CSC8634 Cloud Computing Report

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Business Understanding

This report documents an exploratory data analysis of application checkpoint and system metric output data collected during the rendering of a 3d terapixel image of the city of Newcastle, UK. A terapixel is defined as 10ˆ12 pixels (1,000,000 megapixels), and so are extremely large images and therefore very computationally costly to produce. A path tracing renderer coupled with a scalable public cloud supercomputing architecture was successfully used to render the terapixel image in under a day using 1024 public cloud GPU nodes. The completed terapixel image is accessible for users to explore the city in 3D with zoomable scales ranging from a complete overview to minute detail.

Since the rendering of such large images is extremely demanding, optimization of the architecture and process is essential for keeping the time frames manageable. Since the rendering is carried out on the public cloud on a pay as you go basis, this optimization also helps to keep costs down, especially if continuous updating of the visualization is to take place. One way to increase the rendering speed is to select the specific GPU cards which perform best for the required task.

The data collected during the initial rendering can be analysed to view the performance of each type of GPU card in order to decide on the optimal cards for the task, as well as revealing which GPUs seem to be unsuitable for the task. The data can be manipulated to allow easy comparison of GPU performance, followed by dimensionality reduction techniques and clustering to separate the desirable and undesirable GPU cards.

Data Understanding

The data was downloaded directly from the Newcastle data science student projects GitHub repository, which is a private repository. The data comprises 3 large datasets: `application.checkpoints`, `gpu` and `task.x.y`. The shape of this data is shown below:

```
dim(application.checkpoints)
```

```
## [1] 660400      6
```

```
dim(gpu)
```

```
## [1] 1543681       8
```

```
dim(task.x.y)
```

```
## [1] 65793     5
```

It's clear that the data is very large, with over 650 thousand observation in the `application.checkpoints` dataset across 6 variables, over 1.5 million observations in the `gpu` dataset across 8 variables, and over 65 thousand observations across 5 variables in the `task.x.y` dataset. Each dataset is summarised below:

application.checkpoints

The `application.checkpoints` data is a comprehensive record of timestamped checkpoint events from the rendering process, with one timestamped entry for the start of the event and one for the end. The checkpoint events are as follows (taken from the `eventName` column): + `TotalRender`: entire rendering task (excluding tiling) + `Render`: rendering of image tile + `Saving Config`: configuration overhead + `Uploading`: uploading of output to Azure Blob Storage + `Tiling`: post processing of rendered tile

```
#printing head of application checkpoint data
head(application.checkpoints)
```

```
## # A tibble: 6 x 6
##   timestamp     hostname        eventName  eventType jobId          taskId
##   <chr>         <chr>           <chr>      <chr>     <chr>          <chr>
## 1 2018-11-08T0~ 0d56a730076643~ Tiling     STOP      1024-lvl12-7e~ b47f0263-ba~
## 2 2018-11-08T0~ 0d56a730076643~ Saving Co~ START     1024-lvl12-7e~ 20fb9fcf-a9~
## 3 2018-11-08T0~ 0d56a730076643~ Saving Co~ STOP      1024-lvl12-7e~ 20fb9fcf-a9~
## 4 2018-11-08T0~ 0d56a730076643~ Render     START     1024-lvl12-7e~ 20fb9fcf-a9~
## 5 2018-11-08T0~ 0d56a730076643~ TotalRend~ STOP      1024-lvl12-7e~ 20fb9fcf-a9~
## 6 2018-11-08T0~ 0d56a730076643~ Render     STOP      1024-lvl12-7e~ 3dd4840c-47~
```

gpu

The `gpu` data comprises periodical recording of status of the GPU on each virtual machine. Recorded GPU metrics are as below, which are paired with the timestamp of the measurement, the hostname of the virtual machine, the GPU card serial number and the system ID assigned to the GPU card: + `powerDrawWatt`: power draw of the GPU card in Watts + `gpuTempC`: temperature of GPU in Celsius at specified timestamp + `gpuUtilPerc`: utilisation of the GPU **core/s** (%) + `gpuMemUtilPerc`: utilisation of the GPU **memory** (%)

```
#printing head of gpu data
head(gpu)
```

```
## # A tibble: 6 x 8
##   timestamp hostname gpuSerial gpuUUID powerDrawWatt gpuTempC gpuUtilPerc
##   <chr>     <chr>        <dbl> <chr>           <dbl>    <int>       <int>
## 1 2018-11-~ 8b6a0ee~   3.23e11 GPU-1d~         132.        48          92
## 2 2018-11-~ d824187~   3.24e11 GPU-04~         117.        40          92
## 3 2018-11-~ db871cd~   3.23e11 GPU-f4~         122.        45          91
## 4 2018-11-~ b9a1fa7~   3.25e11 GPU-ad~          50.2       38          90
## 5 2018-11-~ db871cd~   3.23e11 GPU-2d~         142.        41          90
## 6 2018-11-~ 265232c~   3.24e11 GPU-71~         120.        43          88
## # ... with 1 more variable: gpuMemUtilPerc <int>
```

