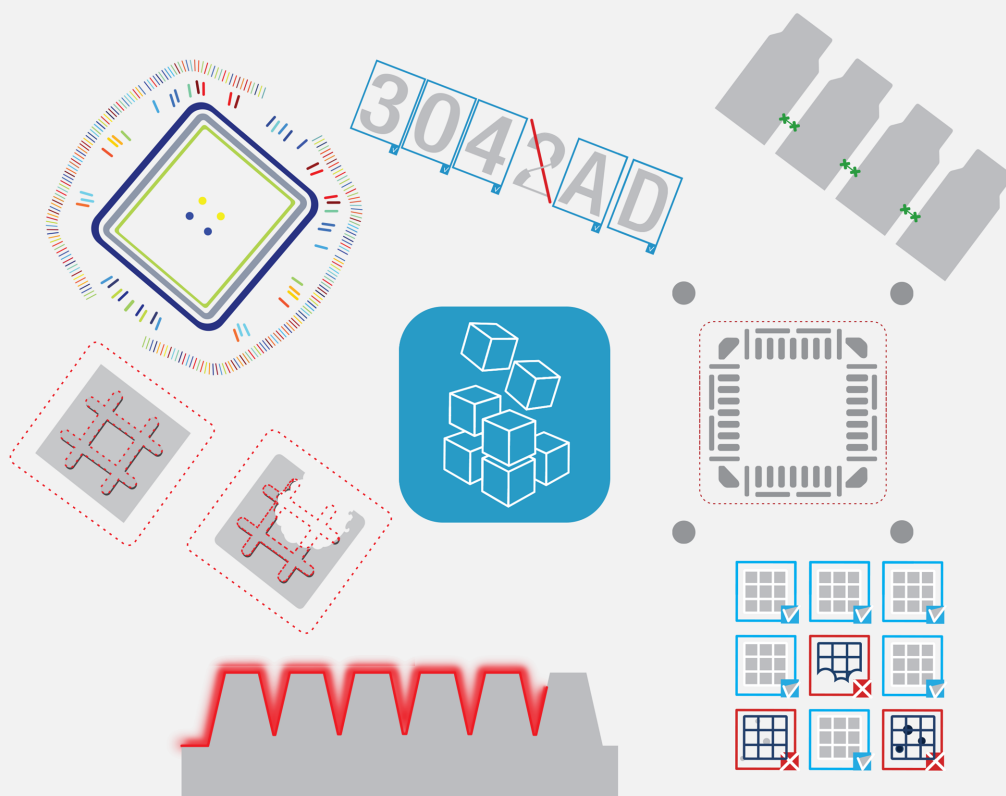


Open eVision

Easy3D Compatibility with Automation Technology 3D Sensors



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Easy3D Compatibility with Automation Technology 3D Sensors

Introduction

AT compact 3D products are integrated laser triangulation sensors. The **cx3D** library distributed with the **AT solution** package supports various operations on 2D and 3D structures, like the calibration of the laser triangulation setup.



TIP

Some AT sensors are **GigE Vision** compatible, so, although we provide no sample, you can integrate them directly by using that standard instead of using the **cx3D** library as illustrated here.

The specifications are available on the manufacturer website:

<https://www.automationtechnology.de/cms/en/c6-series>

- This document explains how to use the 3D data coming from these sensors with **Open eVision** 3D libraries and tools.
- A sample application distributed with source code demonstrates that integration. This application is freely available in the [Easy3D Sensors Compatibility](#) additional resources package on **Euresys** website.

Resources

This document and the sample applications are based on the following resources:

- C6-2040CS sensor, but the sample application is compatible with the entire C6 series.
- **AT solution** Package 2023.12 64 bits
- **Open eVision** 24.02
- Microsoft Visual Studio 2017



NOTE

The versions of this document anterior to the **Open eVision** 22.12 release are compatible with the AT C5 and MCS series. Please check these documents if you are using these series.

