
| 2 | 2 | -0.73183986 | -0.558892291 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.26816 | 0.441108 | 0 | 0 | 0 | 0 |

นายวรวิทย์ ปานวนิช 590111179

| | y_0 | y_1 | | | | | | | | | | | | | | | |
|-------|-------|-------------------|--------------------|-------|-------|-------|-------|--------------|--------------|--------------|--------------|----------|----------|------------------------------|------------------------------|---------------|--------------|
| x_0 | 6 | 7 | | | | | | | | | | | | | | | |
| x_0 | 3 | 5 | 1302%4=2 | | | | | | | | | | | | | | |
| | | | zeta(2) = 120 | | | | | | | | | | | | | | |
| x' | y' | $x=x'\cos+y'\sin$ | $y=-x'\sin+y'\cos$ | x_0 | y_0 | x_1 | y_1 | $f(x_0,y_0)$ | $f(x_0,y_1)$ | $f(x_1,y_0)$ | $f(x_1,y_1)$ | dx | dy | $(f(x_1,y_0)-f(x_0,y_0))*dx$ | $(f(x_0,y_1)-f(x_0,y_0))*dy$ | $[...]*dx*dy$ | $g(x',y')$ |
| -2 | -1 | 0.133836724 | 2.232059079 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.133837 | 0.232059 | 0 | 0 | 0 | 0 |
| -2 | 0 | 0.999893011 | 1.732112573 | 0 | 1 | 1 | 2 | 7 | 0 | 5 | 0 | 0.999893 | 0.732113 | -1.999786022 | -5.124788013 | 1.464068491 | -5.660505545 |
| -2 | 1 | 1.865949298 | 1.232166068 | 1 | 1 | 2 | 2 | 5 | 0 | 0 | 0 | 0.865949 | 0.232166 | -4.329746488 | -1.160830339 | 1.005220217 | -4.48535661 |
| -2 | 2 | 2.732005584 | 0.732219562 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0.732006 | 0.73222 | 0 | 0 | 0 | 0 |
| -1 | -1 | -0.366109781 | 1.366002792 | -1 | 1 | 0 | 2 | 0 | 0 | 7 | 0 | 0.63389 | 0.366003 | 4.437231532 | 0 | -1.62403913 | 2.813192402 |
| -1 | 0 | 0.499946505 | 0.866056287 | 0 | 0 | 1 | 1 | 6 | 7 | 3 | 5 | 0.499947 | 0.866056 | -1.499839516 | 0.866056287 | 0.432981814 | -0.200801416 |
| -1 | 1 | 1.366002792 | 0.366109781 | 1 | 0 | 2 | 1 | 3 | 5 | 0 | 0 | 0.366003 | 0.36611 | -1.098008376 | 0.732219562 | -0.2679944 | -0.633783218 |
| -1 | 2 | 2.232059079 | -0.133836724 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.232059 | 0.866163 | 0 | 0 | 0 | 0 |
| 0 | -1 | -0.866056287 | 0.499946505 | -1 | 0 | 0 | 1 | 0 | 0 | 6 | 7 | 0.133944 | 0.499947 | 0.80366228 | 0 | 0.066964691 | 0.870626971 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 7 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0.866056287 | -0.499946505 | 0 | -1 | 1 | 0 | 0 | 6 | 0 | 3 | 0.866056 | 0.500053 | 0 | 3.000320967 | -1.29922342 | 1.701097549 |
| 0 | 2 | 1.732112573 | -0.999893011 | 1 | -1 | 2 | 0 | 0 | 3 | 0 | 0 | 0.732113 | 0.000107 | 0 | 0.000320967 | -0.00023498 | 8.59831E-05 |
| 1 | -1 | -1.366002792 | -0.366109781 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.633997 | 0.63389 | 0 | 0 | 0 | 0 |
| 1 | 0 | -0.499946505 | -0.866056287 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 6 | 0.500053 | 0.133944 | 0 | 0 | 0.401874132 | 0.401874132 |
| 1 | 2 | 1.232166068 | -1.865949298 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0.232166 | 0.134051 | 0 | 0 | 0 | 0 |
| 1 | -1 | -1.366002792 | -0.366109781 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.633997 | 0.63389 | 0 | 0 | 0 | 0 |
| 2 | -1 | -1.865949298 | -1.232166068 | -2 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0.134051 | 0.767834 | 0 | 0 | 0 | 0 |
| 2 | 0 | -0.999893011 | -1.732112573 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 | 0.000107 | 0.267887 | 0 | 0 | 0 | 0 |
| 2 | 1 | -0.133836724 | -2.232059079 | -1 | -3 | 0 | -2 | 0 | 0 | 0 | 0 | 0.866163 | 0.767941 | 0 | 0 | 0 | 0 |
| 2 | 2 | 0.732219562 | -2.732005584 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 | 0.73222 | 0.267994 | 0 | 0 | 0 | 0 |

นายศิวกร แต่สุวรรณ์ 59011302

หมุนภาพด้วยเทคนิค Backward mapping และใช้การกำหนดค่าระดับความเข้มแสงผลลัพธ์ด้วย
เทคนิคการเฉลี่ยค่าแบบ bilinear interpolation

- กำหนดค่าใน 2D-Array ด้วยการสุ่มค่าระหว่าง 3-7

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 6 | 4 |
| x=1 | 5 | 7 |

- มุมที่หมุนขึ้นกับเลขท้ายของรหัสนศ. Mod 4

$$0649 \% 4 = 1$$

$$\text{zeta}(1) = 60$$

| Rotation | Transform | | | Rotate | 1.047198 |
|----------|-------------|-------------|----|--------|----------|
| x | -0.95241298 | -0.30481062 | x' | cos() | 0.5 |
| y | 0.304810621 | -0.95241298 | y' | sin() | 0.866025 |

Forward mapping

| x | y | f(x,y) | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
|-----|---|--------|----------------------|----------------------|-----------|-----------|
| 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| 0 | 1 | 4 | -0.8660254 | 0.5 | -1 | 1 |
| 1 | 0 | 5 | 0.5 | 0.866025404 | 1 | 1 |
| 1 | 1 | 7 | -0.3660254 | 1.366025404 | 0 | 1 |
| Min | | | -0.8660254 | 0 | -1 | 0 |
| Max | | | 0.5 | 1.366025404 | 1 | 1 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 4 | 0 |
| x=0 | 0 | 6 | 7 | 0 |
| x=1 | 0 | 0 | 5 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

Backward Mapping (Bilinear Interpolation)

| x' | y' | $x = x' \cos + y' \sin$ | $y = -x' \sin + y' \cos$ | x_0 | y_0 | x_1 | y_1 | $f(x_0, y_0)$ | $f(x_0, y_1)$ | $f(x_1, y_0)$ | $f(x_1, y_1)$ |
|------|------|-------------------------|--------------------------|-------|-------|-------|-------|---------------|---------------|---------------|---------------|
| -2 | -1 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 0 | -1.0000 | 1.7321 | -1 | 1 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 1 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 |
| -2 | 2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 |
| -1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 |
| -1 | 0 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 6 | 4 |
| -1 | 1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 4 | 0 | 7 | 0 |
| -1 | 2 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 7 | 0 | 0 | 0 |
| 0 | -1 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 6 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 6 | 6 | 6 | 6 |
| 0 | 1 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 6 | 4 | 5 | 7 |
| 0 | 2 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 7 | 7 | 0 | 0 |
| 1 | -1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 6 | 0 | 5 |
| 1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 5 | 0 | 0 |
| 1 | 2 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 |
| 2 | -1 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 |
| 2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 |

| dx | dy | $[f(x_1, y_0) - f(x_0, y_0)] * dx$ | $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$ | $g(x', y')$ |
|--------|--------|------------------------------------|------------------------------------|---|-------------|
| 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 0.8660 | 3.0000 | 0.0000 | -0.8660 | 2.1340 |
| 0.3660 | 0.3660 | 1.0981 | -1.4641 | -0.4019 | 3.2321 |
| 0.2321 | 0.8660 | -1.6244 | -6.0622 | 1.4067 | 0.7202 |
| 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.4019 | 0.4019 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.0000 |
| 0.8660 | 0.5000 | -0.8660 | -1.0000 | 1.7321 | 5.8660 |
| 0.7321 | 0.0000 | -5.1244 | 0.0000 | 0.0000 | 1.8756 |
| 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 0.1340 | 0.0000 | 0.8038 | -0.0670 | 0.7369 |
| 0.3660 | 0.6340 | 0.0000 | 3.1699 | -1.1603 | 2.0096 |
| 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|--------|--------|--------|
| $x=-2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $x=-1$ | 0.0000 | 2.1340 | 3.2321 | 0.7202 |
| $x=0$ | 0.4019 | 6.0000 | 5.8660 | 1.8756 |
| $x=1$ | 0.0000 | 0.7369 | 2.0096 | 0.0000 |
| $x=2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Floor