task.x.y

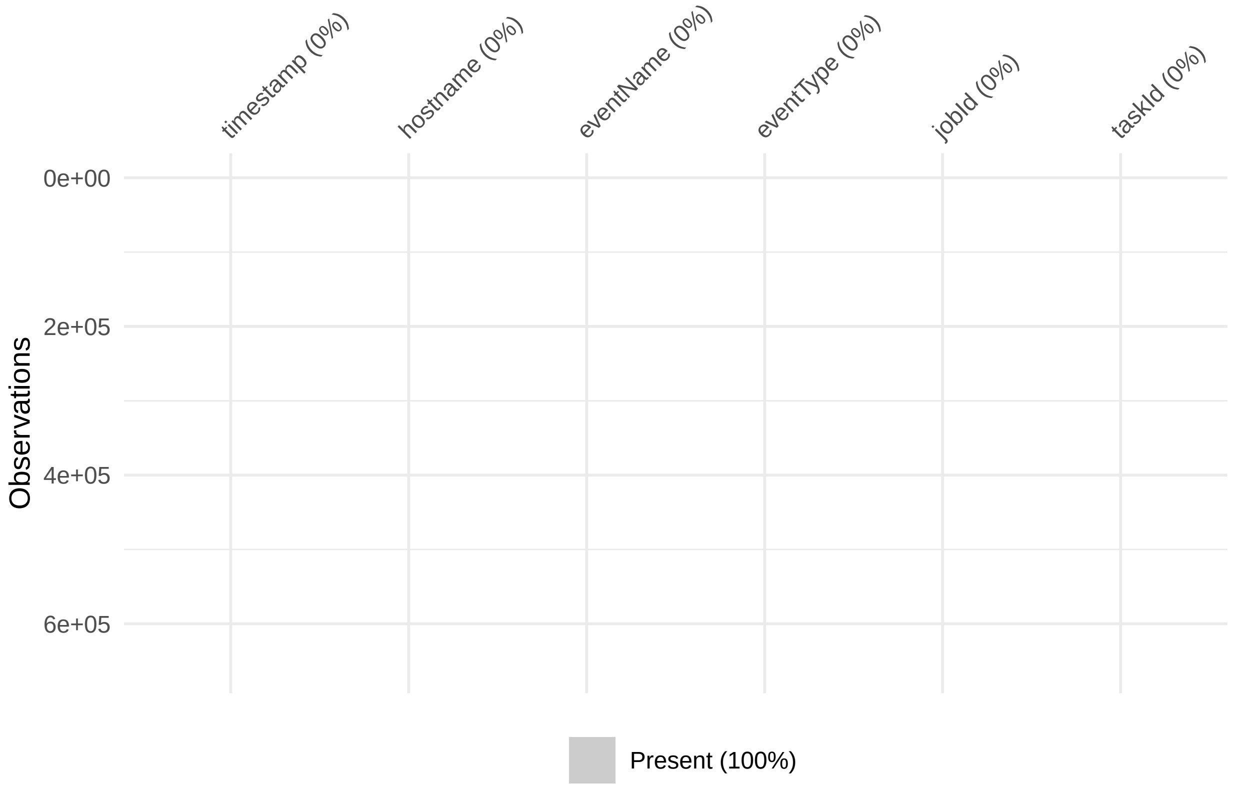
the x and y coordinates of the section of image being rendered for each task. `level` represents the zoom level, of the 12 zoom levels of the visualisation.

```
#printing head of task.x.y data
head(task.x.y)
```

