



Thunder Simulation

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안장훈

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THUNDER SIMULATION

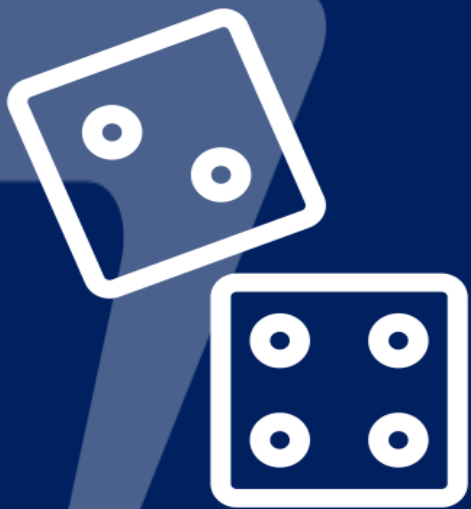
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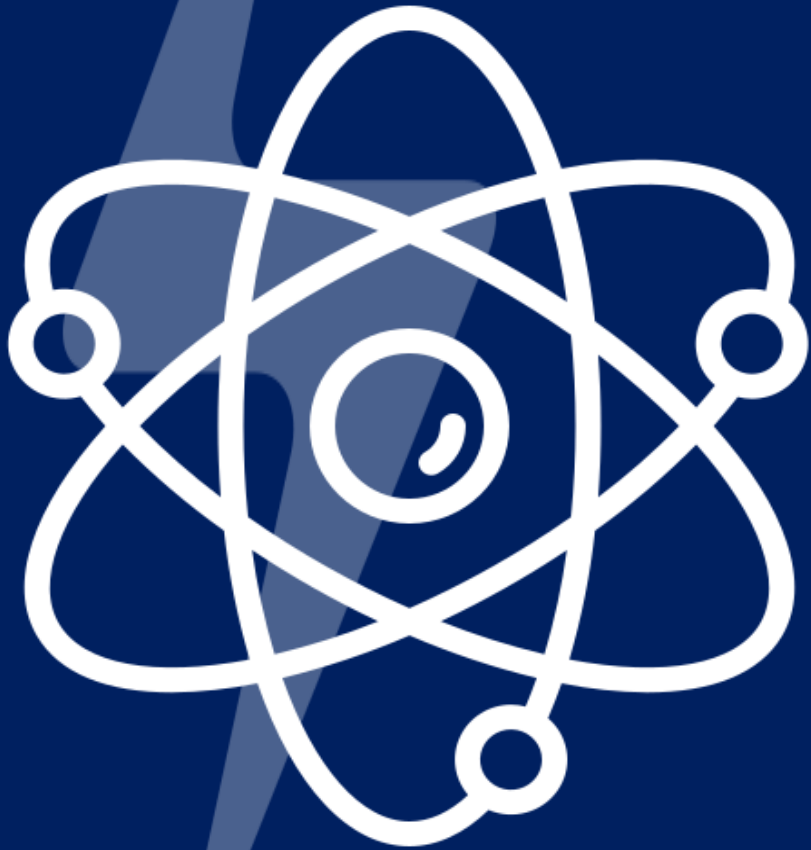


THUNDER SIMULATION

기존 매체에서의 번개 구현



THUNDER SIMULATION



물리 기반 번개 경로 시뮬레이션!

THUNDER SIMULATION

$$\Delta u(x, y) = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$$

<라플라스 방정식>



$$p(i, j) = \frac{\Phi_{i,j}^\eta}{\Phi_{total}}.$$

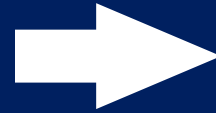
where $\Phi_{total} = \sum_{i \in x} \Phi_i^\eta$, x : 모든 후보 격자

<번개 경로의 확률>

THUNDER SIMULATION

$$p(i, j) = \frac{\Phi_{i,j}^\eta}{\Phi_{total}}.$$

where $\Phi_{total} = \sum_{i \in x} \Phi_i^\eta$, x : 모든 후보 격자



0.01	0	0.04
0.02	0	0.09
0.06	0.12	0.18

<후보 격자>

THUNDER SIMULATION

```
phi =0.0138411
phi =0.00721489
phi =0.0142537
phi =0.0275673
phi =0
phi =0.0282494
phi =0.0558974
phi =0.049185
phi =0.0561302
phi =0.054851
phi =0.028592
phi =0.0564863
phi =0.109247
phi =0
phi =0.11195
phi =0.221517
phi =0.194917
phi =0.222439
```

$\langle \eta = 1 \rangle$

```
phi =0.000191575
phi =5.20546e-05
phi =0.000203168
phi =0.000759959
phi =0
phi =0.000798031
phi =0.00312452
phi =0.00241917
phi =0.00315059
phi =0.0179058
phi =0.00486534
phi =0.0189893
phi =0.0710304
phi =0
phi =0.0745888
phi =0.292036
phi =0.22611
phi =0.294474
```

$\langle \eta = 3.3 \rangle$

```
phi =7.34275e-07
phi =8.55377e-08
phi =8.09022e-07
phi =7.13351e-06
phi =0
phi =7.73273e-06
phi =7.35177e-05
phi =4.82002e-05
phi =7.45328e-05
phi =0.00345142
phi =0.000402065
phi =0.00380276
phi =0.0335307
phi =0
phi =0.0363473
phi =0.345566
phi =0.226562
phi =0.350338
```

$\langle \eta = 5 \rangle$

THUNDER SIMULATION



```
<Lattice>
0.01 0.01 0.04 0.06 0.06 0.06 0.04 0.02
0.02 0.00 0.09 0.13 0.14 0.13 0.09 0.05
0.06 0.12 0.18 0.22 0.23 0.20 0.15 0.08
0.12 0.21 0.29 0.33 0.33 0.30 0.23 0.12
0.18 0.32 0.41 0.46 0.46 0.42 0.33 0.19
0.29 0.47 0.57 0.61 0.61 0.57 0.47 0.29
0.49 0.68 0.76 0.79 0.79 0.76 0.68 0.49
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
```

<격자의 전위값 계산>

```
<Lattice>
0.01 0.01 0.03 0.05 0.05 0.05 0.04 0.02
0.01 0.00 0.07 0.10 0.11 0.10 0.08 0.04
0.05 0.10 0.00 0.18 0.19 0.17 0.13 0.07
0.10 0.18 0.25 0.28 0.28 0.26 0.20 0.11
0.17 0.29 0.37 0.41 0.41 0.37 0.30 0.17
0.27 0.44 0.53 0.57 0.57 0.53 0.44 0.28
0.49 0.67 0.74 0.77 0.77 0.74 0.67 0.49
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
```

