Zebra
Aurora™ Vision

Aurora Vision Studio 5.3

Extensibility

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Creating User Filters

Note 1: Creating user filters requires C/C++ programming skills.

Note 2: With your own C/C++ code you can easily crash the entire application. We are not able to protect against that.

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Introduction

User filters are written in C/C++ and allow the advanced users to extend capabilities of Aurora Vision Studio with virtually no constraints. They can be used to support a new camera model, to communicate with external devices, to add application-specific image processing operations and more.

Prerequisites

To create a user filter you will need:

- an installed Microsoft Visual Studio 2015/2017/2019 for C++, Express Edition (free) or any higher edition,
- the environment variable `AVS_PROFESSIONAL_SDK5_3` in your system (depending on the edition; a proper value of the variable is set during the installation of Aurora Vision Studio),
- C/C++ programming skills.

User filters are grouped in user filter libraries. Every user filter library is a single .dll file built using Microsoft Visual Studio. It can contain one or more filters that can be used in programs developed with Aurora Vision Studio.

User Filter Libraries Location

There are two types of user filter libraries:

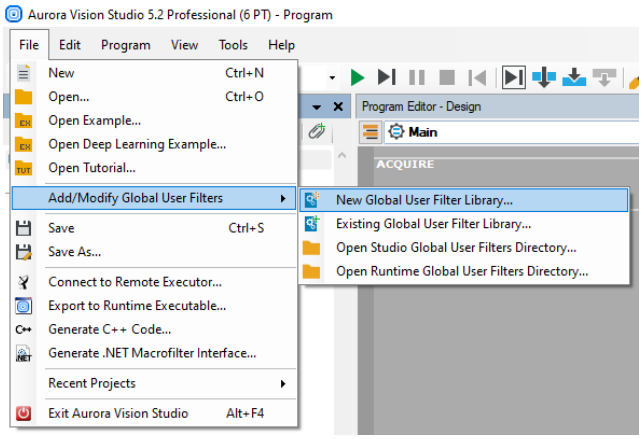
- **Global** – once created or imported to Aurora Vision Studio they can be used in all projects. The filters from such libraries are visible in the Libraries tab of the Toolbox.
- **Local** – belong to specific projects of Aurora Vision Studio. The filters from such libraries are visible only in the project that the library has been added to.

A solution (.sln file) of a global user filter library can be located in any location on your hard disk, but the default and recommended location is `Documents\Aurora Vision Studio 5.3 Professional\Sources\UserFilters` (the exact path can vary depending on the version of Aurora Vision Studio). The output .dll file built using Microsoft Visual Studio and containing global user filters has to be located in `Documents\Aurora Vision Studio 5.3 Professional\Filters\x64` (this time the exact path depends on the version and the edition) and this path is set in the initial settings of the generated Microsoft Visual Studio project. For global user filter libraries, this path must not be changed because Aurora Vision Studio monitors this directory for changes of the .dll files. The Global User Filter .dll file for Aurora Vision Executor has to be located in `Documents\Aurora Vision Studio 5.3 Runtime\Filters\x64` (again, the exact path depends on the version and edition). For 32 bit edition the last subdirectory should be changed from *x64* to *Win32*. The Local User Filter .dll file for Aurora Vision Executor has to be located in path configured in the User Filter properties. You can modify this path by editing user filters library properties in Project Explorer.

A local user filter library is a part of the project developed with Aurora Vision Studio and both source and output .dll files can be located anywhere on the hard drive. Use the Project Explorer task panel to check or modify paths to the output .dll and Microsoft Visual Studio solution files of the user filter library. The changes of the output .dll file are monitored by Aurora Vision Studio irrespectively of the file location. It's a good practice to keep the local user filter library sources (and the output .dll) relatively to the location of the developed project, for example in a subdirectory of the project.

Adding New Global User Filter Libraries

To add a new user filter library, start with *File » Add/Modify Global User Filters » New Global User Filter Library...*.



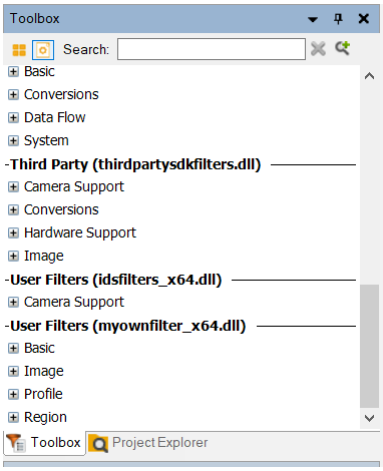
The other option is to use *Create New Local User Filter Library* button from Project Explorer panel.