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 2 | 3 | 0 |
| $x=0$ | 0 | 6 | 5 | 1 |
| $x=1$ | 0 | 0 | 2 | 0 |
| $x=2$ | 0 | 0 | 0 | 0 |

Ceiling

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 3 | 4 | 1 |
| $x=0$ | 1 | 6 | 6 | 2 |
| $x=1$ | 0 | 1 | 3 | 0 |
| $x=2$ | 0 | 0 | 0 | 0 |

Backward mapping (Bilinear Interpolation)

ภาพขนาด 2x2 พิกเซล

| | $y=0$ | $y=1$ |
|-------|-------|-------|
| $x=0$ | 7 | 5 |
| $x=1$ | 6 | 3 |

Rotation using Bilinear Interpolation

มุมที่ใช้ในการหมุน(θ)คือ 30 องศา จะได้ค่า RADIANS(), COS() และ SIN() ดังนี้

| | |
|--------|----------|
| Rotate | 0.523599 |
| cos() | 0.866025 |
| sin() | 0.5 |

1. ทำการตรวจสอบมุมว่าพอหมุนแล้วจะใช้พิกเซลเท่าไหร่ โดยใช้วิธี Forward mapping

$$\text{สูตร } \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

| x | y | $f(x,y)$ | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
|-----|-----|----------|----------------------|----------------------|---------------|---------------|
| 0 | 0 | 7 | 0 | 0 | 0 | 0 |
| 0 | 1 | 5 | -0.5 | 0.866025404 | -1 | 1 |
| 1 | 0 | 6 | 0.866025404 | 0.5 | 1 | 1 |
| 1 | 1 | 3 | 0.366025404 | 1.366025404 | 0 | 1 |

| | | | | | |
|-----|--|-------------|-------------|----|---|
| min | | -0.5 | 0 | -1 | 0 |
| max | | 0.866025404 | 1.366025404 | 1 | 1 |

2. ภาพที่จากทำวิธี Forward mapping

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 0 | 5 | 0 |
| $x=0$ | 0 | 7 | 3 | 0 |
| $x=1$ | 0 | 0 | 6 | 0 |
| $x=2$ | 0 | 0 | 0 | 0 |

จากการทำวิธี Forward mapping จะเห็นได้ว่า ค่า x จะมีค่าตั้งแต่ -2 ถึง 2 และ ค่า y จะมีค่าตั้งแต่ -1 ถึง 2 จากนั้นจะนำช่วงค่า x และ y ไปใช้ในการทำวิธี Backward mapping ต่อ

3. ทำวิธี Backward mapping

$$\text{สูตร} - \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x' \\ y' \end{bmatrix}$$

$$- g(x', y') = f(x_0, y_0) + [f(x_1, y_0) - f(x_0, y_0)]\Delta x + [f(x_0, y_1) - f(x_0, y_0)]\Delta y + [f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)]\Delta x\Delta y$$

| x^i | y^i | $x=x'\cos+y'\sin$ | $y=-x'\sin+y'\cos$ | x_0 | y_0 | x_1 | y_1 |
|-------|-------|-------------------|--------------------|-------|-------|-------|-------|
| -2 | -1 | -2.2321 | 0.1340 | -3 | 0 | -2 | 1 |
| -2 | 0 | -1.7321 | 1.0000 | -2 | 1 | -1 | 1 |
| -2 | 1 | -1.2321 | 1.8660 | -2 | 1 | -1 | 2 |
| -2 | 2 | -0.7321 | 2.7321 | -1 | 2 | 0 | 3 |
| -1 | -1 | -1.3660 | -0.3660 | -2 | -1 | -1 | 0 |
| -1 | 0 | -0.8660 | 0.5000 | -1 | 0 | 0 | 1 |
| -1 | 1 | -0.3660 | 1.3660 | -1 | 1 | 0 | 2 |
| -1 | 2 | 0.1340 | 2.2321 | 0 | 2 | 1 | 3 |
| 0 | -1 | -0.5000 | -0.8660 | -1 | -1 | 0 | 0 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0.5000 | 0.8660 | 0 | 0 | 1 | 1 |
| 0 | 2 | 1.0000 | 1.7321 | 1 | 1 | 1 | 2 |
| 1 | -1 | 0.3660 | -1.3660 | 0 | -2 | 1 | -1 |
| 1 | 0 | 0.8660 | -0.5000 | 0 | -1 | 1 | 0 |
| 1 | 1 | 1.3660 | 0.3660 | 1 | 0 | 2 | 1 |
| 1 | 2 | 1.8660 | 1.2321 | 1 | 1 | 2 | 2 |
| 2 | -1 | 1.2321 | -1.8660 | 1 | -2 | 2 | -1 |
| 2 | 0 | 1.7321 | -1.0000 | 1 | -1 | 2 | -1 |
| 2 | 1 | 2.2321 | -0.1340 | 2 | -1 | 3 | 0 |
| 2 | 2 | 2.7321 | 0.7321 | 2 | 0 | 3 | 1 |

| x' | y' | $f(x_0,y_0)$ | $f(x_0,y_1)$ | $f(x_1,y_0)$ | $f(x_1,y_1)$ | dx | dy | $[f(x_1,y_0)-f(x_0,y_0)]*dx$ | $[f(x_0,y_1)-f(x_0,y_0)]*dy$ | $[f(x_1,y_1)+f(x_0,y_0)-f(x_0,y_1)-f(x_1,y_0)]*dx*dy$ | $g(x',y')$ |
|------|------|--------------|--------------|--------------|--------------|--------|--------|------------------------------|------------------------------|---|------------|
| -2 | -1 | 0 | 0 | 0 | 0 | 0.7679 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 0 | 0 | 0 | 0 | 0 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 1 | 0 | 0 | 0 | 0 | 0.7679 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 2 | 0 | 0 | 0 | 0 | 0.2679 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -1 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | 0 | 0 | 0 | 7 | 5 | 0.1340 | 0.5000 | 0.9378 | 0.0000 | -0.1340 | 0.8038 |
| -1 | 1 | 0 | 0 | 5 | 0 | 0.6340 | 0.3660 | 3.1699 | 0.0000 | -1.1603 | 2.0096 |
| -1 | 2 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -1 | 0 | 0 | 0 | 7 | 0.5000 | 0.1340 | 0.0000 | 0.0000 | 0.4689 | 0.4689 |
| 0 | 0 | 7 | 7 | 7 | 7 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.0000 |
| 0 | 1 | 7 | 5 | 6 | 3 | 0.5000 | 0.8660 | -0.5000 | -1.7321 | -0.4330 | 4.3349 |
| 0 | 2 | 3 | 0 | 3 | 0 | 0.0000 | 0.7321 | 0.0000 | -2.1962 | 0.0000 | 0.8038 |
| 1 | -1 | 0 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | 0 | 7 | 0 | 6 | 0.8660 | 0.5000 | 0.0000 | 3.5000 | -0.4330 | 3.0670 |
| 1 | 1 | 6 | 3 | 0 | 0 | 0.3660 | 0.3660 | -2.1962 | -1.0981 | 0.4019 | 3.1077 |
| 1 | 2 | 3 | 0 | 0 | 0 | 0.8660 | 0.2321 | -2.5981 | -0.6962 | 0.6029 | 0.3087 |
| 2 | -1 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 1 | 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 2 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

