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Depth estimation and segmentation from street view using digital map

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ABSTRACT

In the game, the background is not only a spatial element, but also an element that increases game immersion by giving the story a probability. For this reason, some games with a background modeled on an actual city center are gaining popularity, through games, players can experience places that they cannot visit in real life. It is difficult to create a game set in the city center because it requires a lot of manpower and time to produce background. On the other hand, there are also games that provide virtual experiences to users using services such as Street View and simple rules. It will be very useful if you can create a map based on reality and increase the user's immersion by utilizing the building that is an important element in the background based on Street View. Usually in games, depth maps are used for lighting and shadow generation, or constructing terrain like height maps. We are going to apply a depth map to street view. In this study, we intend to experiment with a simple and low-cost depth estimation algorithm using a digital map. The location and metadata of the building were acquired from the digital map and the depth was estimated. We added depth information to Street View to highlight important buildings as background elements and separate buildings, ground, and sky. Street view studies based on digital maps and metadata can be used in a variety of ways, such as building 3D maps and advertising based on building planes.

Key words: Street View, Depth Map, Panorama Image

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1. Introduction

The background map is a very important factor in the game. The background is not only a spatial component, but an element that shows the user a compelling narrative without speaking directly in the game. Because of this, games with realistic urban backgrounds became popular. Through such a game, players can experience places that they cannot visit in real life. In particular, buildings are elements that give users a great sense of reality[1]. However, the background of the game created by modeling large cities is difficult to try because it requires a lot of manpower and time. Recently, Google allowed map data to be used in games through the map platform service, but the texture part is different from the actual one[2].

Services such as Google Street View[3] or Daum Road View also have virtual experience elements, and there are also simple rule games using this. GeoGuessr is a game where you find yourself in a random location on Google Street View[4], and MapCrunch is a game that takes you from a random location to the airport[5]. Users visit areas they have never been to through the service and get new experiences. This service requires less manpower and cost compared to modeling.

1.1 Related work

There have been studies that generate additional information by processing street view data, not simply experiencing a new area. Most of them have done research to create city models through panoramic images such as street view[6,7]. Alternatively, there have been other studies that have done 3D model reconstruction of buildings from Street View[8]. When using depth maps in games, they are mostly used for light and shadow shading. Alternatively, other studies using depth maps were only used to construct terrain, such as height maps[9]. In this study, we intend to generate 2.5D map data including context using street view images and digital maps. The 2.5D map consists of a panorama image textures and a depth map based on the observation point. The 2.5d map is similar to the height map, but it defines the depth, not the height, and covers the 360° panorama space. The Korean government provides digital maps through the Korea National Geographic Information Institute. This map contains various information about buildings and facilities and is used for several services. We are going to experiment with a simple and inexpensive depth map estimation method. Research using street view based on digital map and its metadata can be utilized in various ways.

2. Methods

We see that the system is divided into Street View and Digital Map parts, and an overview is shown in Figure 1.

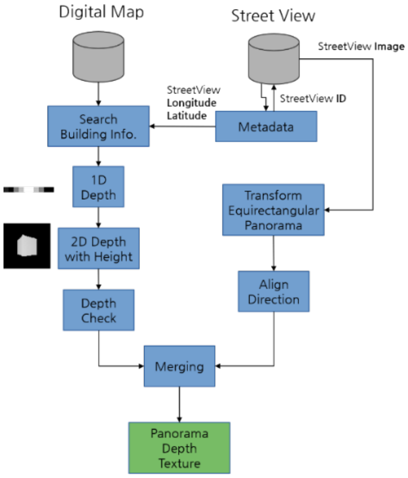


Fig. 1. System Overview

2.1 Street view image

First, it provides latitude and longitude coordinates to the Street View server and receives metadata about the Street View image. The metadata is received in xml format (Fig 2), the metadata contains the ID(pano_id in Fig 2) of the Street View panorama image, the original latitude and longitude, and information about whether the image is rotated or not.


```
<?xml version="1.0" encoding="UTF-8"?>
<panorama>
 - <data_properties elevation_egm96_m="21.668381" best_view_direction_deg="278.86407"
   elevation_wgs84_m="44.434872" original_lng="126.920615" original_lat="37.554636"
   lng="126.920789" lat="37.554626" num_zoom_levels="5" imagery_type="1"
   pano_id="ZcWsbH5csbWj7pIm2i_HHw" image_date="2018-12" tile_height="512"
   tile_width="512" image_height="6656" image_width="13312">
     <copyright>© 2020 Google</copyright>
     <text> </text>
     <country>South Korea</country>
   </data_properties>
   <projection_properties tilt_pitch_deg="2.2" tilt_yaw_deg="-167.2" pano_yaw_deg="227.76"
     projection_type="spherical"/>
```


Fig. 2. Example of received metadata

Use Street View ID to request panoramic images from the server. In this case, a low-resolution panoramic image can be used, or a high-resolution image can be partially requested and then stitched to create a panorama (request and map a 90 FOV image corresponding to the cubemap). The panoramic image is modified to a equiretangular form using the projection parameters in the metadata.