Features

- The following data formats are exposed within **cx3D** (in **Genicam** Standard Features Naming Convention):
 - **UncalibratedC**: uncalibrated 2.5D depth image (or range map). The distance data does not represent a physical unit and may be non-linear.
 - **CalibratedABC**: Point cloud image with three coordinates in grid organization. The pixel coordinates are calibrated and transformed to the world coordinate system (WCS). Invalid pixels are marked with an invalid z-value.
 - **RectifiedC**: rectified 2.5D depth image. The distance data has been rectified to a uniform sampling pattern in X and Y direction.
- These formats support various pixel formats and organizations.
- Easy3D** exposes also similar structures:
 - • A depth map (**EDepthMap8/16/32f**) is a container for uncalibrated 2.5D data. In the context of a laser triangulation setup, these values represent the displacement of the laser line profile, which is not the physical height of the 3D surface.
 - • A point cloud (**EPointCloud**) is a set of 3D points (x, y and z coordinates) representing the scanned object in the world metric space.
 - • A ZMap (**EZMap8/16/32f**) is a grayscale images like depth maps but represent metric and corrected 3D points.
- The correspondences between the **cx3D** and the **Easy3D** classes are:

AT cx3D objects	Euresys Easy3D objects
cx::Image (UncalibratedC) Formats: <ul style="list-style-type: none"> □ CX_PF_MONO_8 □ CX_PF_MONO_10 □ CX_PF_MONO_10p □ CX_PF_MONO_12 □ CX_PF_MONO_12p □ CX_PF_MONO_16 (preferred) □ CX_PF_MONO_32 □ CX_PF_MONO_64 	Easy3D::EDepthMap Formats: <ul style="list-style-type: none"> □ EDepthMap8 for unsigned 8-bit integer □ EDepthMap16 for unsigned 16-bit integer □ EDepthMap32f for 32-bit float.
cx::c3d::PointCloud (CalibratedABC) Formats: <ul style="list-style-type: none"> □ CX_PF_COORD3D_ABC8_PLANAR □ CX_PF_COORD3D_ABC8 □ CX_PF_COORD3D_ABC16 □ CX_PF_COORD3D_ABC16_PLANAR □ CX_PF_COORD3D_ABC32f (preferred) □ CX_PF_COORD3D_ABC32f_PLANAR 	Easy3D::EPointCloud: <ul style="list-style-type: none"> □ A continuous buffer of E3DPoint. E3DPoint is a struct (x,y,z) with 3 floats.
cx::c3d::ZMap (Rectified) Formats : <ul style="list-style-type: none"> □ CX_PF_COORD3D_C16 □ CX_PF_COORD3D_C32f (preferred) 	Easy3D::EZMap Formats: <ul style="list-style-type: none"> □ EZMap8 for unsigned 8-bit integer □ EZMap16 for unsigned 16-bit integer □ EZMap32f for 32-bit float.

Sample C++ codes for the generic conversions from **cx3D** to **Easy3D** formats is provided at the end of this document:

- Easy3D::EDepthMap* DepthMapConversion(const AT::cx::Image& atRangeMap)
 - Create a EDepthMap8 or EDepthMap16 object depending on the format of the cx::Image.
 - For better efficiency, the data are not copied but referenced in the EDepthMap container.
- Easy3D::EPointCloud* PointCloudConversion(const AT::cx::c3d::PointCloud& atPC, float idv)
 - Create an Easy3D::EPointCloud and copy the 3D points.
 - Undefined values (when Z==idv) are not copied.
 - As Easy3D::EPointCloud contains world space points, the scale and offset are applied to the valid c3d::PointCloud positions.
- Easy3D::EZMap* ZMapConversion(const AT::cx::c3d::ZMap& atZmap, float idv)
 - Create an EZMap16 or EZMap32f object depending on the format of c3d::ZMap.
 - Undefined values (when Z==idv) are converted to Easy3D::EZMap undefined values.
 - The scale and offset are kept in the Easy3D::EZMap object.



