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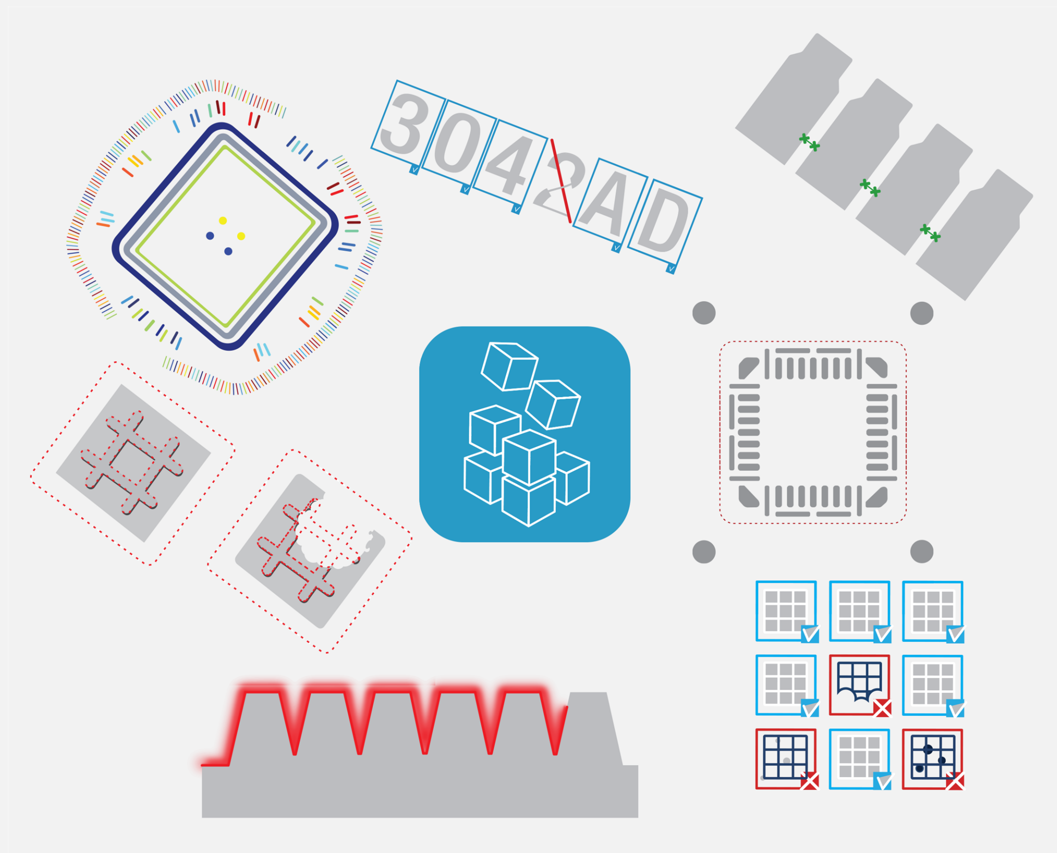
USER GUIDE

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 **cxSupportPackage** supports various operations on 2D and 3D structures, like the calibration of the laser triangulation setup.

The specifications are available on the manufacturer website:
`https://www.automationtechnology.de/cms/en/3d-laser-sensors-for-measurements-by-means-of-laser-triangulation/`

- This document explains how to use the 3D data coming from these sensors with Open eVision**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**Euresys** web site.

Resources

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

- C5-2040CS sensor, but the sample application is compatible with the entire C5 and MCS series.
- **AT** cxSupportPackage 2.5 RC3 64 bits
- **Open eVision** 2.12
- Microsoft Visual Studio 2017

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: □ 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: □ EDepthMap8 for unsigned 8-bit integer □ EDepthMap16 for unsigned 16-bit integer □ EDepthMap32f for 32-bit float.
cx::c3d::CPointCloud (CalibratedABC) Formats: □ 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**: □ A continuous buffer of E3DPoint.E3DPoint is a struct (x,y,z) with 3 floats.
cx::c3d::ZMap (Rectified) Formats : □ CX_PF_COORD3D_C16 □ CX_PF_COORD3D_C32f (preferred)	**Easy3D::EZMap** Formats: □ 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:

