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# 3D Visualization for Massive Deformation Data

## — take the temple deformation data in Angkor Site as an example

**Fan Xiang-tao, Jian Hong-deng and Chen Fu-long**

**2016.09.12**

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# Outline

REAS

Remote Sensing for Environment of Angkor Site

- Background
- Methods
- Results & Conclusion

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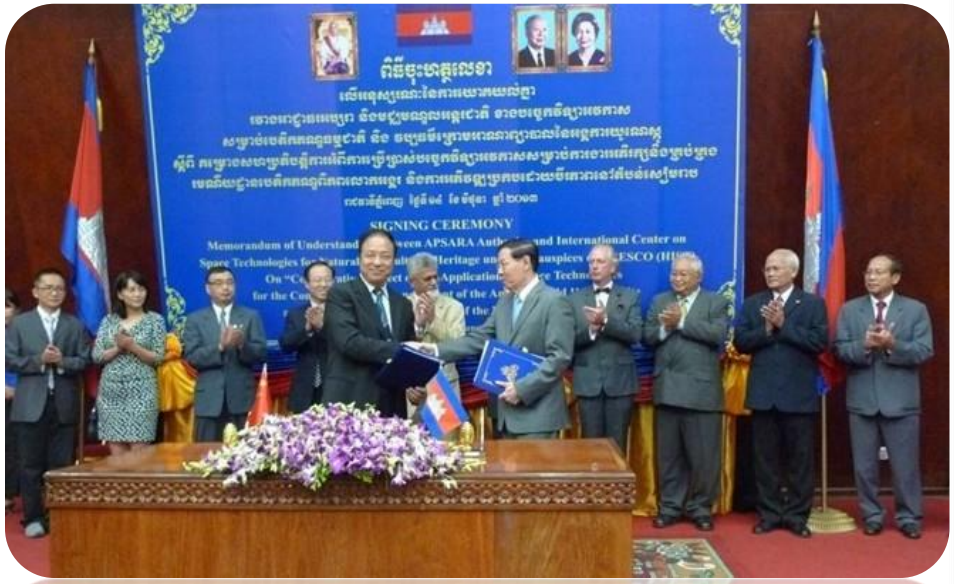
# Background:

# REAS Project

- Prof. Huodong Guo of HIST and RADI and Director BUN Narith of APSARA signed an MOU during the 37th session of the UNESCO World Heritage Committee in Phnom Penh, June 2013



- Cambodian Deputy Prime Minister H. E. Dr. Sok An met with the HIST/RADI delegation, and expressed full support for the proposed collaborative project

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# Background:

# REAS Project

**Project Title: Remote Sensing for Environment of Angkor Site (REAS)**

**Project Start : July 2013 ; Project End: Dec. 2016**

REAS

Remote Sensing for Environment of Angkor Site

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**Objectives:**

- monitoring Angkor site and its surrounding environment
- better understanding the relationship between them

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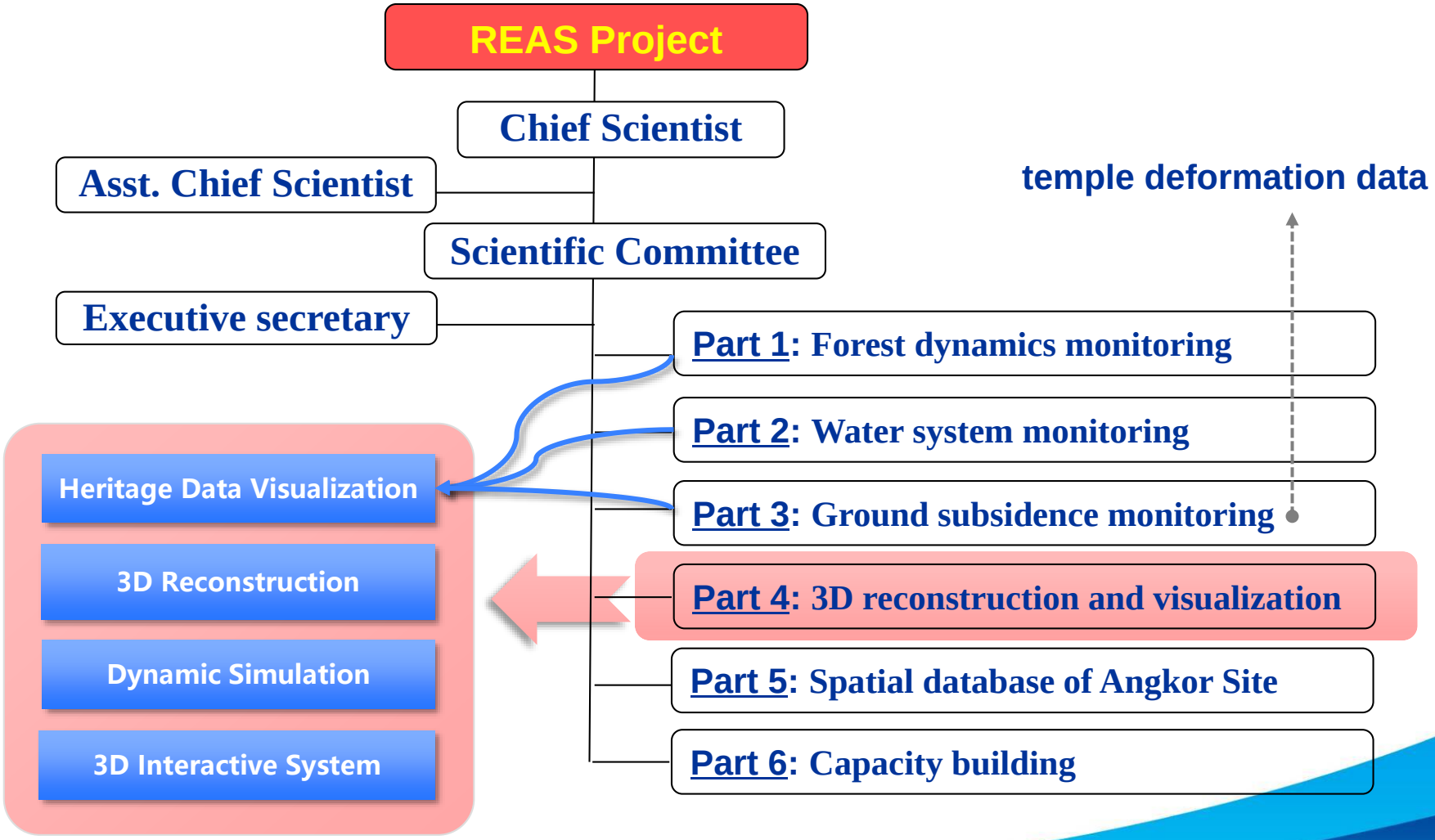
# Background:

# REAS Project



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# Background:
# Temple Deformation Data

## Source

- Provided by Prof. Chen Fu-long
- Driven by an improved PSInSAR model for temple-level monitoring
- Format: KML/XML