<다음 경로 선택>

```
<Lattice>
0.00 0.00 0.01 0.03 0.04 0.04 0.03 0.02
0.01 0.00 0.02 0.06 0.08 0.08 0.07 0.04
0.03 0.04 0.00 0.11 0.14 0.14 0.11 0.06
0.08 0.14 0.17 0.22 0.25 0.23 0.18 0.10
0.15 0.26 0.33 0.37 0.38 0.36 0.28 0.16
0.26 0.42 0.51 0.55 0.55 0.52 0.44 0.27
0.48 0.66 0.73 0.76 0.76 0.74 0.66 0.48
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
```

<격자의 전위값 계산>

THUNDER SIMULATION

```
laplace = InterpolationValue(laplace, lattice);
```



```
laplace = InterpolationHeight(laplace, lattice);
```



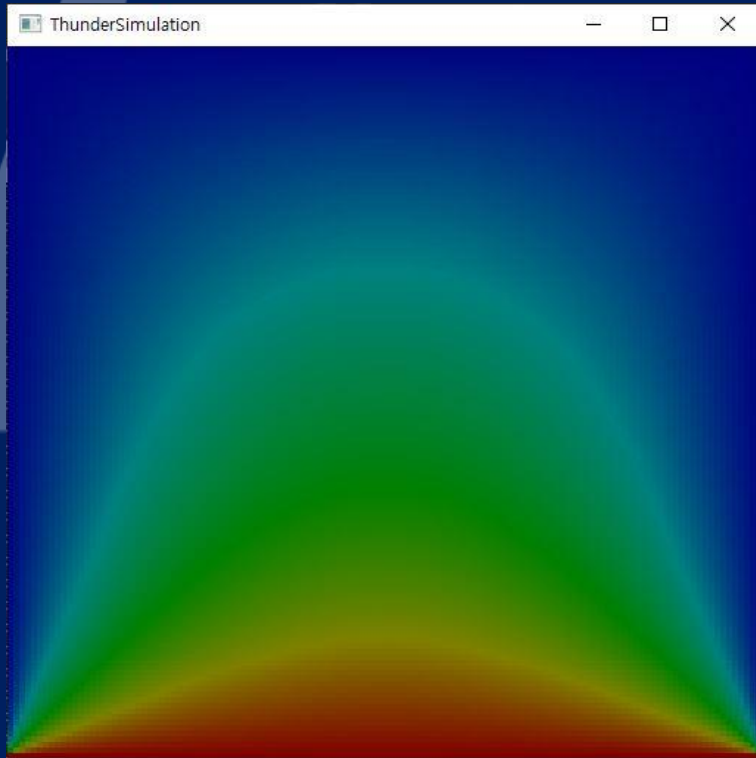
```
laplace = InterpolationWidth(laplace, lattice);
```

격자의 전위값 계산

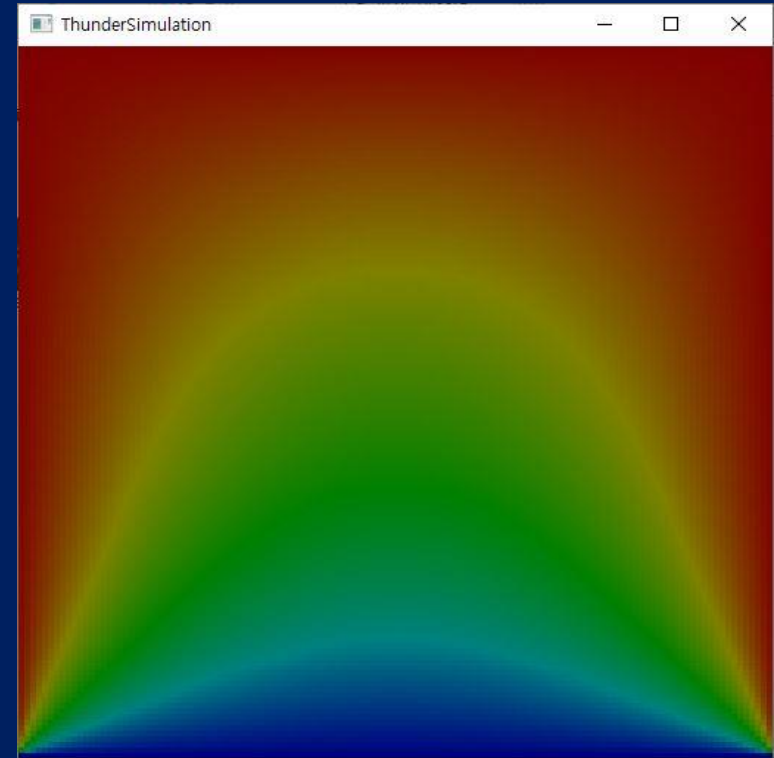
```
laplace = MainChanel(laplace, lattice, mainChanelPos);
```

다음 경로 선택!