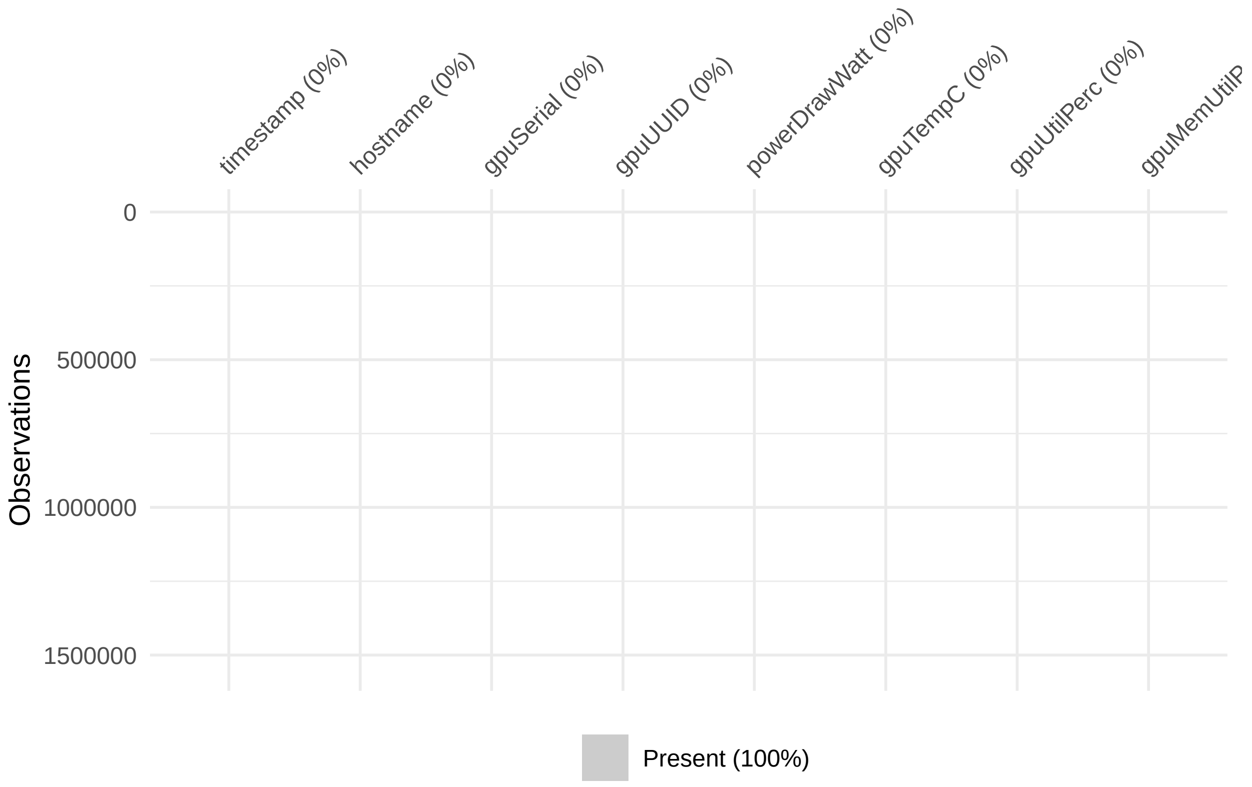
```
## # A tibble: 6 x 5
##   taskId                       jobId                                  x     y level
##   <chr>                        <chr>                              <int> <int> <int>
## 1 00004e77-304c-4fbd-88a1-1~ 1024-lvl12-7e026be3-5fd0-48ee-b7~   116   178    12
## 2 0002afb5-d05e-4da9-bd53-7~ 1024-lvl12-7e026be3-5fd0-48ee-b7~   142   190    12
## 3 0003c380-4db9-49fb-8e1c-6~ 1024-lvl12-7e026be3-5fd0-48ee-b7~   142    86    12
## 4 000993b6-fc88-489d-a4ca-0~ 1024-lvl12-7e026be3-5fd0-48ee-b7~   235    11    12
## 5 000b158b-0ba3-4dca-bf5b-1~ 1024-lvl12-7e026be3-5fd0-48ee-b7~   171    53    12
## 6 000d1def-1478-40d3-a5e3-4~ 1024-lvl12-7e026be3-5fd0-48ee-b7~   179   226    12
```