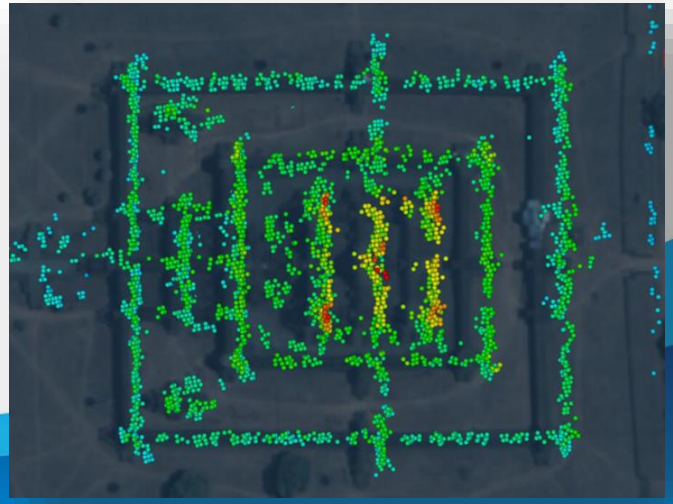
## Position

- Angkor Wat
- Banteay Kdei
- Bayon
- Phnom Bakheng
- Prasat Bakong
- Pre Rup
- Preah Khan
- Ta Prohm

## Style

- Points、placemarks
- Color : FFFFA100
- Scale : 0.3
- Icon : shaded_dot.png
- Coordinates : 103.870946, 13.406598, 23.35
- Altitude Mode : absolute

## Visualization



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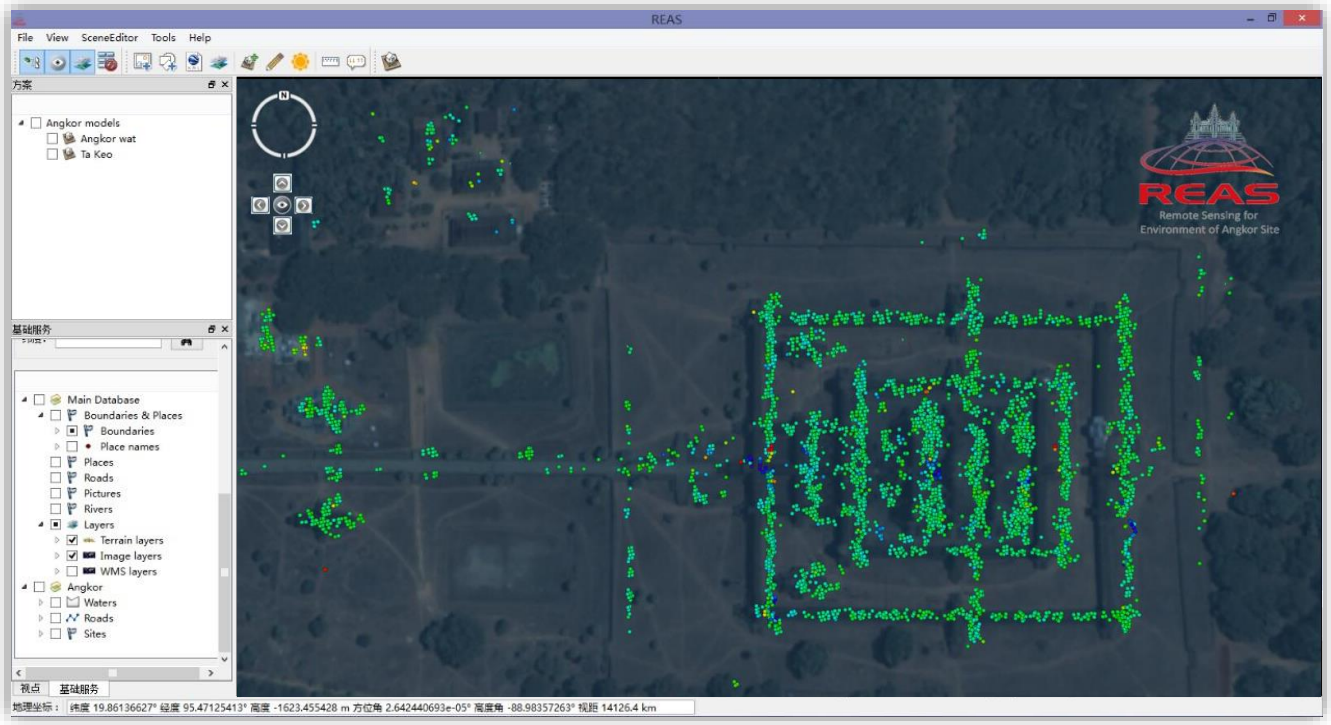
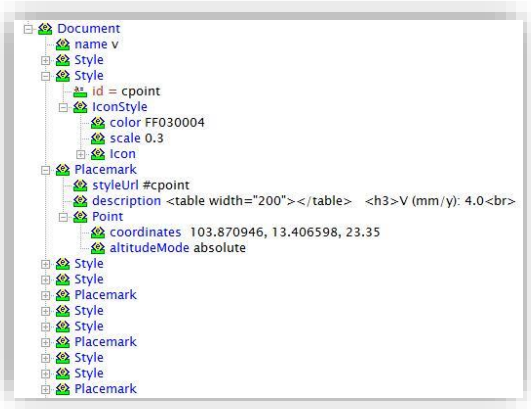
# Background:

# What to do?




- Explore some visualization methods
- Parse and visualize the deformation data

- ✓ Develop and compare different methods to visualize massive deformation data
- ✓ Give some suggestions for deformation data visualization
- ✓ Provide some optional ways for users to view the deformation data

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# Methods:

# Introduction

- Visualize the elevation and deformation points discriminatively, eg. with different color and custom size
- View all the points simultaneously, with no resampling and occlusion processing
- All the points should face to the screen all the time
- High FPS

## 1 Color

- Visualize the points with different color and custom size
- Similar to point clouds visualization

✓ **Colored point**
✓ **Colored point instancing**

## 2 Texture

- Visualize the points with custom image and size
- Blended with different color values