THUNDER SIMULATION

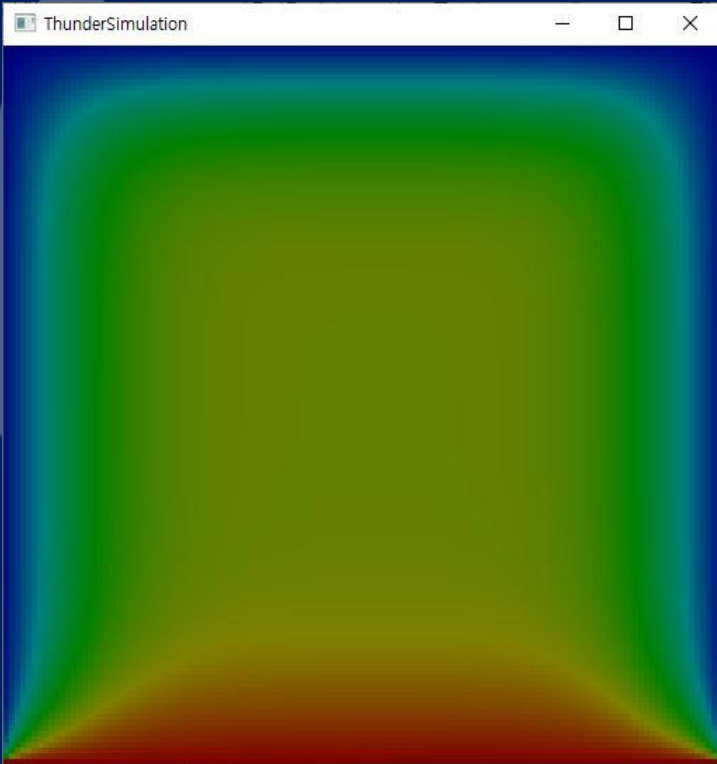


Positive 전위

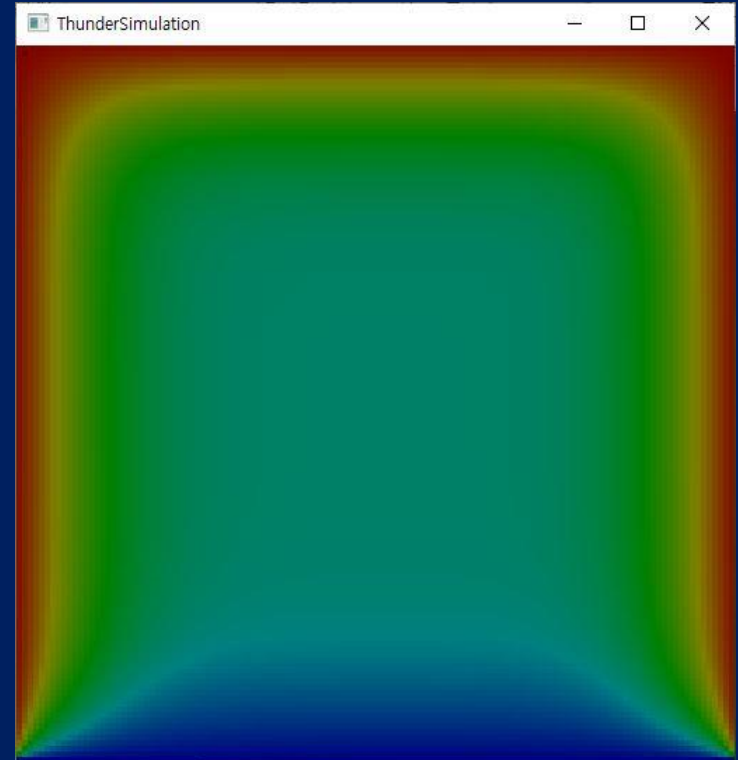


Negative 전위

THUNDER SIMULATION

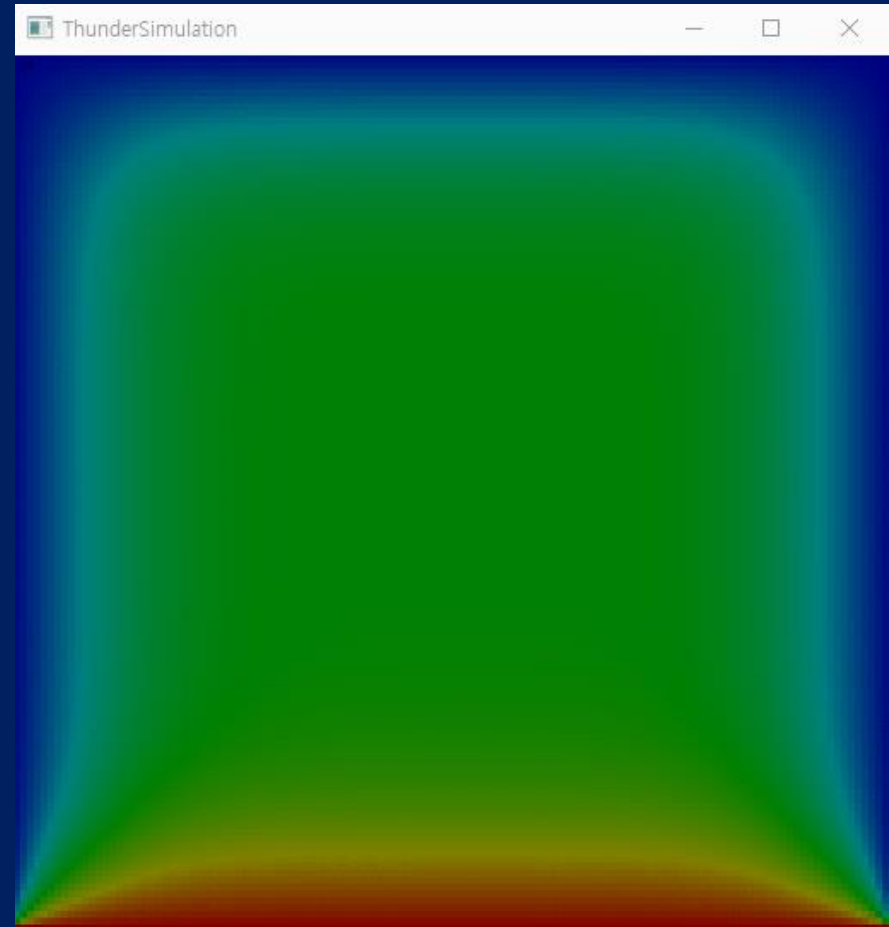
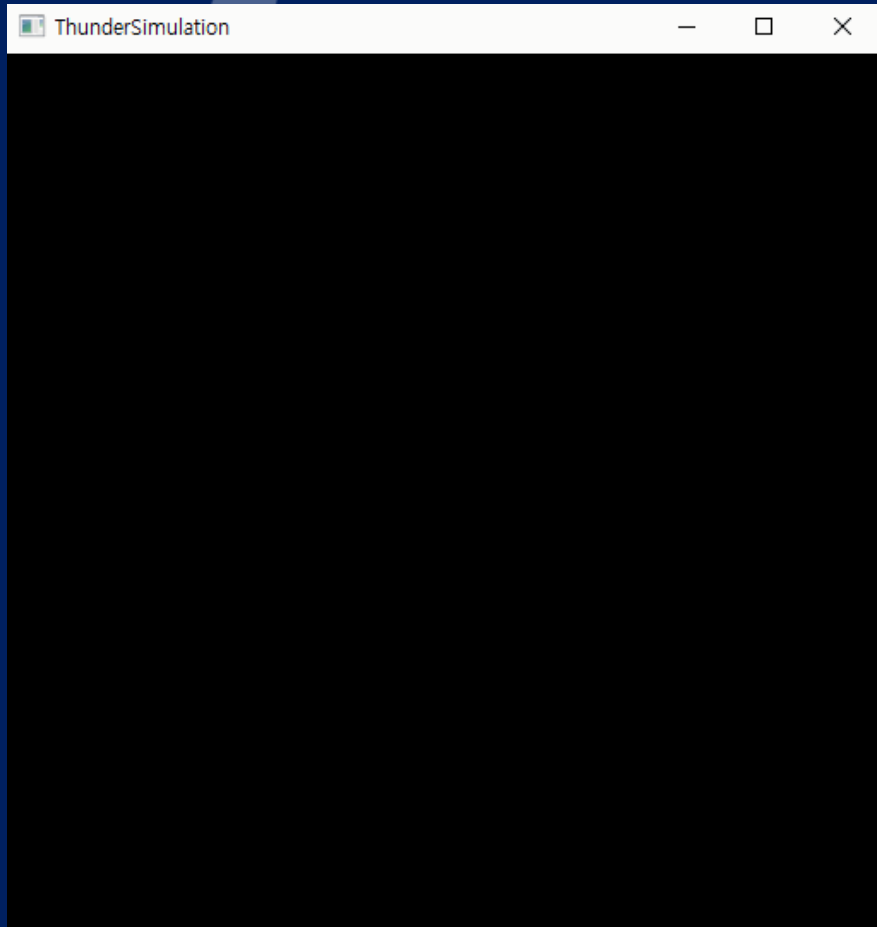