4. ภาพที่จากทำวิธี Backward mapping

a. ค่าจริงที่ได้

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|--------|--------|--------|
| $x=-2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $x=-1$ | 0.0000 | 0.8038 | 2.0096 | 0.0000 |
| $x=0$ | 0.4689 | 7.0000 | 4.3349 | 0.8038 |
| $x=1$ | 0.0000 | 3.0670 | 3.1077 | 0.3087 |
| $x=2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

b. ค่าที่ผ่านการ floor

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 0 | 2 | 0 |
| $x=0$ | 0 | 7 | 4 | 0 |
| $x=1$ | 0 | 3 | 3 | 0 |
| $x=2$ | 0 | 0 | 0 | 0 |

c. ค่าที่ผ่านการ ceiling

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 1 | 3 | 0 |
| $x=0$ | 1 | 7 | 5 | 1 |
| $x=1$ | 0 | 4 | 4 | 1 |
| $x=2$ | 0 | 0 | 0 | 0 |

1. สร้างภาพขนาด 2×2 พิกเซล ในรูปของ 2D-array และกำหนดค่าใน 2D-array ด้วยการ random ค่าระหว่าง 3-7

| | $y=0$ | $y=1$ |
|-------|-------|-------|
| $x=0$ | 5 | 7 |
| $x=1$ | 3 | 4 |

2. ทำการหมุนภาพด้วยเทคนิค Backward mapping และใช้การกำหนดค่าระดับความเข้มแสงผลลัพธ์ด้วยเทคนิคการเคลื่อนค่าแบบ bilinear interpolation

มุ่งที่หมุน คือ $1268\%4 = 0$ จะได้ zeta = 30

| | |
|--------|----------|
| Rotate | 0.523599 |
| cos() | 0.866025 |
| sin() | 0.5 |

- ### 3. Forward Mapping

| x | y | f(x,y) | $x' = x\cos - y\sin$ | $y' = x\sin + y\cos$ | round(x') | round(y') |
|---|---|--------|----------------------|----------------------|---------------|---------------|
| 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| 0 | 1 | 7 | -0.5 | 0.866025404 | -1 | 1 |
| 1 | 0 | 3 | 0.866025404 | 0.5 | 1 | 1 |
| 1 | 1 | 4 | 0.366025404 | 1.366025404 | 0 | 1 |

min -0.5 0 -1

max 0.866025404 1.366025404 1

ภาพจากการทำ Forward Mapping

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 0 | 7 | 0 |
| $x=0$ | 0 | 5 | 4 | 0 |
| $x=1$ | 0 | 0 | 3 | 0 |
| $x=2$ | 0 | 0 | 0 | 0 |

จากนี้จะนำช่วงค่า x และ y ไปใช้ในการทำวิธี Backward mapping ต่อ

| x' | y' | $x=x'\cos+y'\sin$ | $y=-x'\sin+y'\cos$ | x_0 | y_0 | x_1 | y_1 |
|------|------|-------------------|--------------------|-------|-------|-------|-------|
| -2 | -1 | -2.2321 | 0.1340 | -3 | 0 | -2 | 1 |
| -2 | 0 | -1.7321 | 1.0000 | -2 | 1 | -1 | 1 |
| -2 | 1 | -1.2321 | 1.8660 | -2 | 1 | -1 | 2 |
| -2 | 2 | -0.7321 | 2.7321 | -1 | 2 | 0 | 3 |
| -1 | -1 | -1.3660 | -0.3660 | -2 | -1 | -1 | 0 |
| -1 | 0 | -0.8660 | 0.5000 | -1 | 0 | 0 | 1 |
| -1 | 1 | -0.3660 | 1.3660 | -1 | 1 | 0 | 2 |
| -1 | 2 | 0.1340 | 2.2321 | 0 | 2 | 1 | 3 |
| 0 | -1 | -0.5000 | -0.8660 | -1 | -1 | 0 | 0 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0.5000 | 0.8660 | 0 | 0 | 1 | 1 |
| 0 | 2 | 1.0000 | 1.7321 | 1 | 1 | 1 | 2 |
| 1 | -1 | 0.3660 | -1.3660 | 0 | -2 | 1 | -1 |
| 1 | 0 | 0.8660 | -0.5000 | 0 | -1 | 1 | 0 |
| 1 | 1 | 1.3660 | 0.3660 | 1 | 0 | 2 | 1 |
| 1 | 2 | 1.8660 | 1.2321 | 1 | 1 | 2 | 2 |
| 2 | -1 | 1.2321 | -1.8660 | 1 | -2 | 2 | -1 |
| 2 | 0 | 1.7321 | -1.0000 | 1 | -1 | 2 | -1 |
| 2 | 1 | 2.2321 | -0.1340 | 2 | -1 | 3 | 0 |
| 2 | 2 | 2.7321 | 0.7321 | 2 | 0 | 3 | 1 |

| f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0)-f(x0,y0)]*dx | [f(x0,y1)-f(x0,y0)]*dy | [f(x1,y1)+f(x0,y0)-f(x0,y1)-f(x1,y0)]*dx*dy | g(x',y') |
|----------|----------|----------|----------|--------|--------|------------------------|------------------------|---|----------|
| 0 | 0 | 0 | 0 | 0.7679 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7679 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2679 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 5 | 7 | 0.1340 | 0.5000 | 0.6699 | 0.0000 | 0.1340 | 0.8038 |
| 0 | 0 | 7 | 0 | 0.6340 | 0.3660 | 4.4378 | 0.0000 | -1.6244 | 2.8135 |
| 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 5 | 0.5000 | 0.1340 | 0.0000 | 0.0000 | 0.3349 | 0.3349 |
| 5 | 5 | 5 | 5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0000 |
| 5 | 7 | 3 | 4 | 0.5000 | 0.8660 | -1.0000 | 1.7321 | -0.4330 | 5.2990 |
| 4 | 0 | 4 | 0 | 0.0000 | 0.7321 | 0.0000 | -2.9282 | 0.0000 | 1.0718 |
| 0 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 5 | 0 | 3 | 0.8660 | 0.5000 | 0.0000 | 2.5000 | -0.8660 | 1.6340 |
| 3 | 4 | 0 | 0 | 0.3660 | 0.3660 | -1.0981 | 0.3660 | -0.1340 | 2.1340 |
| 4 | 0 | 0 | 0 | 0.8660 | 0.2321 | -3.4641 | -0.9282 | 0.8038 | 0.4115 |
| 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

ภาพที่จากทำวิธี Backward mapping

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|--------|--------|--------|
| $x=-2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $x=-1$ | 0.0000 | 0.8038 | 2.8135 | 0.0000 |
| $x=0$ | 0.3349 | 5.0000 | 5.2990 | 1.0718 |
| $x=1$ | 0.0000 | 1.6340 | 2.1340 | 0.4115 |
| $x=2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

floor

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 0 | 2 | 0 |
| $x=0$ | 0 | 5 | 5 | 1 |
| $x=1$ | 0 | 1 | 2 | 0 |
| $x=2$ | 0 | 0 | 0 | 0 |

ceiling

| | $y=-1$ | $y=0$ | $y=1$ | $y=2$ |
|--------|--------|-------|-------|-------|
| $x=-2$ | 0 | 0 | 0 | 0 |
| $x=-1$ | 0 | 1 | 3 | 0 |
| $x=0$ | 1 | 5 | 6 | 2 |
| $x=1$ | 0 | 2 | 3 | 1 |
| $x=2$ | 0 | 0 | 0 | 0 |