Each dataset appears to

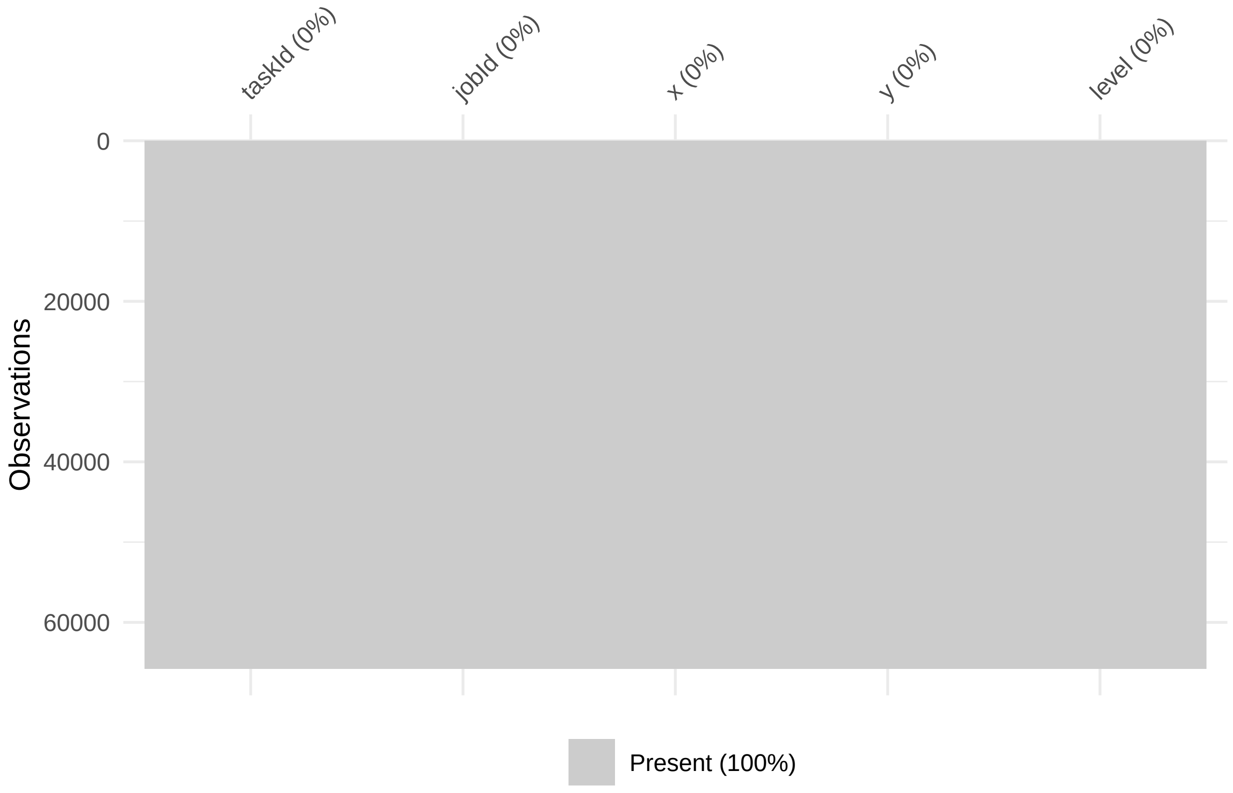
```
vis_miss(application.checkpoints, warn_large_data=FALSE)
```