Positive 전위



Negative 전위

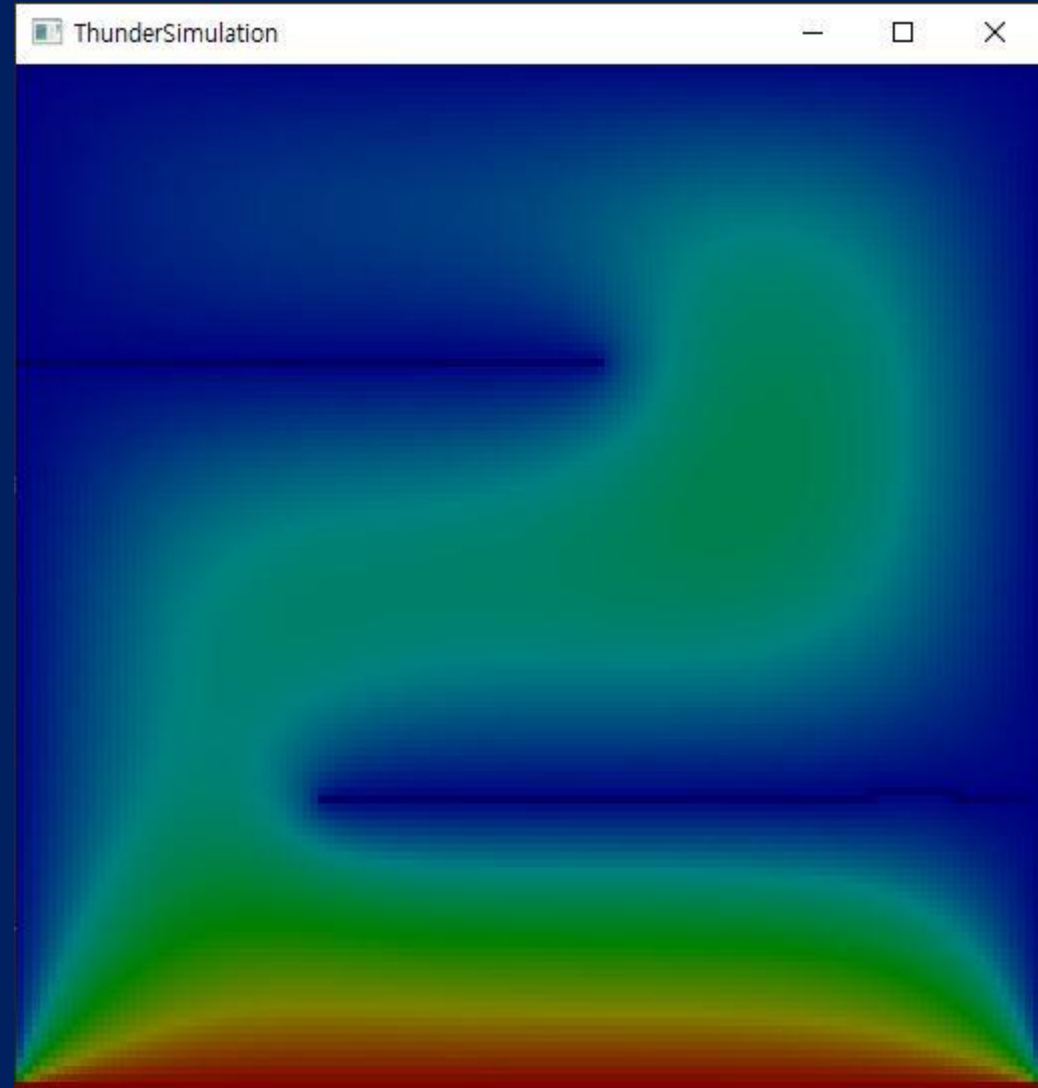
THUNDER SIMULATION



THUNDER SIMULATION

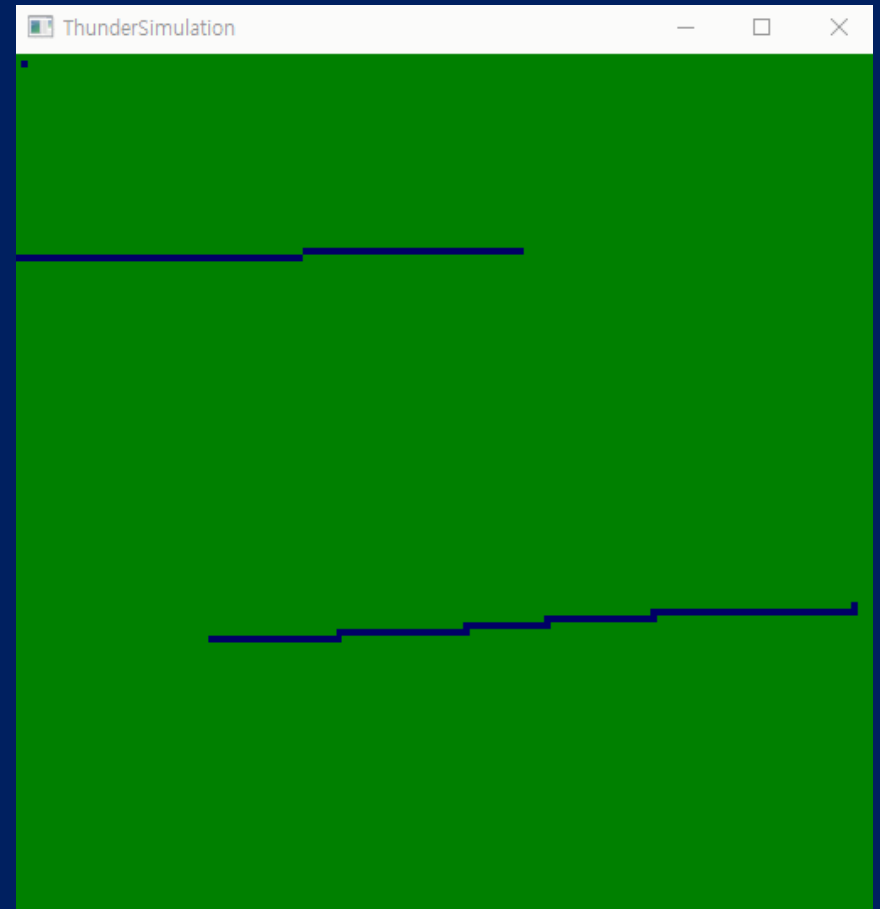
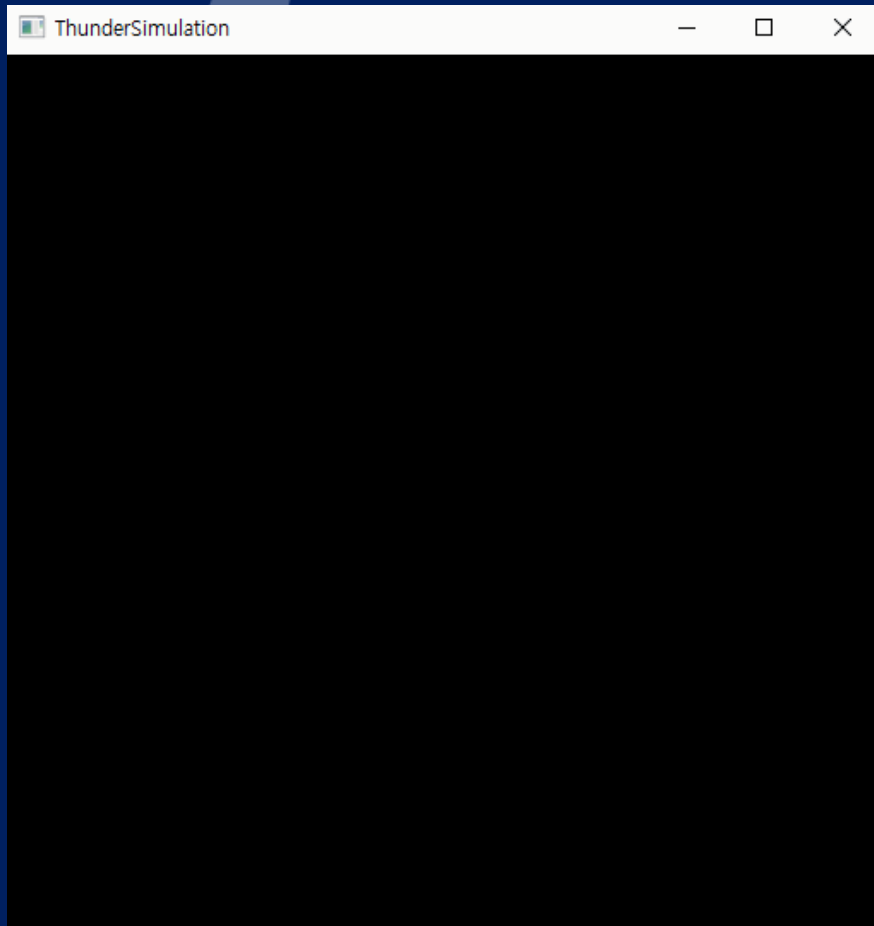
OBSTACLE