Student ID:

1269

MOD(1269,4) : 1

zeta(1)

60

គ្រូនយោ ចំណាំសាស្ត្រ 59011269

| | y=0 | y=1 |
|-----|-----|-----|
| x=0 | 5 | 5 |
| x=1 | 5 | 4 |

| | |
|--------|-------------|
| Rotate | 1.047197551 |
| cos() | 0.5 |
| sin() | 0.866025404 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 0 | 5 | 0 |
| x=0 | 0 | 5 | 4 | 0 |
| x=1 | 0 | 0 | 5 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

Forward mapping

| x | y | f(x,y) | x'=x*cos-y*sin | y'=x*sin+y*cos | round(x') | round(y') |
|---|---|--------|----------------|----------------|-----------|-----------|
| 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| 0 | 1 | 5 | -0.866025404 | 0.5 | -1 | 1 |
| 1 | 0 | 5 | 0.5 | 0.866025404 | 1 | 1 |
| 1 | 1 | 4 | -0.366025404 | 1.366025404 | 0 | 1 |

| | | | | | |
|-----|--|--------------|-------------|----|---|
| min | | -0.866025404 | 0 | -1 | 0 |
| max | | 0.5 | 1.366025404 | 1 | 1 |

| x' | y' | x=x'*cos+y'*sin | y=-x'*sin+y'*cos | x0 | y0 | x1 | y1 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) |
|----|----|-----------------|------------------|----|----|----|----|----------|----------|----------|----------|
| -2 | -1 | -1.8660 | 1.2321 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 0 | -1.0000 | 1.7321 | -1 | 1 | -1 | 2 | 0 | 0 | 0 | 0 |
| -2 | 1 | -0.1340 | 2.2321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 |
| -2 | 2 | 0.7321 | 2.7321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 |
| -1 | -1 | -1.3660 | 0.3660 | -2 | 0 | -1 | 1 | 0 | 0 | 0 | 0 |
| -1 | 0 | -0.5000 | 0.8660 | -1 | 0 | 0 | 1 | 0 | 0 | 5 | 5 |
| -1 | 1 | 0.3660 | 1.3660 | 0 | 1 | 1 | 2 | 5 | 0 | 4 | 0 |
| -1 | 2 | 1.2321 | 1.8660 | 1 | 1 | 2 | 2 | 4 | 0 | 0 | 0 |
| 0 | -1 | -0.8660 | -0.5000 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 5 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 |
| 0 | 1 | 0.8660 | 0.5000 | 0 | 0 | 1 | 1 | 5 | 5 | 5 | 4 |
| 0 | 2 | 1.7321 | 1.0000 | 1 | 1 | 2 | 1 | 4 | 4 | 0 | 0 |
| 1 | -1 | -0.3660 | -1.3660 | -1 | -2 | 0 | -1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0.5000 | -0.8660 | 0 | -1 | 1 | 0 | 0 | 5 | 0 | 5 |
| 1 | 1 | 1.3660 | -0.3660 | 1 | -1 | 2 | 0 | 0 | 5 | 0 | 0 |
| 1 | 2 | 2.2321 | 0.1340 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 |
| 2 | -1 | 0.1340 | -2.2321 | 0 | -3 | 1 | -2 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1.0000 | -1.7321 | 1 | -2 | 1 | -1 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1.8660 | -1.2321 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 |
| 2 | 2 | 2.7321 | -0.7321 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 |

| dx | dy | $[f(x_1, y_0) - f(x_0, y_0)] * dx$ | $[f(x_0, y_1) - f(x_0, y_0)] * dy$ | $[f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$ | $g(x', y')$ |
|--------|--------|------------------------------------|------------------------------------|---|-------------|
| 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.8660 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.6340 | 0.3660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 0.8660 | 2.5000 | 0.0000 | 0.0000 | 2.5000 |
| 0.3660 | 0.3660 | -0.3660 | -1.8301 | 0.1340 | 2.9378 |
| 0.2321 | 0.8660 | -0.9282 | -3.4641 | 0.8038 | 0.4115 |
| 0.1340 | 0.5000 | 0.0000 | 0.0000 | 0.3349 | 0.3349 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0000 |
| 0.8660 | 0.5000 | 0.0000 | 0.0000 | -0.4330 | 4.5670 |
| 0.7321 | 0.0000 | -2.9282 | 0.0000 | 0.0000 | 1.0718 |
| 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.5000 | 0.1340 | 0.0000 | 0.6699 | 0.0000 | 0.6699 |
| 0.3660 | 0.6340 | 0.0000 | 3.1699 | -1.1603 | 2.0096 |
| 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.1340 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.8660 | 0.7679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.7321 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| x=-1 | 0.0000 | 2.5000 | 2.9378 | 0.4115 |
| x=0 | 0.3349 | 5.0000 | 4.5670 | 1.0718 |
| x=1 | 0.0000 | 0.6699 | 2.0096 | 0.0000 |
| x=2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | y=-1 | y=0 | y=1 | y=2 |
|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 3 | 3 | 0 |
| x=0 | 0 | 5 | 5 | 1 |
| x=1 | 0 | 1 | 2 | 0 |
| x=2 | 0 | 0 | 0 | 0 |

| | |
|--------------|----------|
| รหัสนักศึกษา | 59010444 |
| Mod 4 | 0 |
| zeta() | zeta(30) |

| 2D-Array | Y = 0 | Y = 1 |
|----------|-------|-------|
| X = 0 | 7 | 6 |
| X = 1 | 4 | 3 |

***Roundup

| Bilinear Interpolation | | | | | | | | | | | | |
|------------------------|----|---|---|----------|----------|----------|----------|----------|----------|--------|--------|--------|
| X' | Y' | X = X'cos(θ) - Y'sin(θ) | Y = X'sin(θ) + Y'cos(θ) | round(X) | round(Y) | f(X0,Y0) | f(X0,Y1) | f(X1,Y0) | f(X1,Y1) | dX | dY | |
| -3 | -1 | -3.0979 | 0.6346 | -4 | 1 | 0 | 0 | 0 | 0 | 0.9021 | 0.3654 | |
| -3 | 0 | -2.5978 | 1.5005 | -3 | 2 | 0 | 0 | 0 | 0 | 0.4022 | 0.4995 | |
| -3 | 1 | -2.0976 | 2.3665 | -3 | 3 | 0 | 0 | 0 | 0 | 0.9024 | 0.6335 | |
| -3 | 2 | -1.5974 | 3.2324 | -2 | 4 | 0 | 0 | 0 | 0 | 0.4026 | 0.7676 | |
| -2 | -1 | -2.2320 | 0.1344 | -3 | 1 | 0 | 0 | 0 | 0 | 0.7680 | 0.8656 | |
| -2 | 0 | -1.7318 | 1.0004 | -2 | 2 | 0 | 0 | 0 | 0 | 0.2682 | 0.9996 | |
| -2 | 1 | -1.2317 | 1.8663 | -2 | 2 | 0 | 0 | 0 | 0 | 0.7683 | 0.1337 | |
| -2 | 2 | -0.7315 | 2.7322 | -1 | 3 | 0 | 0 | 0 | 0 | 0.2685 | 0.2678 | |
| -1 | -1 | -1.3661 | -0.3657 | -2 | -1 | 0 | 0 | 0 | 0 | 0.6339 | 0.6343 | |
| -1 | 0 | -0.8659 | 0.5002 | -1 | 1 | 0 | 0 | 0 | 3 | 0 | 0.1341 | 0.4998 |
| -1 | 1 | -0.3657 | 1.3661 | -1 | 2 | 0 | 0 | 0 | 0 | 0 | 0.6343 | 0.6339 |
| -1 | 2 | 0.1344 | 2.2320 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.8656 | 0.7680 |
| 0 | -1 | -0.5002 | -0.8659 | -1 | -1 | 0 | 0 | 0 | 0 | 1 | 0.4998 | 0.1341 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 7 | 6 | 4 | 3 | 0.0000 | 0.0000 | |
| 0 | 1 | 0.5002 | 0.8659 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0.4998 | 0.1341 |
| 0 | 2 | 1.0004 | 1.7318 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0.9996 | 0.2682 |
| 1 | -1 | 0.3657 | -1.3661 | 1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.6343 | 0.6339 |
| 1 | 0 | 0.8659 | -0.5002 | 1 | -1 | 0 | 2 | 0 | 0 | 0 | 0.1341 | 0.4998 |
| 1 | 1 | 1.3661 | 0.3657 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0.6339 | 0.6343 |
| 1 | 2 | 1.8663 | 1.2317 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0.1337 | 0.7683 |
| 2 | -1 | 1.2317 | -1.8663 | 2 | -2 | 0 | 0 | 0 | 0 | 0 | 0.7683 | 0.1337 |
| 2 | 0 | 1.7318 | -1.0004 | 2 | -2 | 0 | 0 | 0 | 0 | 0 | 0.2682 | 0.9996 |
| 2 | 1 | 2.2320 | -0.1344 | 3 | -1 | 0 | 0 | 0 | 0 | 0 | 0.7680 | 0.8656 |
| 2 | 2 | 2.7322 | 0.7315 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0.2678 | 0.2685 |