Fig. 3. Example of received panorama image

2.2 Digital map

The digital map is divided into two files, the spatial data file containing the coordinates of the facility (Fig 4) and the attribute data file containing the metadata(Fig 5). The attribute data includes the building's ID, name, type, classification, purpose, and number of floors.


```
$LAYER_NAME
"B0010000"
$END
<HEADER>
$VERSION
1
$END
$GEOMETRIC_METADATA
MASK(POLYGON,POINT)
DIM(2)
BOUND(126.900000, 37.550000, 126.925000, 37.575001)
$END
$POINT_REPRESENT
1 SYMBOL(GM_0, 0.000000, 255)
$END
$REGION_REPRESENT
1 REGIONATTR(SOLID, 1, 65280, SOLID100, 65280, 65280)
$END
<END>
<DATA>
$RECORD 1
POLYGON
NUMPARTS 1
16
126.908439 37.573406
126.908289 37.573305
126.908265 37.573324
126.908236 37.573303
126.908186 37.573335
```


Fig.4. Spatial data file example(Vertex coordinate)

```
$END
$ASPATIAL_FIELD_DEF
ATTRIB("ID",NUMERIC, 9, 0, TRUE)
ATTRIB("명칭",STRING, 256, 0, TRUE)
ATTRIB("구분",STRING, 256, 0, TRUE)
ATTRIB("종류",STRING, 256, 0, TRUE)
ATTRIB("용도",STRING, 256, 0, TRUE)
ATTRIB("주기",STRING, 256, 0, TRUE)
ATTRIB("층수",NUMERIC, 9, 0, TRUE)
ATTRIB("UFID",STRING, 256, 0, TRUE)
$END
<END>
<DATA>
$RECORD 1
1, "요진아파트", "", "무벽건물", "근린생활시설", "", 1,
"1000037608077B0011000000000000016"
$RECORD 2
2, "", "", "연립주택", "주택", "뫼비우스", 5, "1000037608077B0011000
$RECORD 3
3, "", "", "가건물", "기타시설", "", 1, "1000037608077B0011000000000
$RECORD 4
4, "", "", "가건물", "기타시설", "", 1, "1000037608077B0011000000000
$RECORD 5
```

Fig. 5. Attribute data file example(Meta-data)

We connected the two data based on the ID. This ID is a unique number given to each building and consists of a map name, feature code, and a unique number. The system fetches building information within a specific radius based on the query location. The depth is calculated as the distance(m) between the building vertex and the reference point. The system detects the visible side as it traverses the vertices of each building. The building height is estimated based on the number of floors in the building. Elevation is calculated on the top and bottom of the horizontal basis. Interpolation is needed between each vertex. Figure 5 shows the interpolated depth map and the corresponding panoramic image.

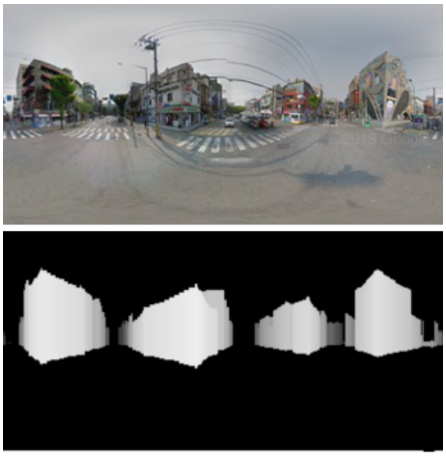
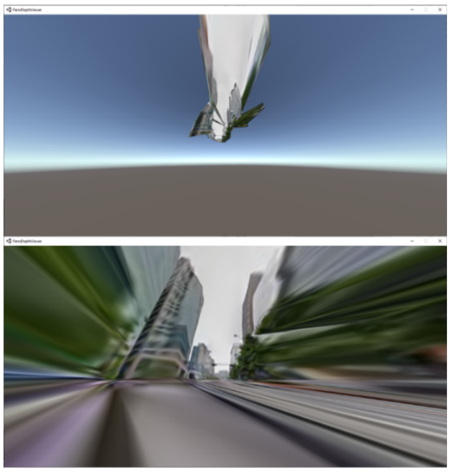


Fig. 6. Depth map and panorama image

3. Conclusion

In this experiment, we set the azimuth angle at 1degree intervals and used a low-resolution panoramic image. We experimented with a simple and inexpensive depth map estimation method. As shown in Fig. 7, the Street View image was constructed using a depth map in 3D space.