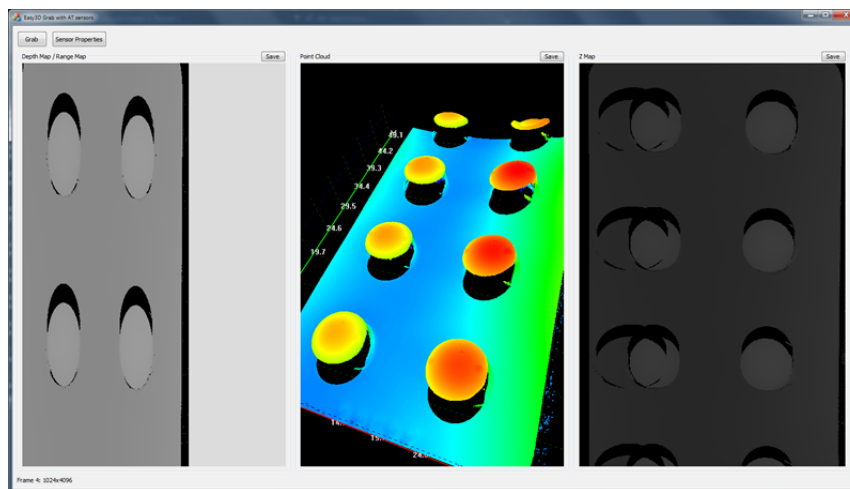
TIP

The **Easy3DGrab** sample application implements the acquisition and conversion for selected formats.

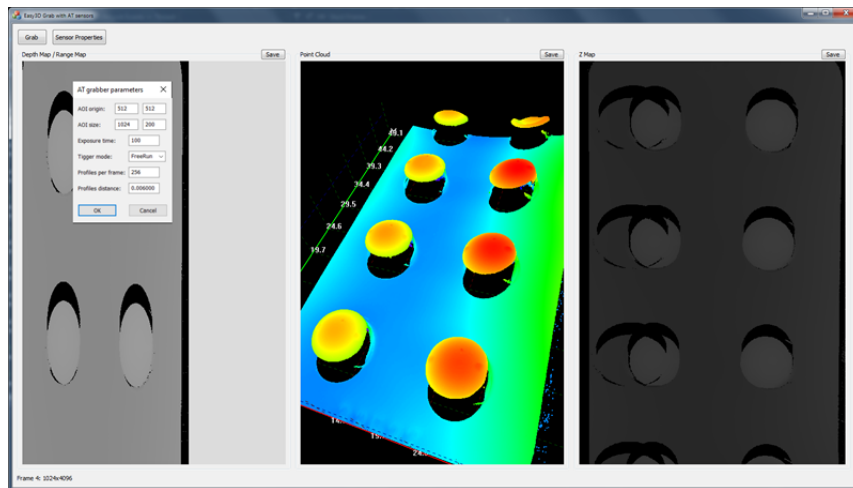
Easy3DGrab sample application

Easy3DGrab is distributed with C++ source code as an **Open eVision** additional resource.

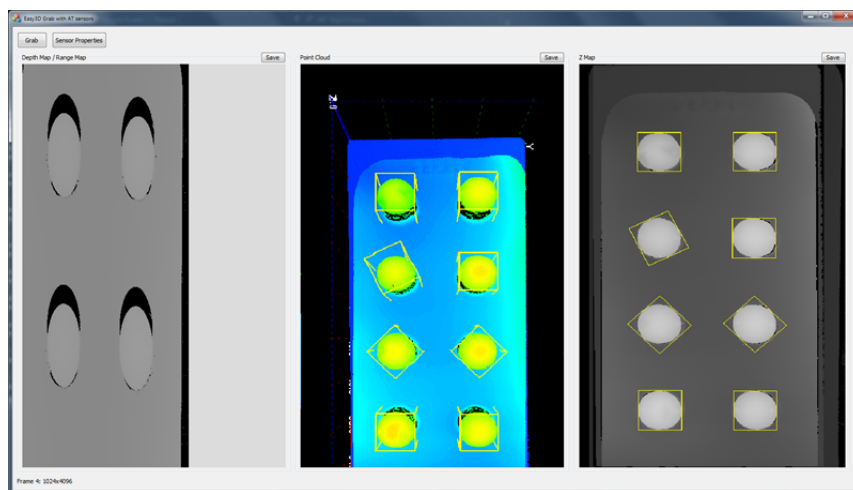
- It features the acquisition of **AT** 3D data, the conversion to depth maps, point clouds and ZMaps.
- You can save these representations.
- Click on the **Grab** button to acquire a new image.
- Open the **Sensor Properties** dialog to access some of the device parameters.
- The **Object extraction** function is exposed but you can use it only with the **Easy3DObject** license.