| | | | | |
|-----|---------|---------|----|----|
| Min | -2.2320 | -1.8663 | -3 | -2 |
| Max | 2.7322 | 2.7322 | 3 | 3 |

| Bilinear Interpolation | | | | | | | | | |
|------------------------|---------------|---------------|---------------|--------|--------|---|---|--|-------------|
| $f(X_0, Y_0)$ | $f(X_0, Y_1)$ | $f(X_1, Y_0)$ | $f(X_1, Y_1)$ | dX | dY | $\frac{[f(X_1, Y_0) - f(X_0, Y_0)] * d}{X}$ | $\frac{[f(X_0, Y_1) - f(X_0, Y_0)] * d}{Y}$ | $\frac{[f(X_1, Y_1) + f(X_0, Y_0) - f(X_1, Y_0) - f(X_0, Y_1)] * d}{X * dY}$ | $g(X', Y')$ |
| 0 | 0 | 0 | 0 | 0.9021 | 0.3654 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.4022 | 0.4995 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.9024 | 0.6335 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.4026 | 0.7676 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7680 | 0.8656 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2682 | 0.9996 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7683 | 0.1337 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2685 | 0.2678 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.6339 | 0.6343 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 3 | 0 | 0.1341 | 0.4998 | 0.4022 | 0.0000 | -0.2010 | 0.2012 |
| 0 | 0 | 0 | 0 | 0.6343 | 0.6339 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.8656 | 0.7680 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 1 | 0.4998 | 0.1341 | 0.0000 | 0.0000 | 0.0670 | 0.0670 |
| 7 | 6 | 4 | 3 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 7.0000 |
| 3 | 0 | 0 | 0 | 0.4998 | 0.1341 | -1.4995 | -0.4022 | 0.2010 | 1.2994 |
| 0 | 0 | 0 | 0 | 0.9996 | 0.2682 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.6343 | 0.6339 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 2 | 0 | 0 | 0.1341 | 0.4998 | 0.0000 | 0.9996 | -0.1340 | 0.8656 |
| 0 | 0 | 0 | 0 | 0.6339 | 0.6343 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.1337 | 0.7683 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7683 | 0.1337 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2682 | 0.9996 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.7680 | 0.8656 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2678 | 0.2685 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | 0 | 0 | 0 | 0.2678 | 0.2685 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | $Y = -2$ | $Y = -1$ | $Y = 0$ | $Y = 1$ | $Y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $X = -3$ | 0 | 0 | 0 | 0 | 0 |
| $X = -2$ | 0 | 0 | 0 | 0 | 0 |
| $X = -1$ | 0 | 0.0670 | 0 | 0.2012 | 0 |
| $X = 0$ | 0 | 0 | 7.0000 | 0 | 0 |
| $X = 1$ | 0 | 0.8656 | 0 | 1.2994 | 0 |
| $X = 2$ | 0 | 0 | 0 | 0 | 0 |
| $X = 3$ | 0 | 0 | 0 | 0 | 0 |

| | $Y = -2$ | $Y = -1$ | $Y = 0$ | $Y = 1$ | $Y = 2$ |
|----------|----------|----------|---------|---------|---------|
| $X = -3$ | 0 | 0 | 0 | 0 | 0 |
| $X = -2$ | 0 | 0 | 0 | 0 | 0 |
| $X = -1$ | 0 | 1.0000 | 0 | 1.0000 | 0 |
| $X = 0$ | 0 | 0 | 7.0000 | 0 | 0 |
| $X = 1$ | 0 | 1.0000 | 0 | 2.0000 | 0 |
| $X = 2$ | 0 | 0 | 0 | 0 | 0 |
| $X = 3$ | 0 | 0 | 0 | 0 | 0 |

2d image from randint

| | 0 | 1 | 2 |
|---|---|---|---|
| 0 | 4 | 6 | 4 |
| 1 | 3 | 7 | 5 |
| 2 | 6 | 3 | 3 |

student mod 4

1

Transformation Matrix

| degree | 0 | 1 | 2 | 3 |
|--------|----|----|-----|-----|
| | 30 | 60 | 120 | 150 |

| Forward | Backward | |
|---------|----------|--------|
| cos() | -sin() | cos() |
| sin() | cos() | -sin() |

$$\begin{matrix} -0.95 & 0.305 \\ -0.3 & -0.95 \end{matrix}$$

$$\begin{matrix} -0.95 & 0.305 \\ 0.305 & -0.95 \end{matrix}$$

Get output array size

Corners ()

Forward Mapping

| x | y | x_out | y_out | x_out | y_out |
|---|---|-------|-------|-------|-------|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 2 | 0.61 | -1.9 | 1 | -2 |
| 2 | 0 | -1.9 | -0.61 | -2 | -1 |
| 2 | 2 | -1.3 | -2.51 | -1 | -3 |

59010337

ກົມ ຖະນົາທິກຸລີ:

$$\begin{matrix} \max & 1 & 0 \\ \min & -2 & -3 \end{matrix}$$

Summary output array size = 4*4

Output Array

| | -3 | -2 | -1 | 0 |
|----|-------|-------|-------|-------|
| -2 | -2.59 | -1.54 | -2.07 | 2.231 |
| -1 | -3.54 | -2.77 | 2.196 | 2.119 |
| 0 | -3.3 | -1.2 | 2.181 | 0 |
| 1 | 0 | 2.078 | 1.933 | 0.219 |

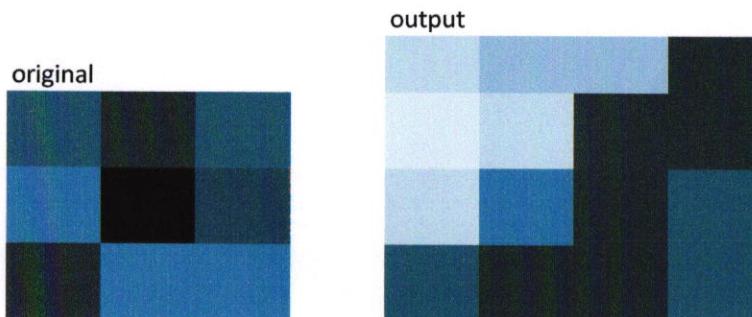
| | -3 | -2 | -1 | 0 | 1 | 2 | 2 | 6 |
|----|----|----|----|---|---|---|---|---|
| -3 | -3 | -2 | -2 | 2 | 1 | 2 | 2 | 6 |
| -4 | -4 | -3 | 2 | 2 | 0 | 1 | 6 | 6 |
| -3 | -3 | -1 | 2 | 0 | 1 | 3 | 6 | 4 |
| 0 | 0 | 2 | 2 | 0 | 4 | 6 | 6 | 4 |