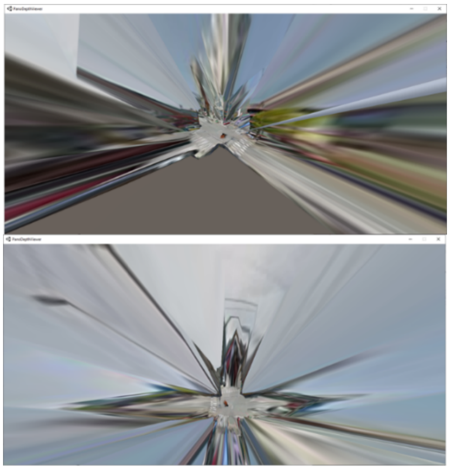


Fig. 8. Depth map visualization

Through this experiment, we saw the possibility of image-based merging, not just the latitude and longitude coordinates of the digital map and Street View. In Fig 8, the building(white area), land(green area), and sky(blue area) show the separation by the horizon. This can be used to replace the sky with a dynamic sky with weather changes(Fig 9). Land can be represented as a space that users can move around.

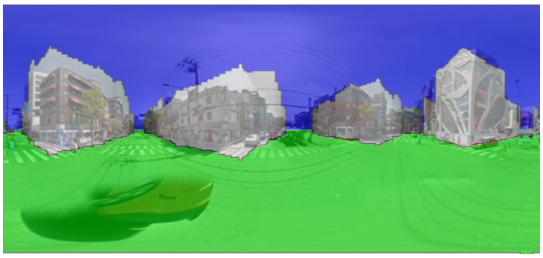


Fig. 8. Example of segmentation

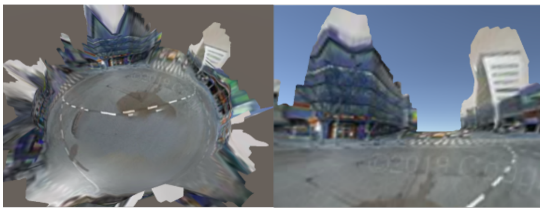


Fig. 9. Example of replacing the sky

In some case, the matching result was not better than expected. One of the main reasons is that the Google street view image was expected to be an ideal panorama image, but it was not and the distortion was considerable. Fig 9 shows distortion, building is not straight. Green is a horizontal line and red is a vertical line for reference.

Fig. 9. Example of panorama image distortion in

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<국문초록>

수치지도를 사용한 스트리트 뷰 이미지 깊이 추정 및 세분화

게임에서 배경은 단지 공간적 구성 요소뿐만 아니라 사용자에게 게임 속에서 몰입감을 높여주는 요소이다. 때문에 실제 도심을 모델로 한 배경의 일부 게임들이 인기를 끌고 있다. 도심을 배경으로 하는 게임의 배경은 만드는데 많은 인력과 시간을 필요로 하기 때문에 제작하기 힘들다. 한편 스트리트 뷰와 같은 서비스와 간단한 룰을 이용해서 가상의 체험을 제공해주는 게임들도 존재한다. 스트리트 뷰를 기반으로 배경에서 중요 요소인 건물을 살려 사용자의 몰입감을 높이고 실제에 기반한 맵을 만들 수 있다면 매우 유용할 것이다. 일반적으로 게임에서 깊이 맵은 빛과 그림자 셰이딩 또는 높이 맵으로 지형을 구성하는데 활용된다. 우리는 이 깊이 맵을 스트리트 뷰에 적용하고자 한다. 우리는 이 연구에서 수치지도를 이용해 간단하고 저비용의 깊이 추정 알고리즘을 실험하고자 한다. 건물에 대한 위치 및 메타데이터는 수치지도로 부터 획득하여 깊이 추정을 진행하였다. 스트리트 뷰에 깊이 정보를 더하여 배경 요소에 중요한 건물을 강조하고 또한 건물과 지면, 하늘을 분리하였다. 디지털 지도와 메타 데이터를 기반으로 한 스트리트 뷰 연구는 다양한 방법으로 활용 될 수 있다.

<결론 및 향후 연구>

본 연구에서 디지털 지도에 기반하여 깊이 정보를 추정하고 이를 스트리트 뷰 이미지에 적용하여 스트리트 뷰 이미지가 디지털 지도에 대응 할 수 있도록 하였다. 배경 맵에서 중요한 요소인 건물들을 구분하여 사용자의 몰입감을 높이고 세분화를 통해 스트리트 뷰를 이용한 배경 맵을 구성할 수 있는 기반을 구성하였다. 우리는 이 연구를 발전시켜 깊이 맵과 파노라마 이미지의 해상도를 높이고 다중의 스트리트 뷰를 연결하여 밀도 높은 3차원 배경 맵을 만들어 간단한 게임이 가능한 공간을 구성하고자 한다.

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