The Easy3DGrab application: EDepthMap (left), EPointCloud (center), EZMap (right)



Tuning the C5-CS sensor parameters to filter the range data



Automatic extraction of 3D objects with Easy3DObject library

C++ code sample to convert cx3D to Easy3D objects

Converting an AT range map (UncalibratedC) to Easy3D::EDepthMap

```
// Create an Open eVision EDepthMap8 or EDepthMap16 depending on the format of the AT range map.
// The pixel buffer of the given range map is directly referenced in the depth map, no copy is performed.
// The EDepthMap must be explicitly released after usage.

Easy3D::EDepthMap* DepthMapConversion(const AT::cx::Image& atRangeMap)
{
    Easy3D::EDepthMap* eDepthMap = NULL;

    switch (atRangeMap.pixelFormat())
    {
    case cx_pixel_format::CX_PF_MONO_8:
        eDepthMap = new Easy3D::EDepthMap8();
        eDepthMap->SetBufferPtr(atRangeMap.width(), atRangeMap.height(), atRangeMap.data(),
(int)atRangeMap.linePitch() * 8);
        break;

    case cx_pixel_format::CX_PF_MONO_16:
        eDepthMap = new Easy3D::EDepthMap16();
        eDepthMap->SetBufferPtr(atRangeMap.width(), atRangeMap.height(), atRangeMap.data(),
(int)atRangeMap.linePitch() * 8);
        break;

    default:
        throw std::exception("RangeMap format not supported");
        break;
    }
    return eDepthMap;
}
```

Converting an AT point cloud (PointCloud) to Easy3D::EPointCloud

```
// Create an Open eVision EPointCloud depending on the format of the AT PointCloud.
// The 3D positions are converted in "world space" by applying scale and offset.
// Undefined point are discarded.
// The EPointCloud object must be explicitly released after usage.

Easy3D::EPointCloud* PointCloudConvection(AT::cx::c3d::PointCloud& atPC, float idv)
{
    Easy3D::EPointCloud* ePC = new Easy3D::EPointCloud();
    std::vector<Easy3D::E3DPoint> vector3DPoints;
    vector3DPoints.reserve(atPC.points.size());

    Easy3D::E3DPoint scale(atPC.scale.x, atPC.scale.y, atPC.scale.z);
    Easy3D::E3DPoint offset(atPC.offset.x, atPC.offset.y, atPC.offset.z);

    switch (atPC.points.pixelFormat())
    {
    case cx_pixel_format::CX_PF_COORD3D_ABC8_PLANAR:
    {
        int8_t* atPCp = static_cast<int8_t*>(atPC.points.data());
        int dataSize = atPC.points.planePitch() / sizeof(int8_t);
        for (int ii = 0; ii < dataSize; ++ii)
        {
            if (atPCp[ii + 2 * dataSize] != idv)
            {
                Easy3D::E3DPoint p(atPCp[ii] * scale.X + offset.X, atPCp[ii + dataSize] * scale.Y + offset.Y, atPCp[ii
+ 2 * dataSize] * scale.Z + offset.Z);
                vector3DPoints.push_back(p);
            }
        }
        break;
    }
    case cx_pixel_format::CX_PF_COORD3D_ABC8:
    {
        for (unsigned y = 0; y < atPC.points.height(); y++)
        {
            Point3i8* row = atPC.points.row < Point3i8>(y);
            for (unsigned x = 0; x < atPC.points.width(); x++)
            {
                const Point3i8 atP = row[x];
                if (atP.z != idv)
                {
                    Easy3D::E3DPoint p(atP.x * scale.X + offset.X, atP.y * scale.Y + offset.Y, atP.z * scale.Z +
offset.Z);
                    vector3DPoints.push_back(p);
                }
            }
        }
        break;
    }
    case cx_pixel_format::CX_PF_COORD3D_ABC16:
    {
        for (unsigned y = 0; y < atPC.points.height(); y++)
        {
            Point3i16* row = atPC.points.row < Point3i16>(y);
            for (unsigned x = 0; x < atPC.points.width(); x++)
            {
                const Point3i16 atP = row[x];
                if (atP.z != idv)
                {
                    Easy3D::E3DPoint p(atP.x * scale.X + offset.X, atP.y * scale.Y + offset.Y, atP.z * scale.Z +
offset.Z);
                    vector3DPoints.push_back(p);
                }
            }
        }
    }
}
```



```

    }
    }
    }
    break;
}
case cx_pixel_format::CX_PF_COORD3D_ABC16_PLANAR:
{
    int16_t* atPCp = static_cast<int16_t*>(atPC.points.data());
    int dataSize = atPC.points.planePitch() / sizeof(int16_t);
    for (int ii = 0; ii < dataSize; ++ii)
    {
        if (atPCp[ii + 2 * dataSize] != idv)
        {
            Easy3D::E3DPoint p((float)atPCp[ii] * scale.X + offset.X, (float)atPCp[ii + dataSize] * scale.Y +
offset.Y, (float)atPCp[ii + 2 * dataSize] * scale.Z + offset.Z);
            vector3DPoints.push_back(p);
        }
    }
    break;
}
case cx_pixel_format::CX_PF_COORD3D_ABC32f:
{
    for (unsigned y = 0; y < atPC.points.height(); y++)
    {
        AT::cx::Point3f* row = atPC.points.row < AT::cx::Point3f>(y);
        for (unsigned x = 0; x < atPC.points.width(); x++)
        {
            const AT::cx::Point3f atP = row[x];
            if (!isnan(atP.z) && atP.z != idv)
            {
                Easy3D::E3DPoint p(atP.x * scale.X + offset.X, atP.y * scale.Y + offset.Y, atP.z * scale.Z +
offset.Z);
                vector3DPoints.push_back(p);
            }
        }
    }
    break;
}
case cx_pixel_format::CX_PF_COORD3D_ABC32f_PLANAR:
{
    float* atPCp = static_cast<float*>(atPC.points.data());
    int dataSize = atPC.points.planePitch() / sizeof(float);
    for (int ii = 0; ii < dataSize; ++ii)
    {
        if (!isnan(atPCp[ii + 2 * dataSize]) && atPCp[ii + 2 * dataSize] != idv)
        {
            Easy3D::E3DPoint p(atPCp[ii] * scale.X + offset.X, atPCp[ii + dataSize] * scale.Y + offset.Y, atPCp[ii
+ 2 * dataSize] * scale.Z + offset.Z);
            vector3DPoints.push_back(p);
        }
    }
    break;
}
default:
{
    //need to convert or ordinate AT value
    throw std::exception("PointCloud format not supported");
    break;
}
}

ePC->AddPoints(vector3DPoints);

return ePC;