Backward Mapping

Bilinear Interpolation

| x_out | y_out | x | y | x0 | y0 | f(x0, y0) | f(x0, y1) | f(x1, y0) | f(x1, y1) | dx | dy | term1 | term2 | term3 | g(x_out, y_out) |
|-------|-------|--------|--------|----|----|-----------|-----------|-----------|-----------|--------|--------|--------|----------|----------|-----------------|
| -2 | -3 | 2.8193 | 2.2476 | 2 | 2 | 3 | 0 | 0 | 0 | 0.8193 | 0.2476 | -2.458 | -0.74285 | 0.608588 | -2.59204 |
| -2 | -2 | 2.5144 | 1.2952 | 2 | 1 | 3 | 3 | 0 | 0 | 0.5144 | 0.2952 | -1.543 | 0 | 0 | -1.54334 |
| -2 | -1 | 2.2096 | 0.3428 | 2 | 0 | 6 | 3 | 0 | 0 | 0.2096 | 0.3428 | -1.258 | -1.02838 | 0.215585 | -2.07061 |
| -2 | 0 | 1.9048 | -0.61 | 1 | -1 | 0 | 3 | 0 | 6 | 0.9048 | 0.3904 | 0 | 1.171136 | 1.059675 | 2.230811 |
| -1 | -3 | 1.8668 | 2.5524 | 1 | 2 | 5 | 0 | 3 | 0 | 0.8668 | 0.5524 | -1.734 | -2.76214 | 0.957739 | -3.53809 |
| -1 | -2 | 1.562 | 1.6 | 1 | 1 | 7 | 5 | 3 | 3 | 0.562 | 0.6 | -2.248 | -1.20003 | 0.674458 | -2.77371 |
| -1 | -1 | 1.2572 | 0.6476 | 1 | 0 | 3 | 7 | 6 | 3 | 0.2572 | 0.6476 | 0.7717 | 2.590409 | -1.16605 | 2.19603 |
| -1 | 0 | 0.9524 | -0.305 | 0 | -1 | 0 | 4 | 0 | 3 | 0.9524 | 0.6952 | 0 | 2.780758 | -0.66211 | 2.11865 |
| 0 | -3 | 0.9144 | 2.8572 | 0 | 2 | 4 | 0 | 5 | 0 | 0.9144 | 0.8572 | 0.9144 | -3.42896 | -0.78389 | -3.29841 |
| 0 | -2 | 0.6096 | 1.9048 | 0 | 1 | 6 | 4 | 7 | 5 | 0.6096 | 0.9048 | 0.6096 | -1.80965 | 0 | -1.20003 |
| 0 | -1 | 0.3048 | 0.9524 | 0 | 0 | 4 | 6 | 3 | 7 | 0.3048 | 0.9524 | -0.305 | 1.904826 | 0.580611 | 2.180627 |
| 0 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | -3 | -0.038 | 3.162 | -1 | 3 | 0 | 0 | 0 | 0 | 0.962 | 0.162 | 0 | 0 | 0 | 0 |
| 1 | -2 | -0.343 | 2.2096 | -1 | 2 | 0 | 0 | 0 | 4 | 0.6572 | 0.2096 | 2.6288 | 0 | -0.5511 | 2.077733 |
| 1 | -1 | -0.648 | 1.2572 | -1 | 1 | 0 | 0 | 0 | 6 | 0.3524 | 0.2572 | 2.1144 | 0 | -0.18129 | 1.933096 |
| 1 | 0 | -0.952 | 0.3048 | -1 | 0 | 0 | 0 | 0 | 4 | 0.0476 | 0.3048 | 0.1903 | 0 | 0.02901 | 0.219358 |

0 1 2 3 4 5 6 7



$$\text{term1} = [f(x_1, y_0) - f(x_0, y_0)] * dx$$

$$\text{term2} = [f(x_0, y_1) - f(x_0, y_0)] * dy$$

$$\text{term3} = [f(x_0, y_0) + f(x_1, y_1) - f(x_0, y_1) - f(x_1, y_0)] * dx * dy$$

จัดทำโดย นายวุฒินันท์ ชัยศรีวิเรนทร์ 59011256

| | |
|---|---|
| 4 | 2 |
| 5 | 7 |

$$59011256 \bmod 4 = 0 = 30 \text{ degree}$$

| x' | y' | $x = x'\cos + y'\sin$ | $y = x'\sin + y'\cos$ | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy |
|----|----|-----------------------|-----------------------|----|----|----------|----------|----------|----------|--------|--------|
| -2 | -1 | -2.2321 | 0.1340 | -3 | 0 | 0 | 0 | 0 | 0 | 0.7680 | 0.1340 |
| -2 | 0 | -1.7321 | 1.0000 | -2 | 1 | 0 | 0 | 0 | 0 | 0.2680 | 0.0000 |
| -2 | 1 | -1.2321 | 1.8660 | -2 | 1 | 0 | 0 | 0 | 0 | 0.7680 | 0.8660 |
| -2 | 2 | -0.7321 | 2.7321 | -1 | 2 | 0 | 0 | 0 | 0 | 0.2680 | 0.7321 |
| -1 | -1 | -1.3660 | -0.3660 | -2 | -1 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 |
| -1 | 0 | -0.8660 | 0.5000 | -1 | 0 | 0 | 0 | 4 | 2 | 0.1340 | 0.5000 |
| -1 | 1 | -0.3660 | 1.3660 | -1 | 1 | 0 | 0 | 2 | 0 | 0.6340 | 0.3660 |
| -1 | 2 | 0.1340 | 2.2321 | 0 | 2 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 |
| 0 | -1 | -0.5000 | -0.8660 | -1 | -1 | 0 | 0 | 0 | 4 | 0.5000 | 0.1340 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 4 | 2 | 5 | 7 | 0.0000 | 0.0000 |
| 0 | 1 | 0.5000 | 0.8660 | 0 | 0 | 4 | 2 | 5 | 7 | 0.5000 | 0.8660 |
| 0 | 2 | 1.0000 | 1.7321 | 1 | 1 | 7 | 0 | 0 | 0 | 0.0000 | 0.7321 |
| 1 | -1 | 0.3660 | -1.3660 | 0 | -2 | 0 | 0 | 0 | 0 | 0.3660 | 0.6340 |
| 1 | 0 | 0.8660 | -0.5000 | 0 | -1 | 0 | 4 | 0 | 5 | 0.8660 | 0.5000 |
| 1 | 1 | 1.3660 | 0.3660 | 1 | 0 | 5 | 7 | 0 | 0 | 0.3660 | 0.3660 |
| 1 | 2 | 1.8660 | 1.2321 | 1 | 1 | 7 | 0 | 0 | 0 | 0.8660 | 0.2321 |
| 2 | -1 | 1.2321 | -1.8660 | 1 | -2 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 |
| 2 | 0 | 1.7321 | -1.0000 | 1 | -1 | 0 | 0 | 0 | 0 | 0.7321 | 0.0000 |
| 2 | 1 | 2.2321 | -0.1340 | 2 | -1 | 0 | 0 | 0 | 0 | 0.2321 | 0.8660 |
| 2 | 2 | 2.7321 | 0.7321 | 2 | 0 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 |

$$\begin{aligned}
 g(x', y') &= f(x_0, y_0) + [f(x_1, y_0) - f(x_0, y_0)]\Delta x \\
 &\quad + [f(x_0, y_1) - f(x_0, y_0)]\Delta y \\
 &\quad + [f(x_1, y_1) + f(x_0, y_0) - f(x_0, y_1) - f(x_1, y_0)]\Delta x \Delta y
 \end{aligned}$$