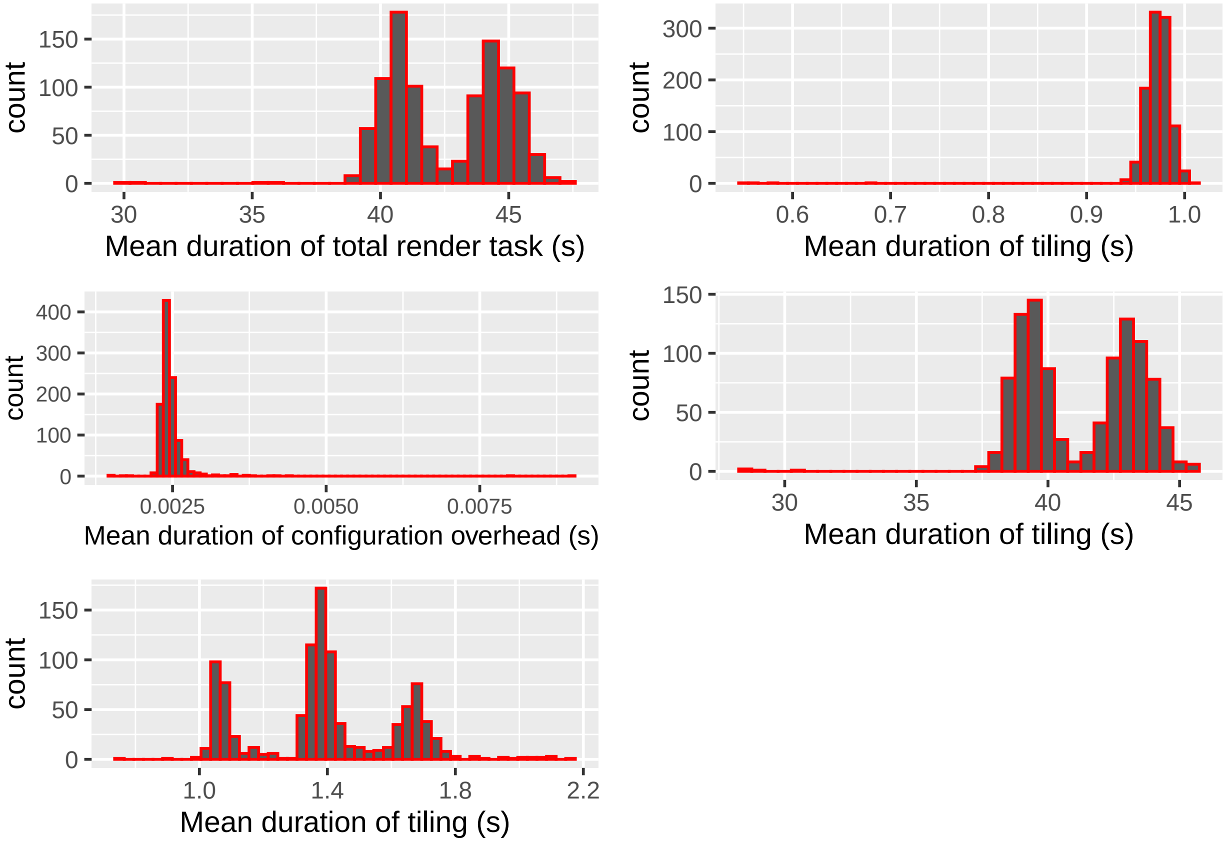


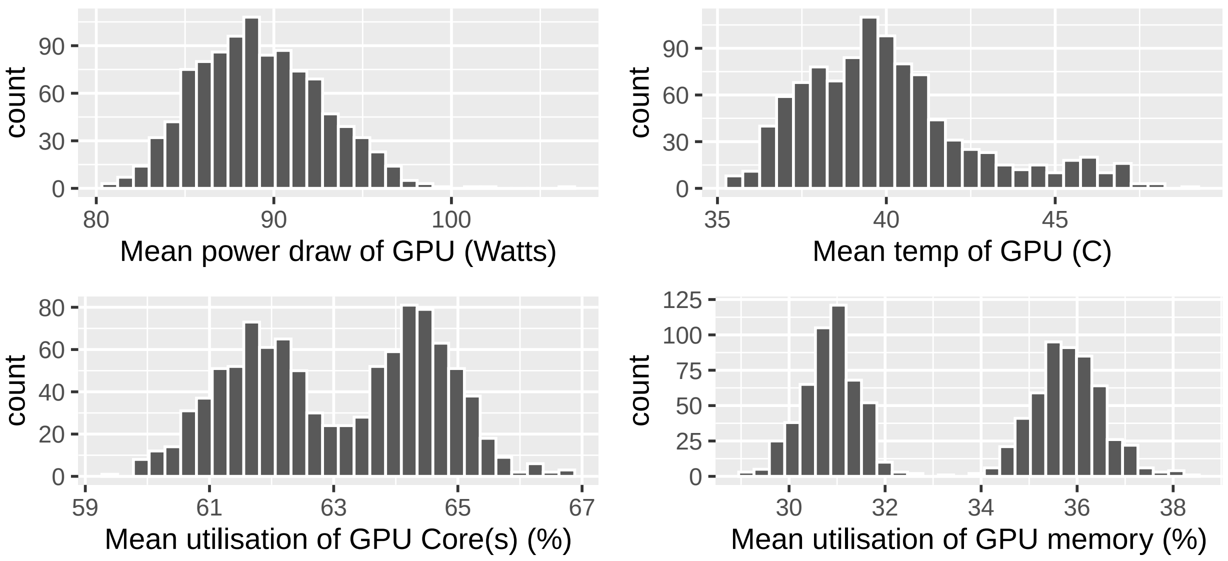
```
vis_miss(gpu, warn_large_data=FALSE)
```



```
vis_miss(task.x.y)
```


taskId (0%)
jobId (0%)
x (0%)
y (0%)
level (0%)
Observations
0
20000
40000
60000
Present (100%)


count
150
100
50
0
30
35
40
45
Mean duration of total render task (s)
count
300
200
100
0
0.6
0.7
0.8
0.9
1.0
Mean duration of tiling (s)
count
400
300
200
100
0
0.0025
0.0050
0.0075
Mean duration of configuration overhead (s)
count
150
100
50
0
30
35
40
45
Mean duration of tiling (s)
count
150
100
50
0
1.0
1.4
1.8
2.2
Mean duration of tiling (s)



References

http://www.gigamacro.com/worlds-first-terapixel-macro-image/