✓ **Textured quad**
✓ **Textured quad instancing**

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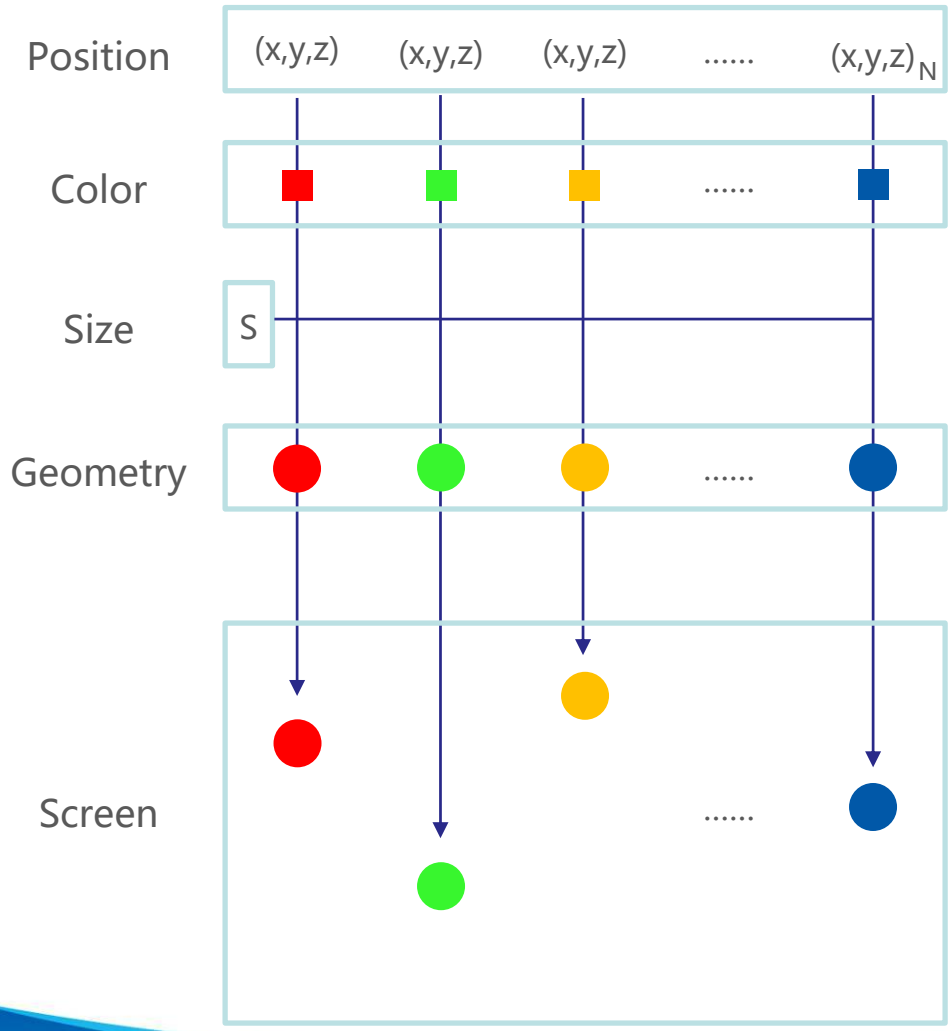
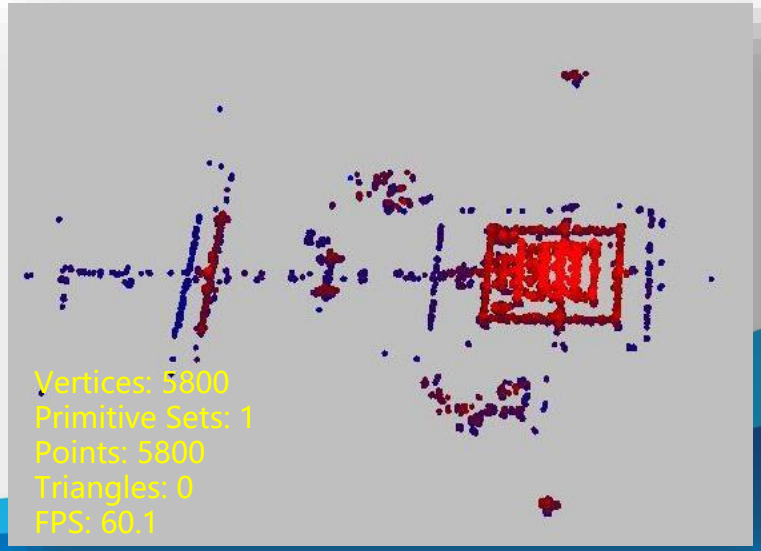
# Methods:

# Colored Point




- Traditional fixed rendering pipeline
- Geometry vertices are equal to the points
- Color: separately defined
- Size: user defined



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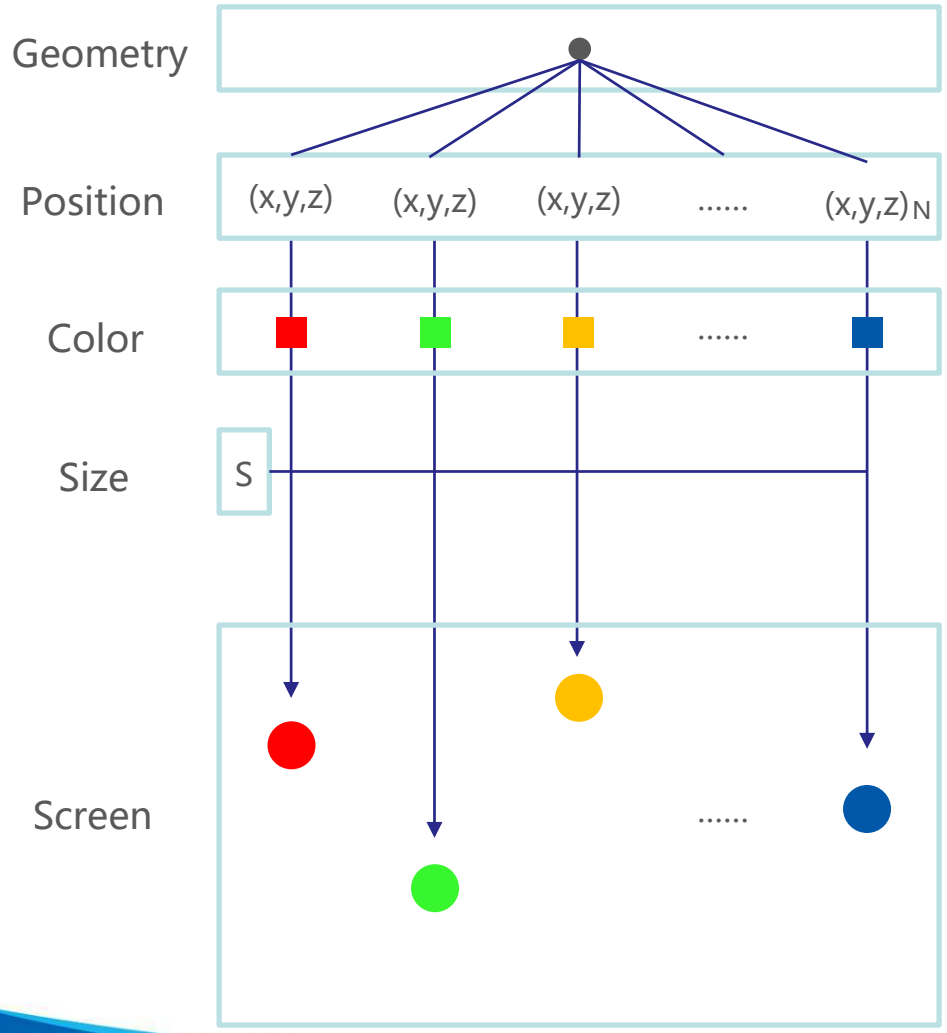
# Methods:

# Colored Point Instancing



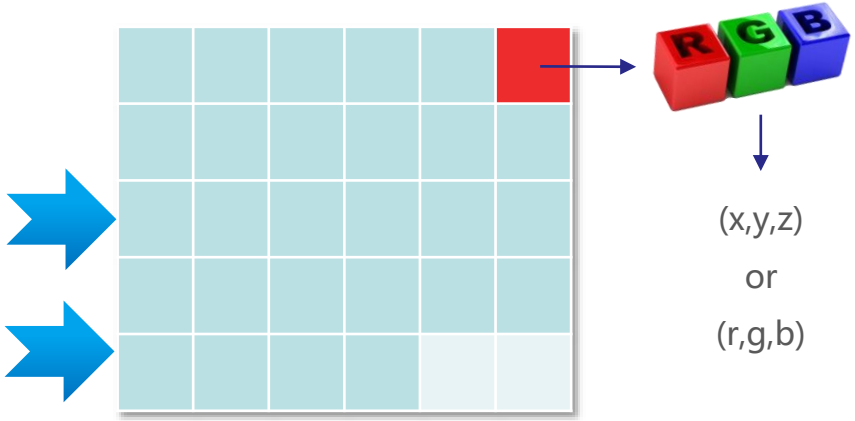




Image to store positions or colors

- Pass the images (stored coordinates and colors), image size as uniforms to the vertex and fragment shader
- Draw the geometry vertex N times with different coordinates and colors

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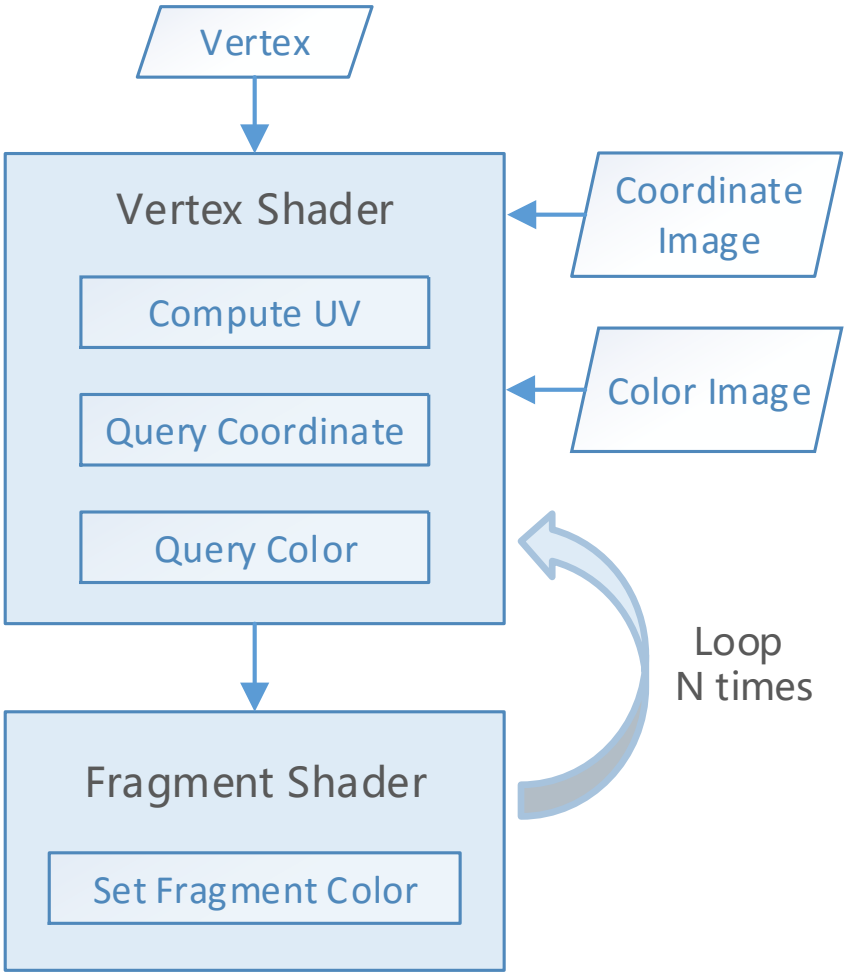
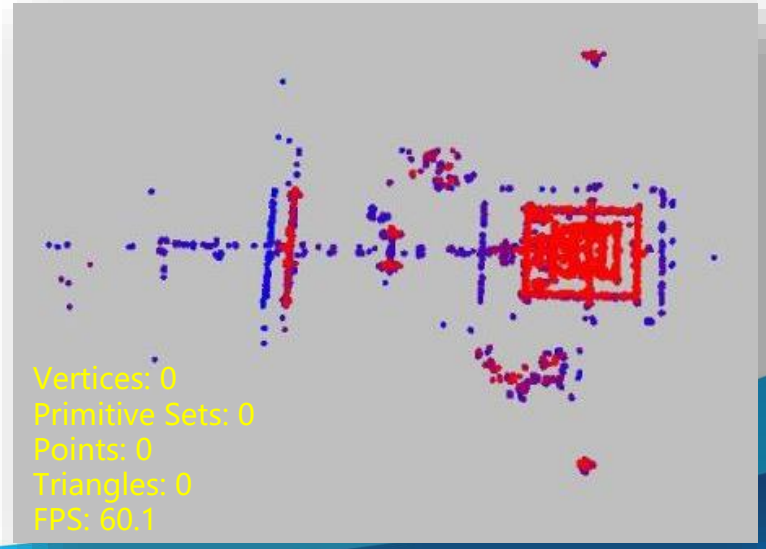
# Methods:

# Colored Point Instancing




- Geometry instancing
- Geometry vertex: 0
- Point in scene: 0
- Color: separately defined
- Size: user defined