| f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y0)-f(x0,y0)]*dx | [f(x0,y1)-f(x0,y0)]*dy | [....]*dx*dy | g(x',y') |
|----------|----------|----------|----------|--------|--------|------------------------|------------------------|--------------|----------|
| 0 | 0 | 0 | 0 | 0.7680 | 0.1340 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.2680 | 0.0000 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.7680 | 0.8660 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.2680 | 0.7321 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0 | 0 | 0 | 0 |
| 0 | 0 | 4 | 2 | 0.1340 | 0.5000 | 0.5360 | 0 | -0.1340 | 0.402 |
| 0 | 0 | 2 | 0 | 0.6340 | 0.3660 | 1.2680 | 0 | -0.4640 | 0.804 |
| 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 4 | 0.5000 | 0.1340 | 0 | 0 | 0.2680 | 0.2680 |
| 4 | 2 | 5 | 7 | 0.0000 | 0.0000 | 0 | 0 | 0 | 4 |
| 4 | 2 | 5 | 7 | 0.5000 | 0.8660 | 0.5000 | -1.7320 | 1.7320 | 4.5 |
| 7 | 0 | 0 | 0 | 0.0000 | 0.7321 | 0 | -5.1247 | 0 | 1.8753 |
| 0 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0 | 0 | 0 | 0 |
| 0 | 4 | 0 | 5 | 0.8660 | 0.5000 | 0 | 2.0000 | 0.4330 | 2.433 |
| 5 | 7 | 0 | 0 | 0.3660 | 0.3660 | -1.8300 | 0.7320 | -0.2680 | 3.6340 |
| 7 | 0 | 0 | 0 | 0.8660 | 0.2321 | -6.0620 | -1.6247 | 1.4070 | 0.7203 |
| 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.7321 | 0.0000 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.7680 | 0.1340 | 0 | 0 | 0 | 0 |

| | y = -1 | y = 0 | y = 1 | y = 2 |
|--------|--------|-------|--------|--------|
| x = -2 | 0 | 0 | 0 | 0 |
| x = -1 | 0 | 0.804 | 0.804 | 0 |
| x = 0 | 0.2680 | 4 | 4.5 | 1.8753 |
| x = 1 | 0 | 2.433 | 3.6340 | 0 |
| x = 2 | 0 | 0 | 0 | 0 |

| | y = -1 | y = 0 | y = 1 | y = 2 |
|--------|--------|-------|-------|-------|
| x = -2 | 0 | 0 | 0 | 0 |
| x = -1 | 0 | 0 | 0 | 0 |
| x = 0 | 0 | 4 | 5 | 2 |
| x = 1 | 0 | 2 | 4 | 0 |
| x = 2 | 0 | 0 | 0 | 0 |

| x=0 | y=0 | y=1 |
|-----|-----|-----|
| x=1 | 6 | 4 |
| x=1 | 7 | 4 |

1138964= 2 zeta(2) 120

முனிகாட்டுயத்தீடு Backward mapping
கார்க்காண்ட்டர் தொழில்மேம்பால்காட்டுயத்தீடு bilinear interpolation

| Rotation | Transform |
|----------|--|
| x y | 0.81418097 0.58061118 -0.5806112 0.81418097 |

| Rotate | 2.0943951 |
|--------|-----------|
| cosθ | -0.5 |
| sinθ | 0.8660254 |

Forward mapping

| x | y | f(x,y) | x'=xcos-y sin | y'=x sin+y cos | round(x) | round(y) |
|---|---|--------|---------------|----------------|----------|----------|
| 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| 0 | 1 | 4 | -0.866025404 | -0.5 | -1 | -1 |
| 1 | 0 | 7 | -0.5 | 0.866025404 | -1 | 1 |
| 1 | 1 | 4 | -1.366025404 | 0.366025404 | -1 | 0 |

| min | -1.366025404 | -0.5 | -1 | -1 |
|-----|--------------|-------------|----|----|
| max | 0 | 0.866025404 | 0 | 1 |

| x=-2 | y=-2 | y=-1 | y=0 | y=1 | y=2 |
|------|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 0 | 0 | 0 |
| x=-1 | 0 | 4 | 4 | 7 | 0 |
| x=0 | 0 | 0 | 6 | 0 | 0 |
| x=1 | 0 | 0 | 0 | 0 | 0 |

| x' | y' | x=x'cos+y'sin | y=x'sin+y'cos | x0 | y0 | x1 | y1 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | [f(x1,y)-f(x0,y0)]*dx | [f(x0,y1)-f(x0,y0)]*dy | [f(x1,y1)+f(x0,y0)-f(x0,y1)-f(x1,y0)]*dx*dy | g(x,y') |
|----|----|---------------|---------------|----|----|----|----|----------|----------|----------|----------|--------|--------|-----------------------|------------------------|---|---------|
| -2 | -2 | -0.7321 | 2.7321 | -1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0.2679 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | -1 | 0.1340 | 2.2321 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0.1340 | 0.2321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -2 | 0 | 1.0000 | 1.7321 | 1 | 1 | 1 | 2 | 4 | 0 | 4 | 0 | 0.0000 | 0.7321 | 0.0000 | -2.9282 | 0.0000 | 1.0718 |
| -2 | 1 | 1.8660 | 1.2321 | 1 | 1 | 2 | 2 | 4 | 0 | 0 | 0 | 0.8660 | 0.2321 | -3.4641 | -0.9282 | 0.8038 | 0.4115 |
| -2 | 2 | 2.7321 | 0.7321 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0.7321 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -2 | -1.2321 | 1.8660 | -2 | 1 | -1 | 2 | 0 | 0 | 0 | 0 | 0.7679 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| -1 | -1 | -0.3660 | 1.3660 | -1 | 1 | 0 | 2 | 0 | 0 | 4 | 0 | 0.6340 | 0.3660 | 2.5359 | 0.0000 | -0.9282 | 1.6077 |
| -1 | 0 | 0.5000 | 0.8660 | 0 | 0 | 1 | 1 | 6 | 4 | 7 | 4 | 0.5000 | 0.8660 | 0.5000 | -1.7321 | -0.4330 | 4.3349 |
| -1 | 1 | 1.3660 | 0.3660 | 1 | 0 | 2 | 1 | 7 | 4 | 0 | 0 | 0.3660 | 0.3660 | -2.5622 | -1.0981 | 0.4019 | 3.7417 |
| -1 | 2 | 2.2321 | -0.1340 | 2 | -1 | 3 | 0 | 0 | 0 | 0 | 0 | 0.2321 | 0.8660 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -2 | -1.7321 | 1.0000 | -2 | 1 | -1 | 1 | 0 | 0 | 0 | 0 | 0.2679 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0 | -1 | -0.8660 | 0.5000 | -1 | 0 | 0 | 1 | 0 | 0 | 6 | 4 | 0.1340 | 0.5000 | 0.8038 | 0.0000 | -0.1340 | 0.6599 |
| 0 | 0 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 6 | 6 | 6 | 6 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.0000 |
| 0 | 1 | 0.8660 | -0.5000 | 0 | -1 | 1 | 0 | 0 | 6 | 0 | 7 | 0.8660 | 0.5000 | 0.0000 | 3.0000 | 0.4330 | 3.4330 |
| 0 | 2 | 1.7321 | -1.0000 | 1 | -1 | 2 | -1 | 0 | 0 | 0 | 0 | 0.7321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | -2 | -2.2321 | 0.1340 | -3 | 0 | -2 | 1 | 0 | 0 | 0 | 0 | 0.7679 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | -1 | -1.3660 | -0.3660 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0.6340 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 0 | -0.5000 | -0.8660 | -1 | -1 | 0 | 0 | 0 | 0 | 6 | 5 | 0.5000 | 0.1340 | 0.0000 | 0.0000 | 0.4019 | 0.4019 |
| 1 | 1 | 0.3660 | -1.3660 | 0 | -2 | 1 | -1 | 0 | 0 | 0 | 0 | 0.3660 | 0.6340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1 | 2 | 1.2321 | -1.8660 | 1 | -2 | 2 | -1 | 0 | 0 | 0 | 0 | 0.2321 | 0.1340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| floor | y=-2 | y=-1 | y=0 | y=1 | y=2 |
|-------|--------|--------|--------|--------|--------|
| x=-2 | 0.0000 | 0.0000 | 1.0718 | 0.4115 | 0.0000 |
| x=-1 | 0.0000 | 1.6077 | 4.3349 | 3.7417 | 0.0000 |
| x=0 | 0.0000 | 0.5699 | 6.0000 | 3.4330 | 0.0000 |
| x=1 | 0.0000 | 0.0000 | 0.4019 | 0.0000 | 0.0000 |

