Point cloud generation Visionary devices

SICK AG | Mobile Perception
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GigE Vision / GenICam 3D model

How to present camera‘s 3D output data to a generic application

- GenICam SFNC standard defines feature model to describe generated 3D data to a generic application
- https://www.emva.org/wp-content/uploads/GenICam_SFNC_v2_7.pdf (chapter 21 „3D Scan Control“)
- The data model used by Visionary devices needs extension of that model – proposal submitted to the technical committee, review (& ratification) in progress
- This presentation provides overview of the newly proposed output mode „ProjectedC“ and instructions how to build the point cloud (X/Y/Z point coordinates) from acquired data

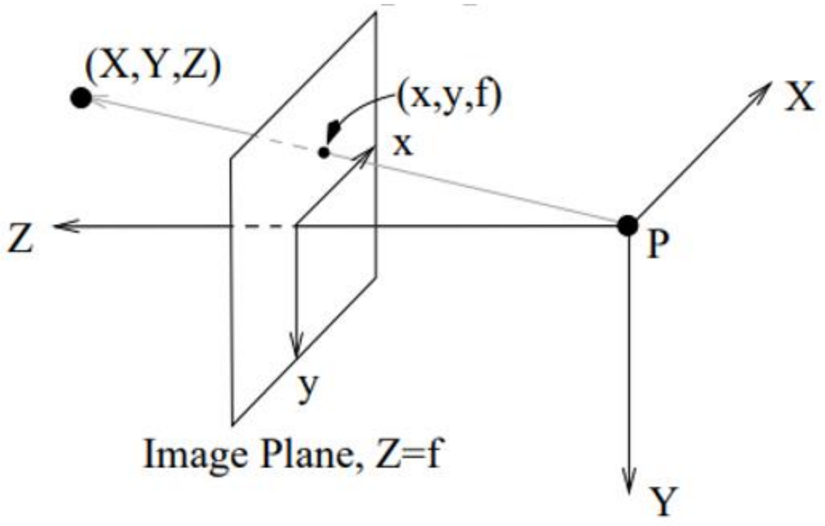
Projective camera geometry

Proposed „ProjectedC“ standard mode overview

Image formation can be approximated with a simple pinhole camera

Knowing camera intrinsic parameters, the range (Z) value itself is enough to reconstruct the other coordinates

(source: https://www.cs.toronto.edu/~jepson/csc420/notes/imageProjection)



The 3D point coordinates (X, Y, Z) for a pixel (x, y) is given by the projective transformation

$$\begin{pmatrix} x \\ y \\ f \end{pmatrix} = \frac{f}{Z} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

Considering the principal point (optical center) coordinates o_x/o_y and aspect ratio a of not-ideally-square pixels, we can calculate with camera intrinsic matrix in form

$$M_{in} = \begin{pmatrix} f & 0 & o_x \\ 0 & fa & o_y \\ 0 & 0 & 1 \end{pmatrix}$$

Main parameters describing the 3D scene

Which features to read for each acquired frame

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The intrinsic parameters can be read *per-frame* through following camera „chunk" features (actual use on next slide):

```
// write (select coordinate of interest)
ChunkScan3dCoordinateSelector = „CoordinateC"
// read
scaleC = ChunkScan3dCoordinateScale
offsetC = ChunkScan3dCoordinateOffset
princPtU = ChunkScan3dPrincipalPointU
princPtV = ChunkScan3dPrincipalPointV
focLen = ChunkScan3dFocalLength
aspectR = ChunkScan3dAspectRatio
```

Notes:

- *Read through „chunk" (per-frame) features, chunk mode must be ON (ChunkModeActive)*
- *The parameters remain constant, however, non-chunk versions of the features might be introduced in the future*

Generating the point cloud

Compute all point coordinates from acquired range map

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Given the parameters read in the previous step, the 3D coordinates corresponding to individual pixels can be calculated:

```
for (row = 0; row < imageHeight; row++)
for (col = 0; col < imageWidth; col++)
{
  xp = (col - princPtU) / focLen
  yp = (row - princPtV) / (focLen * aspectR)


  scaledC = image[row][col]* scaleC + offsetC

  xc = xp * scaledC
  yc = yp * scaledC
  zc = scaledC
}
```

Note: The calculated coordinates are given im millimeters (as also reported through ChunkScan3dDistanceUnit)

Invalid data

Identify invalid pixels

- Pixels with invalid data („no measurement“) encoded using **zero** range map value
- Ignore such pixels when calculating the point cloud (previous step)
- *(the invalid data value also reported through standard features ChunkScan3dInvalidDataFlag/ChunkScan3dInvalidDataValue)*

Reference coordinate system

Use device-specific calibration results to transform the coordinate system

- The camera outputs measurement in its device-specific „anchor“ coordinate system…
- …which can (for example due to inevitable mounting inaccuracies) differ from the ideal „reference“ coordinate system
- Reference system: right hand Cartesian, Z pointing away from the device
- Standard features to query parameters of the anchor-reference transformations (rotations and translation):
  - ChunkScan3dCoordinateReferenceSelector
  - ChunkScan3dCoordinateReferenceValue
- The features currently presented by the firmware, but **not connected** to actual calibration results
  - **Do not use** in the moment, to be finished in a **future firmware version**

Multiple data components

Acquiring RGB information together with the 3D range data

- Besides the range data, the device can also output RGB color information for each pixel
- Device features to control the component selection: ComponentSelector, ComponentEnable
- Refer to the provided sample programs (Python scripts) how to configure which components to acquire and how to identify them within the acquired data
- *Note: some older GigE Vision receivers not aware of GigE Vision „multi-part“ feature might not be able to acquire more than one component at once*