장애물



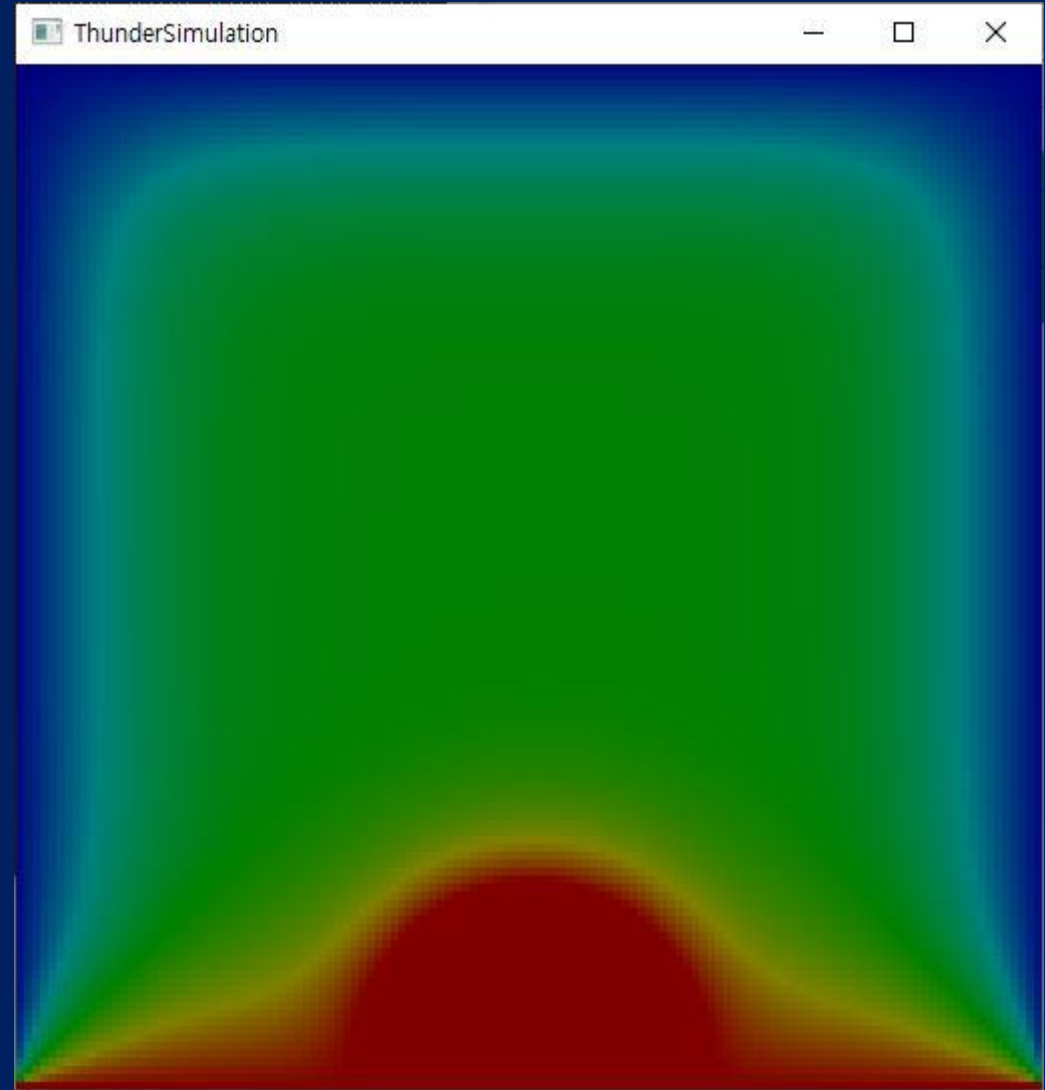
THUNDER SIMULATION

OBSTACLE