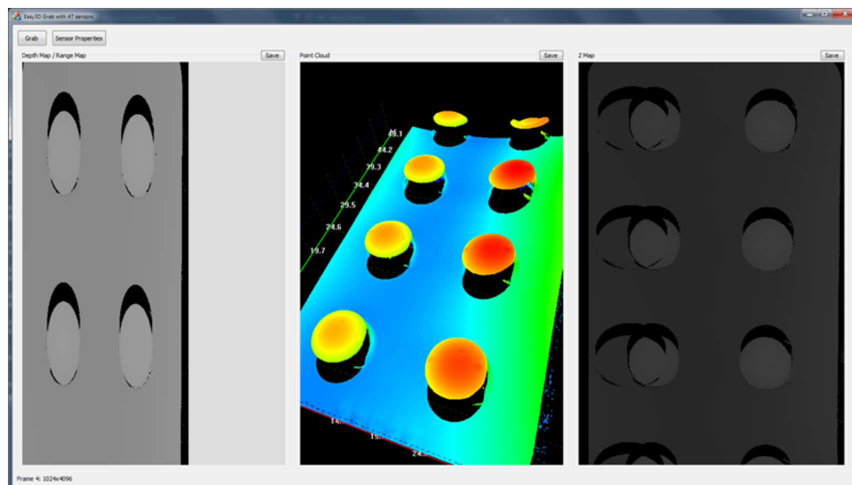
- `Easy3D::EDepthMap* DepthMapConvertion(const AT::cx::Image& atRangeMap)`
  - Create a EDepthMap8 or EDepthMap16 object depending on the format of the cx::Image.
  - For better efficiency, the data are not copied but referenced in the EDepthMap container.
- `Easy3D::EPointCloud* PointCloudConvection(const 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* ZMapConvertion(const AT::cx::c3d::ZMap& atZmap, float idv)`
  - Create a `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.

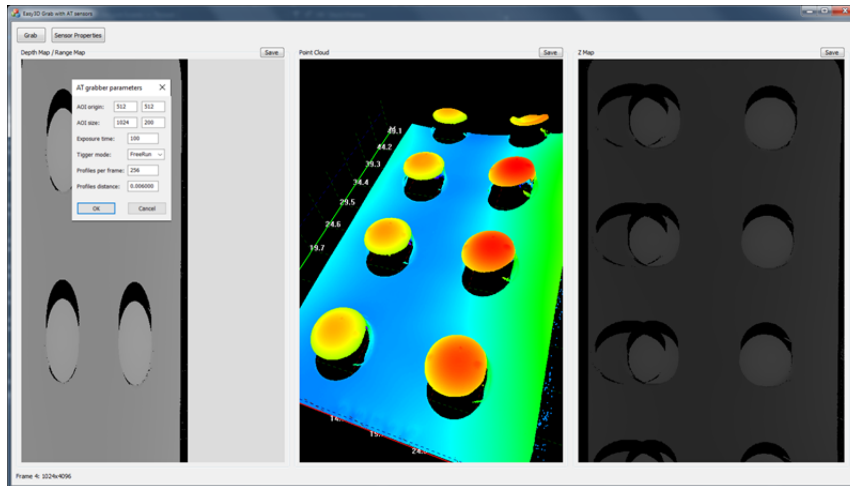
TIP
The **Easy3DGrab** sample application implements the acquisition and conversion for selected formats.

Easy3DGrab sample application

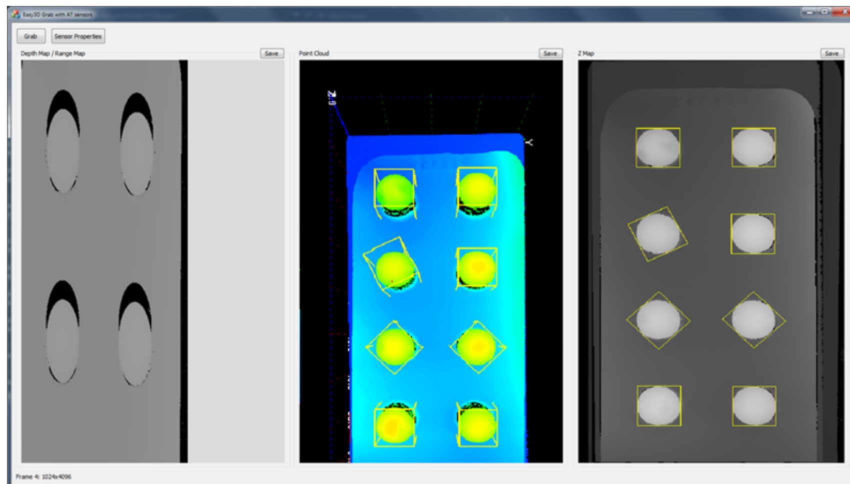
Easy3DGrab is distributed with C++ source code as an **Open eVision** additional resource.
- It features the acquisition of **AT** 3D data, the conversion to depth maps, point clouds and ZMaps.
- You can save these representations.
- Click on the Grab button to acquire a new image.
- Open the Sensor 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* DepthMapConvertion(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* ZMapConvertion(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_COORD3D_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_COORD3D_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;
}
```