```

Converting an AT rectified map (ZMap) to Easy3D::EZMap

```
// Create an Open eVision EZMap depending on the format of the AT ZMap.
// The EZMap object must be explicitly released after usage.

Easy3D::EZMap* ZMapConversion(AT::cx::c3d::ZMap& atZmap, float idv)
{
    Easy3D::EZMap* eZmap = NULL;

    unsigned int width = atZmap.img.width();
    unsigned int height = atZmap.img.height();

    switch (atZmap.img.pixelFormat())
    {
    case cx_pixel_format::CX_PF_C00RD3D_C16:
    {
        Easy3D::EZMap16* eZmap16 = new Easy3D::EZMap16(width, height);
        int16_t Easy3DUndefinedValue = eZmap16->GetUndefinedValue().Value;

        for (unsigned int yy = 0; yy < height; ++yy)
        {
            int16_t* r = atZmap.img.row<int16_t>(yy);
            for (int xx = 0; xx < width; ++xx)
            {
                if (r[xx] == idv)
                    eZmap16->SetPixel(Easy3DUndefinedValue, xx, yy);
                else
                    eZmap16->SetPixel(r[xx], xx, yy);
            }
        }

        eZmap = eZmap16;
        break;
    }
    case cx_pixel_format::CX_PF_C00RD3D_C32f:
    {
        Easy3D::EZMap32f* eZmap32f = new Easy3D::EZMap32f(width, height);
        float Easy3DUndefinedValue = eZmap32f->GetUndefinedValue().Value;

        for (unsigned int yy = 0; yy < height; ++yy)
        {
            float* r = atZmap.img.row<float>(yy);
            for (int xx = 0; xx < width; ++xx)
            {
                if (r[xx] == idv)
                    eZmap32f->SetPixel(Easy3DUndefinedValue, xx, yy);
                else
                    eZmap32f->SetPixel(r[xx], xx, yy);
            }
        }

        eZmap = eZmap32f;
        break;
    }
    default:
        //need to convert or ordinate AT value
        throw std::exception("Zmap format not supported");
        break;
    }

    eZmap->SetResolution(atZmap.scale.x, atZmap.scale.y, atZmap.scale.z);

    return eZmap;
}
```