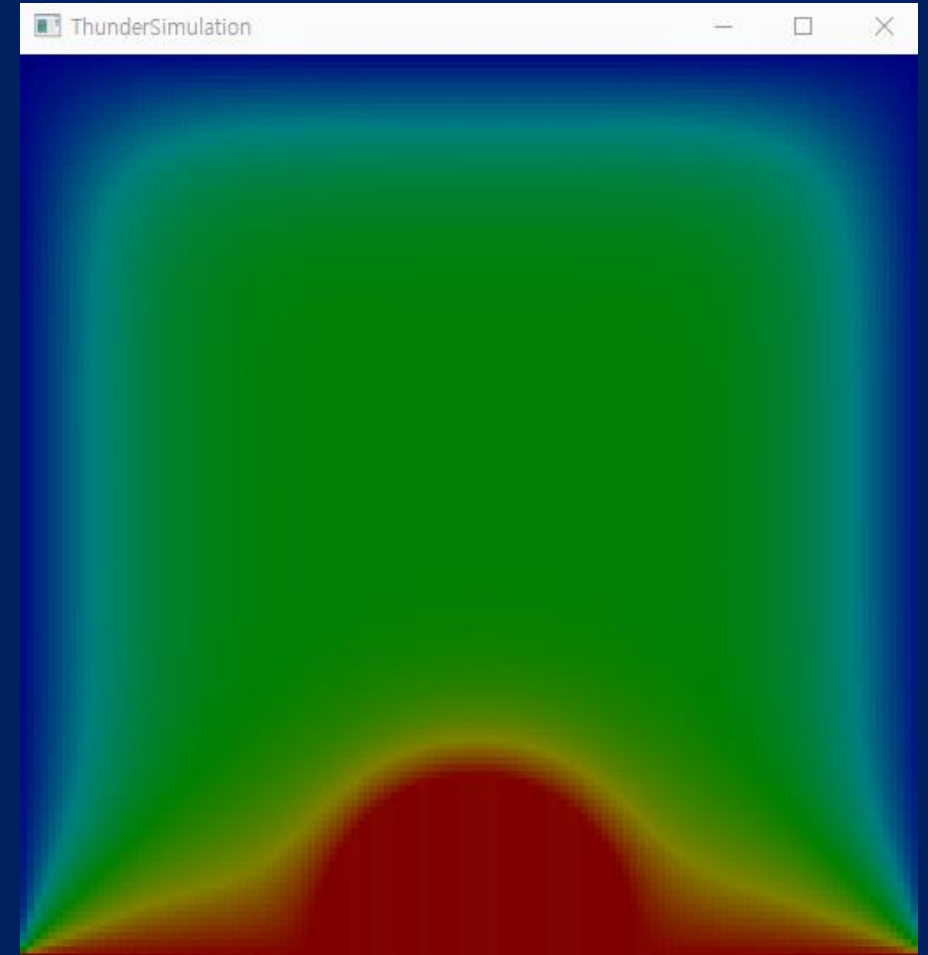
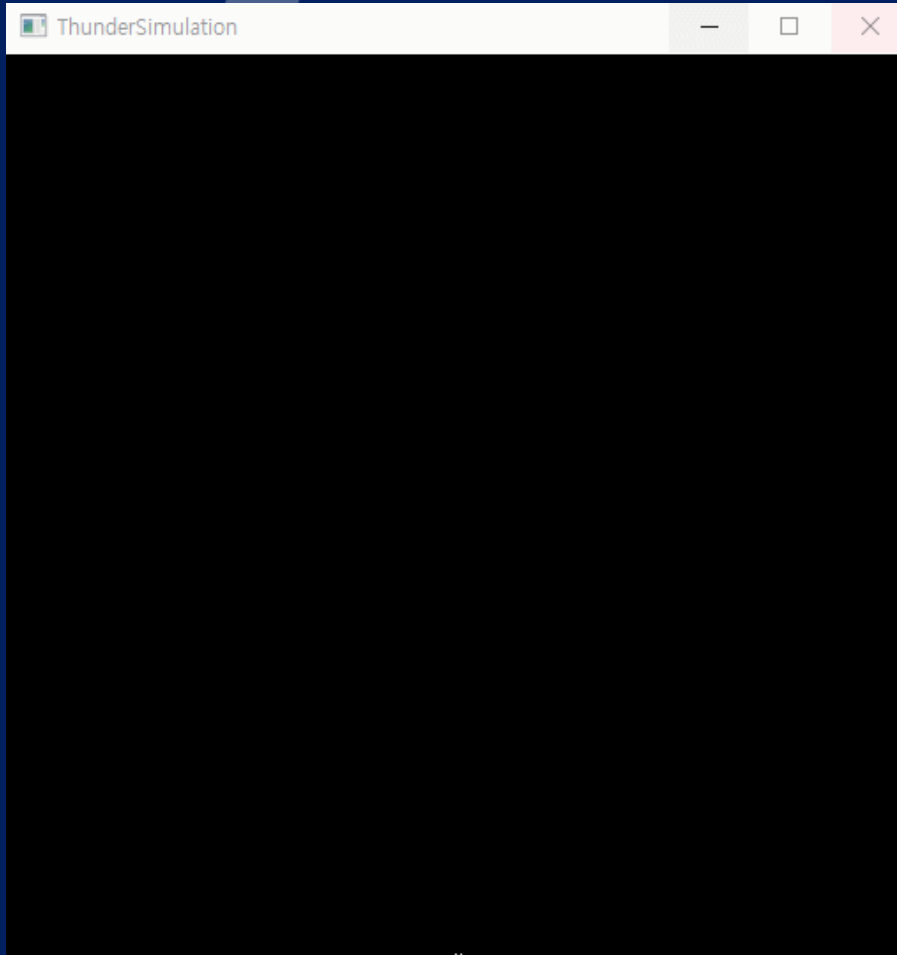
THUNDER SIMULATION