| ceiling | y=-2 | y=-1 | y=0 | y=1 | y=2 |
|---------|------|------|-----|-----|-----|
| x=-2 | 0 | 0 | 2 | 1 | 0 |
| x=-1 | 0 | 2 | 5 | 4 | 0 |
| x=0 | 0 | 1 | 6 | 4 | 0 |
| x=1 | 0 | 0 | 1 | 0 | 0 |

นายรัชดาลัย สิงห์เรืองคล 59011138

174 ปริญญา รังษีนุกูล 59011138

| x,y | 0 | 1 |
|-----|---|---|
| 0 | 3 | 5 |
| 1 | 7 | 6 |

| x,y | -1 | 0 | 1 |
|-----|----|---|---|
| 0 | 3 | 5 | |
| 1 | 7 | 6 | |

| x,y | 0 | 1 |
|-----|---|---|
| -1 | 3 | 5 |
| 0 | 7 | 6 |
| 1 | | |

| x,y | -1 | 0 | 1 |
|-----|----|---|---|
| -1 | 3 | 5 | |
| 0 | 7 | 6 | |
| 1 | | | |

| | |
|--------|----------|
| 0772%4 | 0 |
| Rotate | 30 |
| cos() | 0.866025 |
| sin() | 0.5 |

| x,y | x' | y' | round(x') | round(y') |
|-----|----------|----------|-----------|-----------|
| 0,0 | 0 | 0 | 0 | 0 |
| 0,1 | -0.5 | 0.866025 | -1 | 1 |
| 1,0 | 0.866025 | 0.5 | 1 | 1 |
| 1,1 | 0.366025 | 1.366025 | 0 | 1 |

| min | -0.5 | 0 | -1 | 0 |
|-----|----------|----------|----|---|
| max | 0.866025 | 1.366025 | 1 | 1 |

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|----|---|---|---|
| -2 | | | | | |
| -1 | | | | | 5 |
| 0 | | | 3 | 6 | |
| 1 | | | | 7 | |

| x' | y' | x | y | x0 | y0 | f(x0,y0) | f(x0,y1) | f(x1,y0) | f(x1,y1) | dx | dy | f(x0,y0)*dx | f(x0,y0)*dx | [...]*dx*dy | g(x',y') | |
|----|----|---------|---------|----|----|----------|----------|----------|----------|----------|----------|-------------|-------------|-------------|----------|---|
| 1 | -2 | -0.134 | -2.2321 | -1 | -3 | 0 | 0 | 0 | 0 | 0.866025 | 0.767949 | 0 | 0 | 0 | 0 | |
| -1 | -2 | -1.866 | -1.2321 | -2 | -2 | 0 | 0 | 0 | 0 | 0.133975 | 0.767949 | 0 | 0 | 0 | 0 | |
| 0 | -2 | -1 | -1.7321 | -1 | -2 | 0 | 0 | 0 | 0 | 0 | 0.267949 | 0 | 0 | 0 | 0 | |
| 1 | -1 | 0.36603 | -1.366 | 0 | -2 | 0 | 0 | 0 | 0 | 0.366025 | 0.633975 | 0 | 0 | 0 | 0 | |
| -2 | -2 | -2.7321 | -0.7321 | -3 | -1 | 0 | 0 | 0 | 0 | 0.267949 | 0.267949 | 0 | 0 | 0 | 0 | |
| -1 | -1 | -1.366 | -0.366 | -2 | -1 | 0 | 0 | 5 | 0 | 0.633975 | 0.633975 | 3.169873 | 0 | -2.0096 | 1.16025 | |
| 0 | -1 | -0.5 | -0.866 | -1 | -1 | 0 | 0 | 3 | 0 | 0.5 | 0.133975 | 1.5 | 0 | -0.201 | 1.29904 | |
| 1 | 0 | 0.86603 | -0.5 | 0 | -1 | 0 | 0 | 0 | 0 | 0.866025 | 0.5 | 0 | 0 | 0 | 0 | |
| -2 | -1 | -2.2321 | 0.13397 | -3 | 0 | 0 | 0 | 0 | 0 | 0.767949 | 0.133975 | 0 | 0 | 0 | 0 | |
| -1 | 0 | -0.866 | 0.5 | -1 | 0 | 3 | 5 | 7 | 6 | 0.133975 | 0.5 | 0.535898 | 1 | -0.201 | 4.33494 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 7 | 6 | 0 | 0 | 0 | 0 | 0 | 3 | |
| 0 | 1 | 0.5 | 0.86603 | 0 | 0 | 0 | 3 | 0 | 0 | 0.5 | 0.866025 | 0 | 2.59808 | -1.299 | 1.29904 | |
| 1 | 1 | 1.36603 | 0.36603 | 1 | 0 | 0 | 0 | 0 | 0 | 0.366025 | 0.366025 | 0 | 0 | 0 | 0 | |
| -2 | 0 | -1.7321 | 1 | -2 | 1 | 6 | 0 | 0 | 0 | 0.267949 | 0 | -1.6077 | 0 | 0 | 4.3923 | |
| -2 | 1 | -1.2321 | 1.86603 | -2 | 1 | 6 | 0 | 0 | 0 | 0.767949 | 0.866025 | -4.6077 | -5.1962 | 3.99038 | 0.18653 | |
| -1 | 1 | -0.366 | 1.36603 | -1 | 1 | 7 | 6 | 0 | 0 | 0.633975 | 0.366025 | -4.43782 | -0.366 | 0.23205 | 2.4282 | |
| 0 | 2 | 1 | 1.73205 | 1 | 1 | 0 | 7 | 0 | 0 | 0 | 0.732051 | 0 | 5.12436 | 0 | 5.12436 | |
| 1 | 2 | 1.86603 | 1.23205 | 1 | 1 | 0 | 0 | 0 | 0 | 0.866025 | 0.232051 | 0 | 0 | 0 | 0 | |
| -2 | 2 | -0.7321 | 2.73205 | -1 | 2 | 0 | 0 | 0 | 0 | 0 | 0.267949 | 0.732051 | 0 | 0 | 0 | 0 |
| -1 | 2 | 0.13397 | 2.23205 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0.133975 | 0.232051 | 0 | 0 | 0 | 0 |

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|----------|---------|---------|---------|
| -2 | 0 | 0.411543 | 4.3923 | 0.18653 | 0 |
| -1 | 0 | 1.16025 | 4.33294 | 2.4282 | 0 |
| 0 | 0 | 1.29904 | 3 | 1.29904 | 5.12436 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |

| x',y' | -2 | -1 | 0 | 1 | 2 |
|-------|----|----|---|---|---|
| -2 | 0 | 0 | 4 | 0 | 0 |
| -1 | 0 | 1 | 4 | 2 | 0 |
| 0 | 0 | 1 | 3 | 1 | 5 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 |