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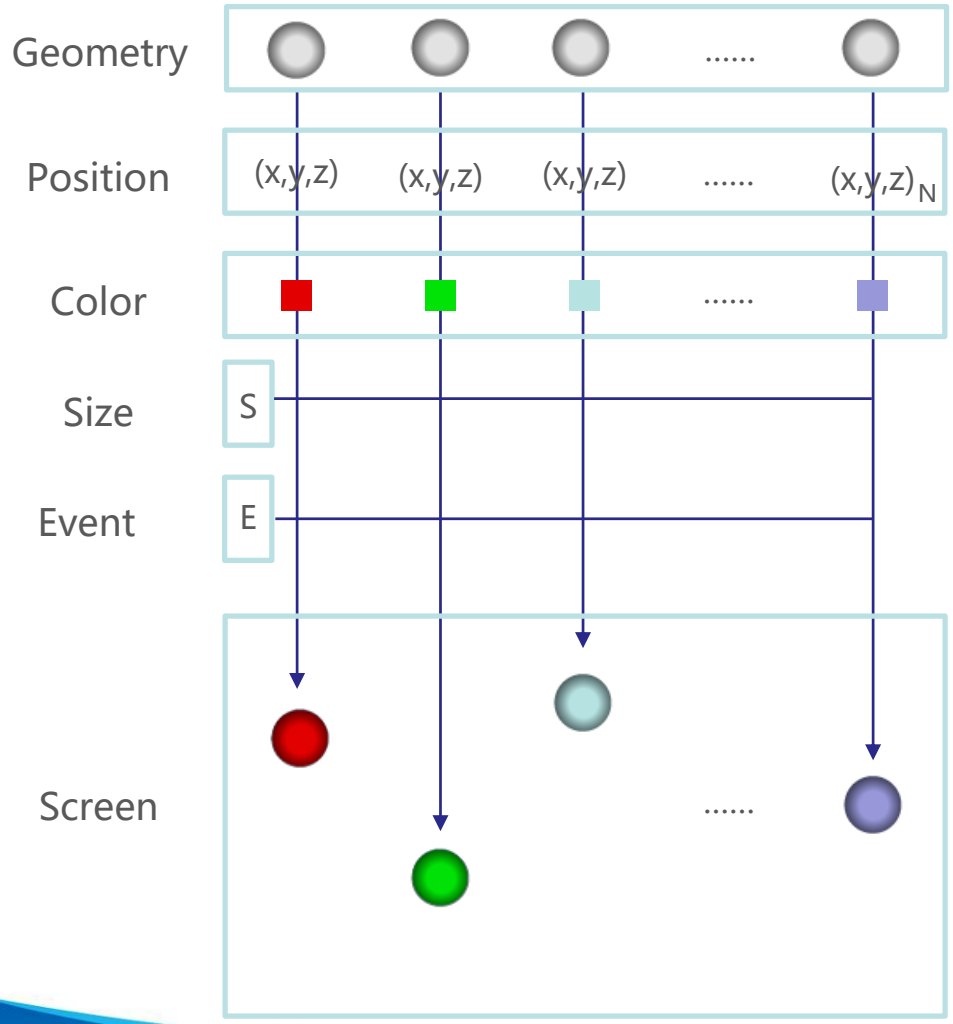
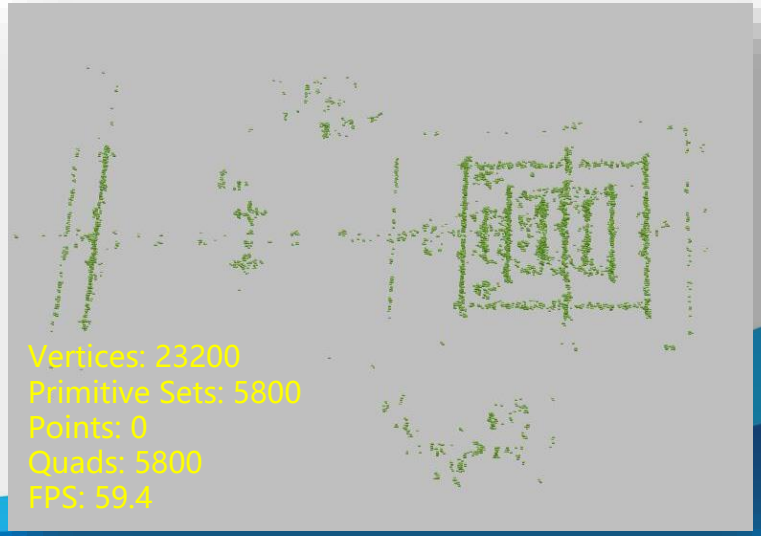
# Methods:

# Textured quad




- Similar to rendering Billboards
- Color: separately defined, blending with geometry texture
- Size: user defined
- Geometry vertices: N * 4
- Quads: N
- Rotation event update in real-time, making sure the quads face to screen



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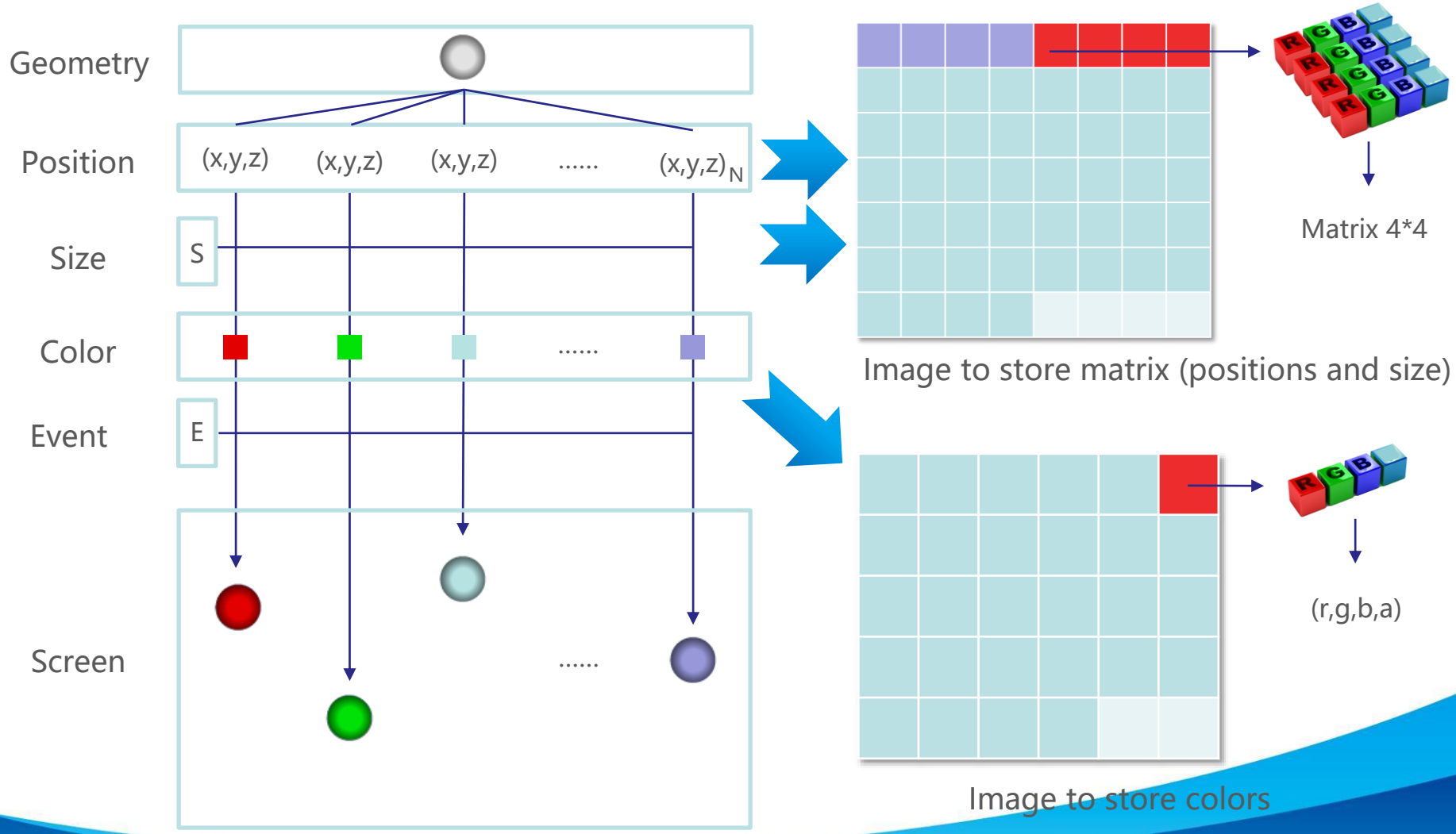
# Methods:

# Textured quad instancing



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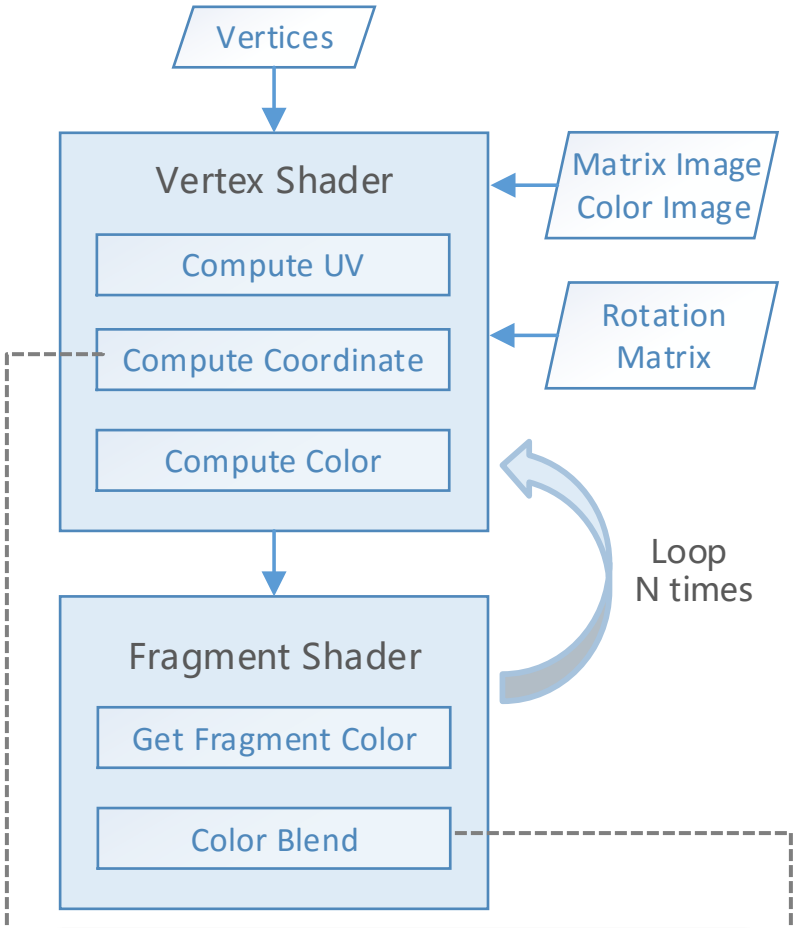
# Methods:

# Textured quad instancing

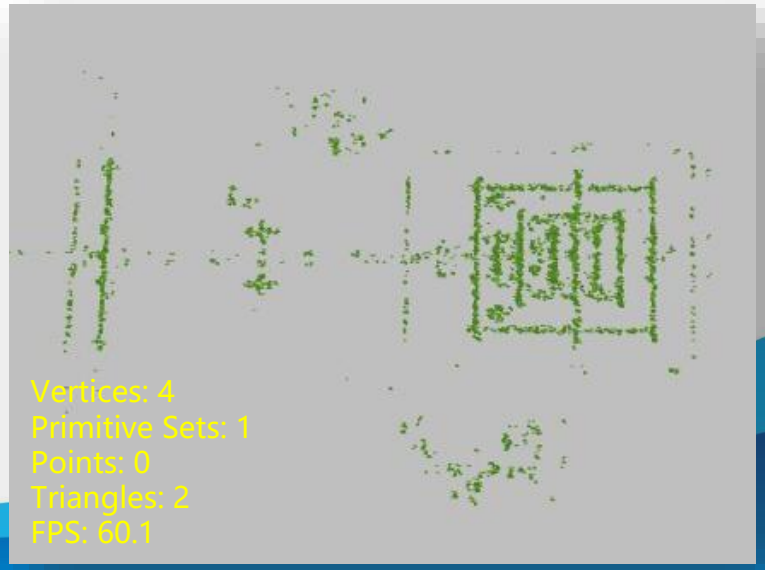



$$\text{Position} = MVP * M_{ins} * M_{rot} * P_v$$

$$\alpha = Tex.x$$

$$\text{Fragcolor} = vec4(\ \alpha\ * C,\ Tex.a\ )$$

- Geometry texture instancing
- Color: separately defined, blending with geometry texture
- Size: user defined
- Geometry vertices: 4
- Triangles: 2
- Rotation Matrix update in real-time, making sure the quads face to screen



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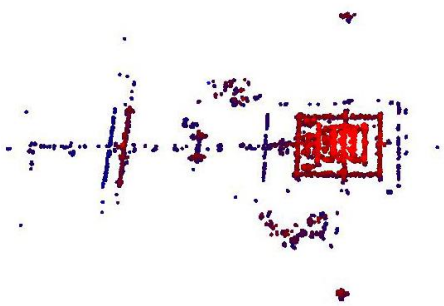
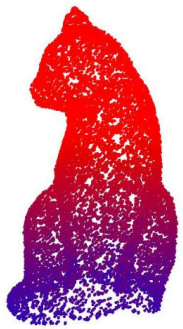
# Methods:

# Algorithm Test

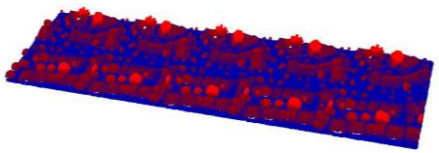


Point: 5800 ( 5.8 k )



20 k

200 k



500 k

- ThinkPad T440s
- CPU: i5-4200U
- RAM: 8GB
- GPU: NVIDIA GeForce GT 730M, 1GB

- Vertices
- Primitive Sets
- Points
- Quads
- Triangles
- Memory
- FPS

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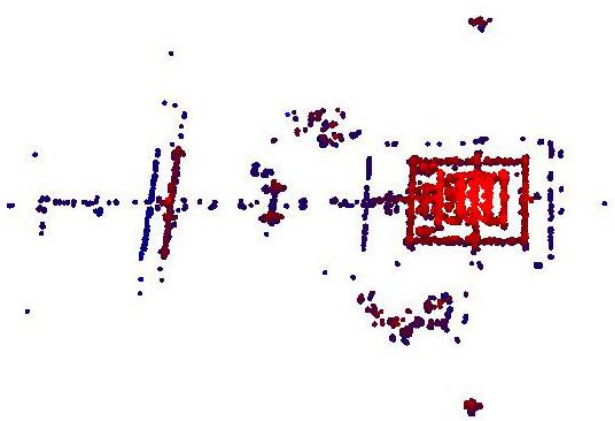
# Methods:

# Algorithm Test

| Algorithm | Vertices | Primitive Sets | Points | Quads | Triangles | Memory | FPS |
|---|---|---|---|---|---|---|---|
| **Colored point** | 5800 | 1 | 5800 | 0 | 0 | 30.1 | 60.1 |
| **Colored point instancing** | 0 | 0 | 0 | 0 | 0 | 29.0 | 60.2 |
| **Textured quad** | 23200 | 5800 | 0 | 5800 | 0 | 68.6 | 59.4 |
| **Textured quad instancing** | 4 | 1 | 0 | 0 | 2 | 34.0 | 60.1 |



- Parameters of ***Colored point*** can be the reference
- ***Colored point instancing*** has no points/quads/triangles, as all the points are drew on the screen directly
- ***Textured quad*** has more vertices ( 4 in each quad), taking more memory but running a low fps
- ***Textured quad instancing*** only has 4 vertices, the texture and matrix images takes more memory than *colored point*, but running a high fps

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# Methods:

# Algorithm Test

| Algorithm | Vertices | Primitive Sets | Points | Quads | Triangles | Memory | FPS |
|---|---|---|---|---|---|---|---|
| **Colored point** | 20k | 1 | 20k | 0 | 0 | 30.0 | 60.0 |
| **Colored point instancing** | 0 | 0 | 0 | 0 | 0 | 31.7 | 60.1 |
| **Textured quad** | 80k | 20k | 0 | 20k | 0 | 125.9 | 27.0 |
| **Textured quad instancing** | 4 | 1 | 0 | 0 | 2 | 35.3 | 60.1 |

- ***Colored point instancing*** and ***Textured quad instancing*** still have the same number of vertices and triangles, and keep a high fps
- ***Textured quad*** takes more memory and the fps drops rapidly

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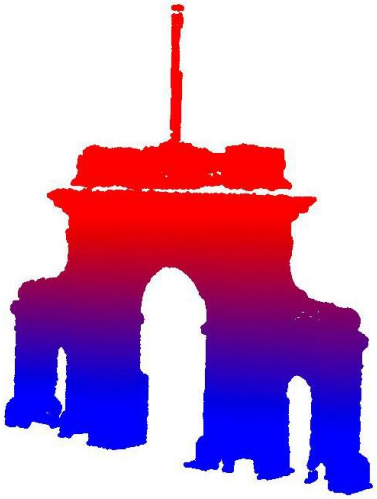
# Methods:

# Algorithm Test

| Algorithm | Vertices | Primitive Sets | Points | Quads | Triangles | Memory | FPS |
|---|---|---|---|---|---|---|---|
| **Colored point** | 200k | 1 | 200k | 0 | 0 | 42.8 | 60.0 |
| **Colored point instancing** | 0 | 0 | 0 | 0 | 0 | 47.3 | 60.0 |
| **Textured quad** | 800k | 200k | 0 | 200k | 0 | 816.3 | 1.8 |
| **Textured quad instancing** | 4 | 1 | 0 | 0 | 2 | 93.4 | 60.0 |



- ***Colored point instancing*** and ***Textured quad instancing*** still have the same number of vertices and triangles, and keep a high fps
- ***Textured quad instancing*** takes more memory because of the matrix image
- The result of ***Textured quad*** is terrible!

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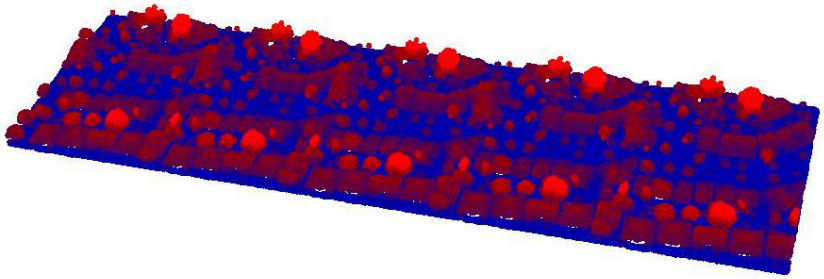
# Methods:

# Algorithm Test

| Algorithm | Vertices | Primitive Sets | Points | Quads | Triangles | Memory | FPS |
|---|---|---|---|---|---|---|---|
| **Colored point** | 500k | 1 | 500k | 0 | 0 | 54.2 | 59.9 |
| **Colored point instancing** | 0 | 0 | 0 | 0 | 0 | 69.7 | 52.5 |
| **Textured quad instancing** | 4 | 1 | 0 | 0 | 2 | 167.9 | 51.7 |



- ***Colored point instancing*** and ***Textured quad instancing*** still have the same number of vertices and triangles, and keep a high fps
- But the memory of ***Colored point instancing*** and ***Textured quad instancing*** rises, and the fps drops a little

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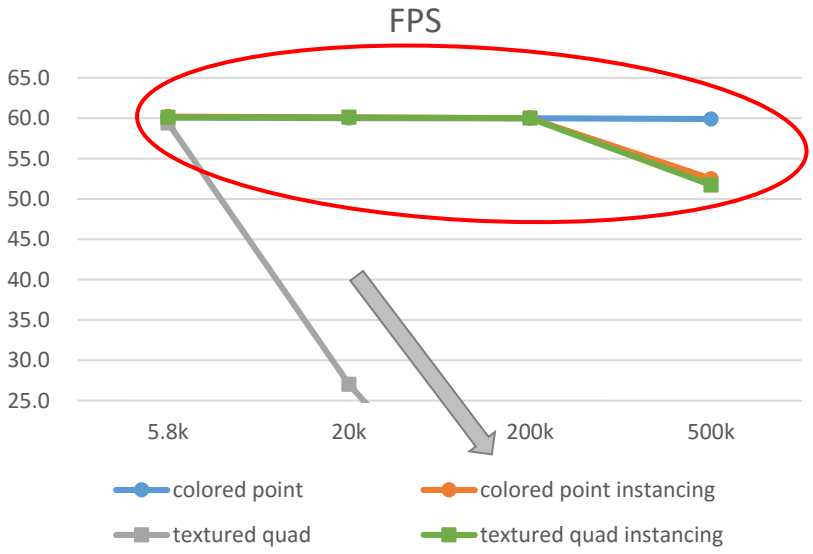
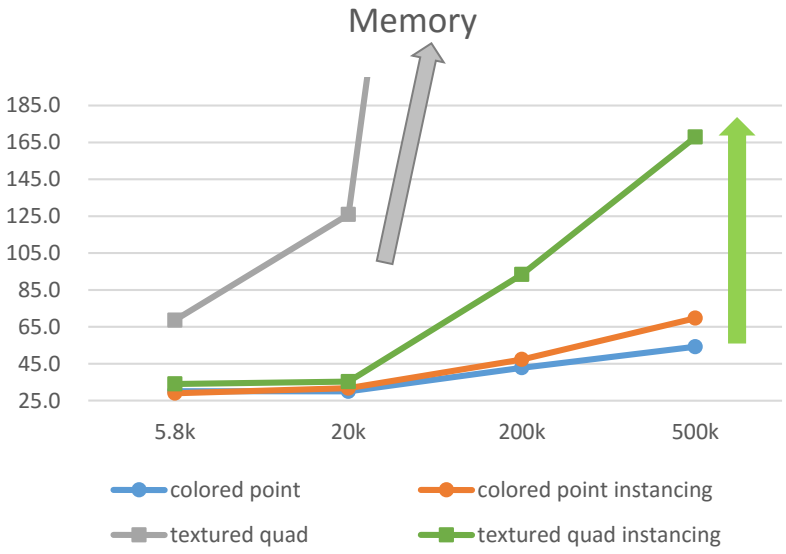
# Methods:

# Algorithm Test




## As the number of vertices grows:

- ***Colored point*** , ***Colored point instancing*** and ***Textured quad instancing*** perform very well in massive point visualization, rendering 0.5 million points at a high fps ( more than 50fps )
- ***Textured quad instancing*** will take more memory because of the matrix image
- ***Textured quad*** will take much more memory and the fps drops rapidly

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# Results & Conclusion: deformation data visualization

- **Temple deformation data visualization in REAS**

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# Results & Conclusion: Deformation Data Visualization

- **Angkor Wat, points: 5800**

Before loading the elevation and deformation data – Vertices: 33961, FPS: 60.1

Elevation

Colored point, FPS: 60.0

Textured quad, FPS: 42.2

Deformation

Colored point instancing, FPS: 60.1

Textured quad instancing , FPS: 60.6

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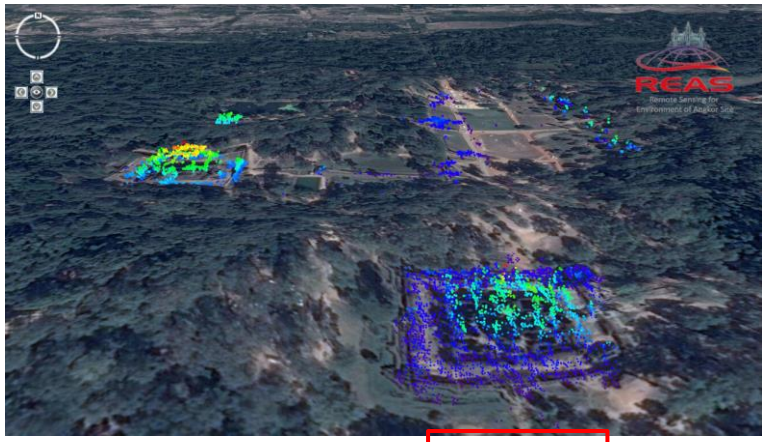
# Results & Conclusion: deformation data visualization

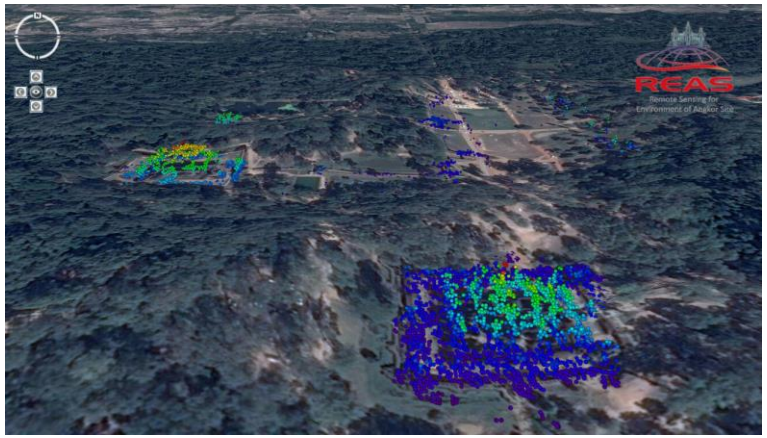
- **Bayon, points: 5659**

Before loading the elevation and deformation data – Vertices: 78565, FPS: 43.9

Elevation

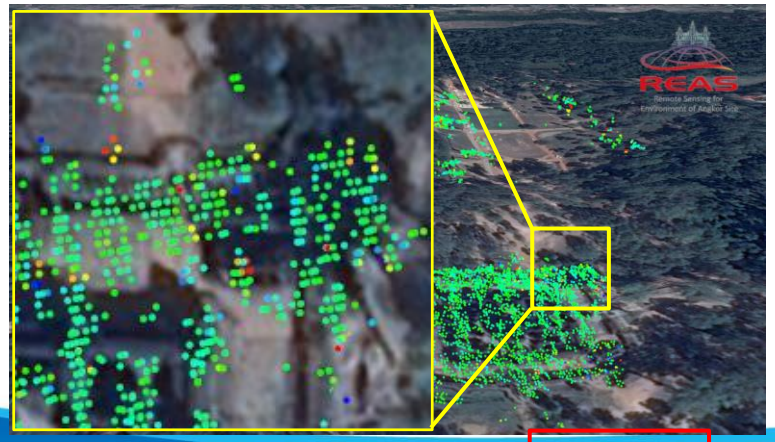


Colored point, FPS: 43.6

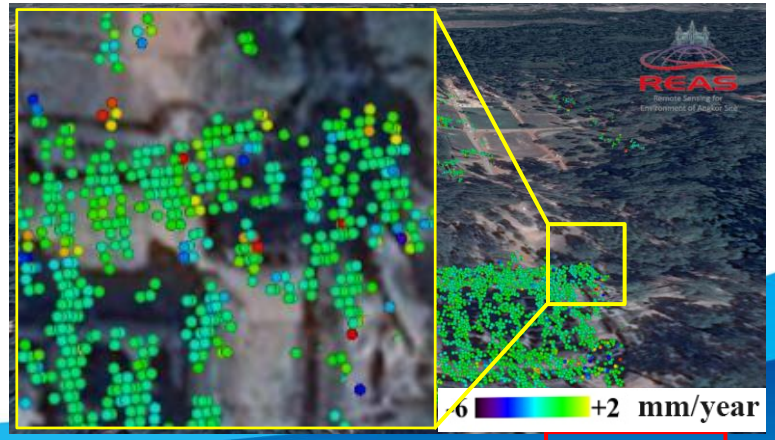


Textured quad, FPS: 32.0

Deformation



Colored point instancing, FPS: 43.8




Textured quad instancing , FPS: 44.0

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# Results & Conclusion: Suggestions

- ***Colored point***, ***Colored point instancing*** and ***Textured quad instancing*** also perform very well in a **Digital Earth System**
- ***Textured quad*** will depress the fps in a Digital Earth System even when rendering thousands of textured points

**For massive deformation data ( point cloud data ) visualization:**

- ✓ Please **ignore** the ***Texture quad*** / billboard / placemark technique
- ✓ If rendered as pure color points, the ***Colored point*** and ***Colored point instancing*** are good choices
- ✓ If rendered with texture and color, the ***Textured quad instancing*** is suggested

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# Thank you !

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