LIGHTNING ROD



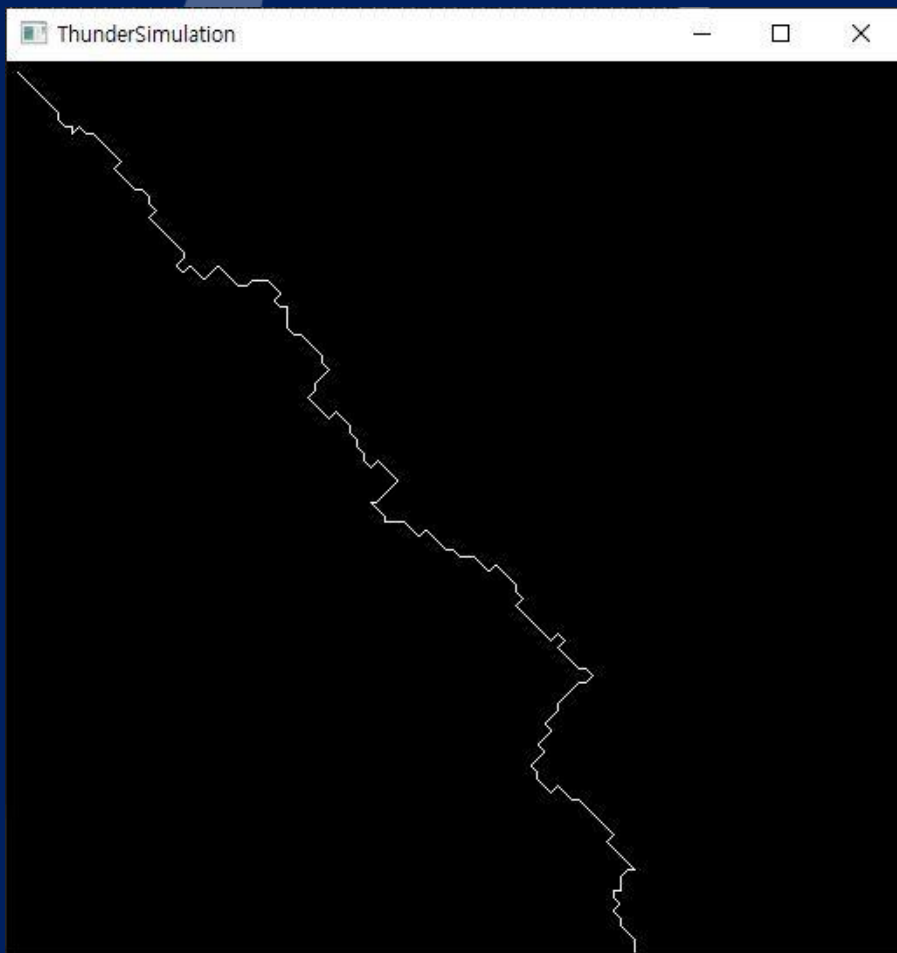
THUNDER SIMULATION

LIGHTNING ROD



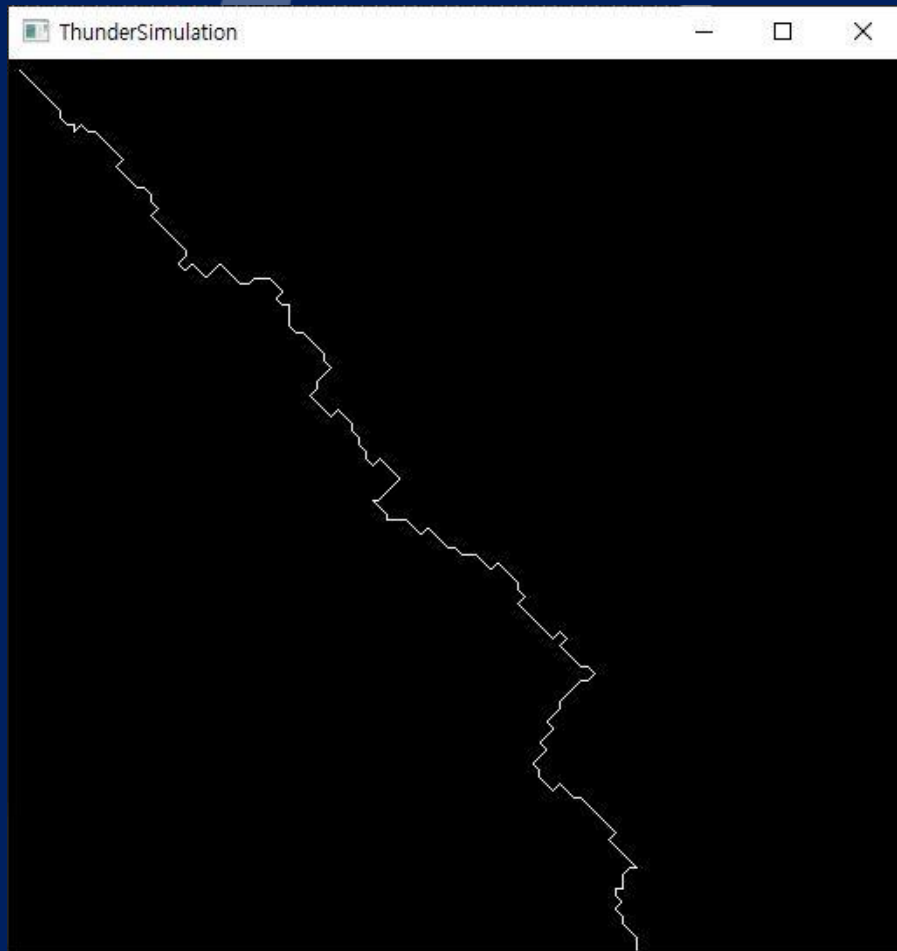
THUNDER SIMULATION

JITTERING

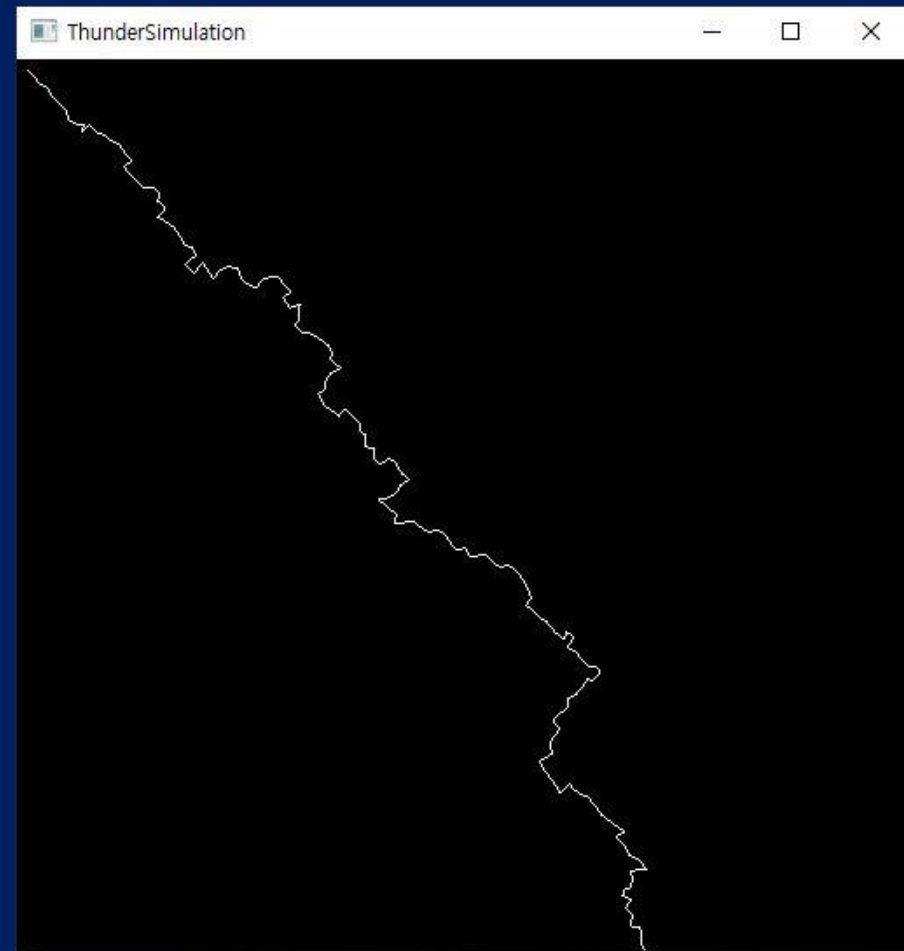


THUNDER SIMULATION

JITTERING

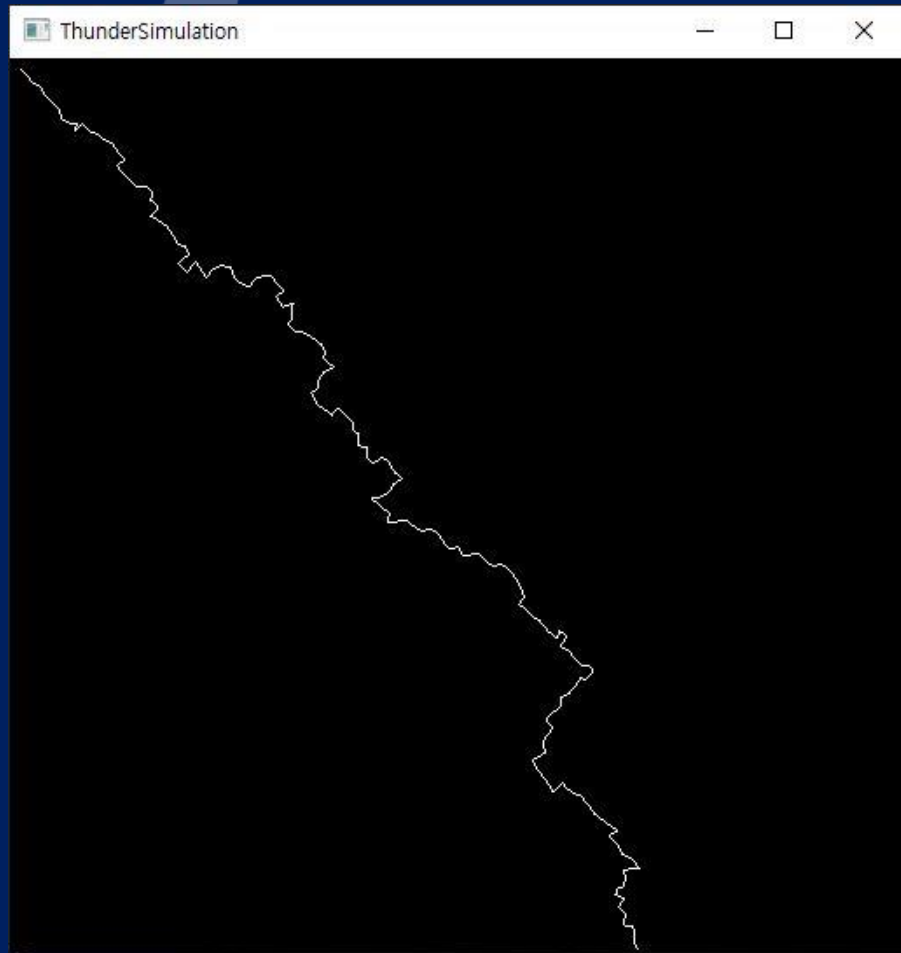


JITTERING SAMPLING



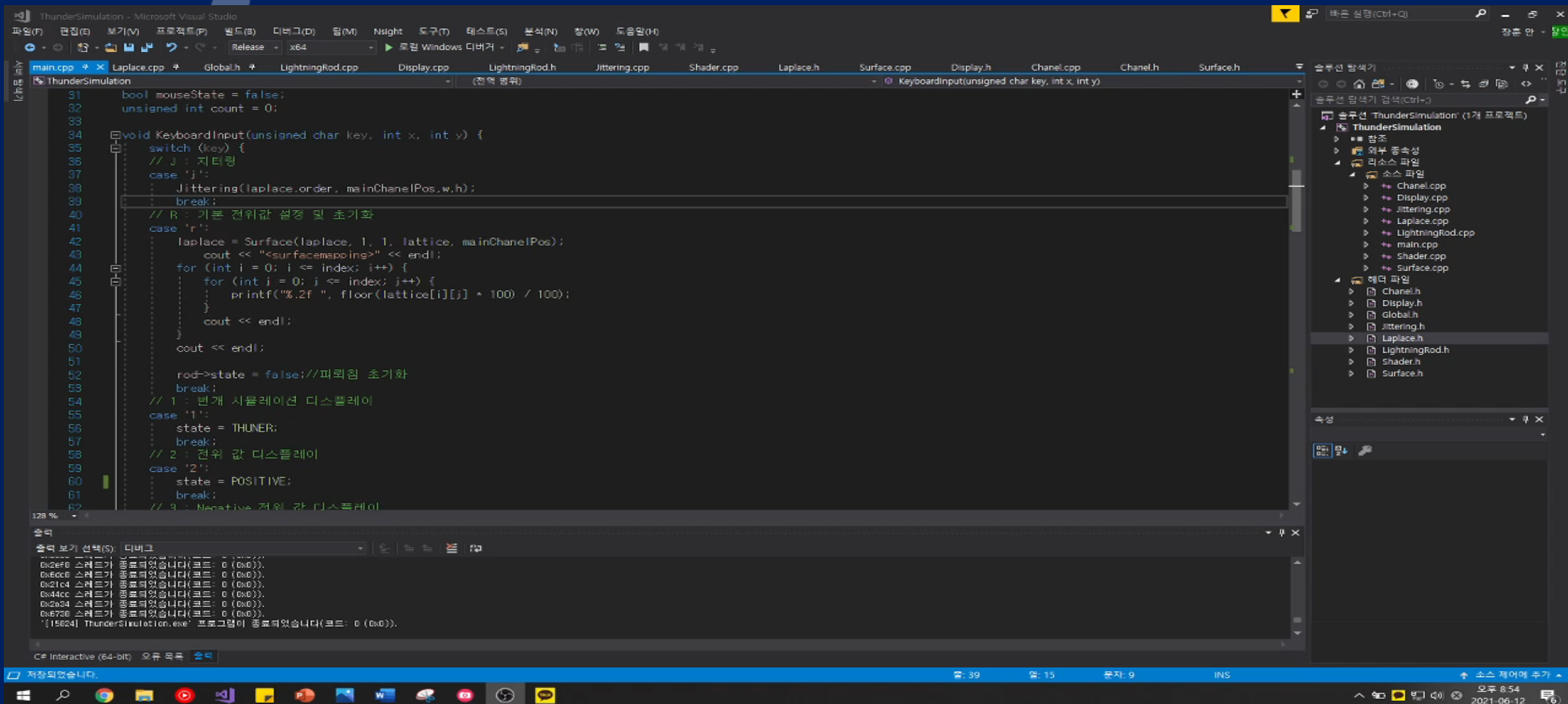
THUNDER SIMULATION

JITTERING



THUNDER SIMULATION

VIDEO



THUNDER SIMULATION

아쉬운점

```
void printProgramInfoLog(GLuint obj);  
void printShaderInfoLog(GLuint obj);  
int printOglError(char *file, int line);  
void setShaders();  
void initGLEW();  
void initGL();  
int textFileWrite(const char *fn, const char *s);  
char *textFileRead(const char *fn);
```

Shader 효과!



서브 격자 생성



THANK YOU!