A dialog box will appear where you should choose:

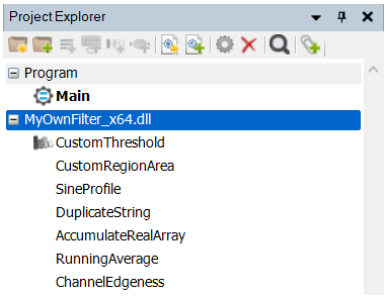
- name for the new library,
- type of the library: local (available in current project only) or global (available in all projects),
- location of the solution directory,
- version of Microsoft Visual Studio (2015, 2017 or 2019),
- whether Microsoft Visual Studio should be opened automatically,
- whether the code of example user filters should be added to the solution - good idea for users with less experience with user filters programming.

If you choose Microsoft Visual Studio to be opened, you can build this solution instantly. A new library of filters will be created and after a few seconds loaded to Aurora Vision Studio. Switch back to Aurora Vision Studio to see the new filters in:

- Appropriate categories of Libraries tab (global user filters, category in Libraries tab is based on the category set in filter code)



- Project Explorer (local user filters)

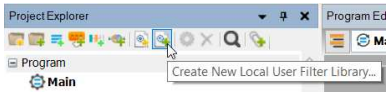


You can work simultaneously in both Microsoft Visual Studio and Aurora Vision Studio. Any time the C++ code is built, the filters will get reloaded. Just re-run your program in Aurora Vision Studio to see what has changed.

If you do not see your filters in the above-mentioned locations, make sure that they have been compiled correctly in an architecture compatible with your Aurora Vision Studio architecture: x86 (Win32) or x64.

Adding New Local User Filter Libraries

To add a new local user filter use the "Create New Local User Filter Library.." button in the Project Explorer panel as on the image below:



Developing User Filters

User Filter Project Configuration

User filter project files (.sln and .vcproj) are generated by Aurora Vision Studio during adding new user filter library.

The settings of user filter project are gathered in *.props* file available in *props* subdirectory of the Aurora Vision Studio SDK (environment variable `AVS_PROFESSIONAL_SDK5_3`), typically `C:\Program Files\Aurora Vision\Aurora Vision Studio 5.3 Professional\SDK\props`.

If you want to configure the existing project to be a valid user filter library, please use the proper *.props* file (file with *v140* suffix is dedicated for Microsoft Visual Studio 2015, *v141* for 2017 and *v142* for 2019).

Basic User Filter Example

Example below shows whole source code for basic user filter. In this example filter is making a simple threshold operation on an 8-bit image.

```
#include "UserFilter.h"
#include "AVL_Lite.h"

#include "UserFilterLibrary.hxx"

namespace avs
{
 // Example image processing filter
 class CustomThreshold : public UserFilter
 {
 private:
  // Non-trivial outputs must be defined as a filed to retain data after filter execution.
  avl::Image outImage;

 public:
  // Defines the inputs, the outputs and the filter metadata
  void Define() override
  {
   SetName  (L"CustomThreshold");
   SetCategory (L"Image::Image Thresholding");
   SetImage (L"CustomThreshold_16.png");
   SetImageBig (L"CustomThreshold_48.png");
   SetTip  (L"Binarizes 8-bit images");

   //      Name      Type    Default  Tool-tip
   AddInput    (L"inImage",    L"Image",    L"",  L"Input image"    );
   AddInput    (L"inThreshold",    L"Integer<0, 255>", L"128",  L"Threshold value");
   AddOutput    (L"outImage",    L"Image",      L"Output image"   );
  }

  // Computes output from input data
  int Invoke() override
  {
   // Get data from the inputs
   avl::Image inImage;
   int inThreshold;

   ReadInput(L"inImage", inImage);
   ReadInput(L"inThreshold", inThreshold);

   if (inImage.Type() != avl::PlainType::UInt8)
    throw atl::DomainError("Only uint8 pixel type are supported.");

   // Get image properties
   int height = inImage.Height();

   // Prepare output image in this same format as input
   outImage.Reset(inImage, atl::NIL);

   // Enumerate each row
   for (int y = 0; y < height; ++y)
   {
    // Get row pointers
    const atl::uint8* p = inImage.RowBegin<atl::uint8>(y);
    const atl::uint8* e = inImage.RowEnd<atl::uint8>(y);
    atl::uint8*       q = outImage.RowBegin<atl::uint8>(y);

    // Loop over the pixel components
    while (p < e)
    {
     (*q++) = (*p++) < inThreshold ? 0 : 255;
    }
   }

   // Set output data
   WriteOutput(L"outImage", outImage);

   // Continue program
   return INVOKE_NORMAL;
  }
 };

 // Builds the filter factory
 class RegisterUserObjects
 {
 public:
  RegisterUserObjects()
  {
   // Remember to register every filter exported by the user filter library
   RegisterFilter(CreateInstance<CustomThreshold>);
  }
 };

 static RegisterUserObjects registerUserObjects;
}
```

Structure of User Filter Class

A user filter is a class derived from the *UserFilter* class defined in *UserFilter.h* header file. When creating a filter without state you have to override two methods:

- **Define** – defines the interface of the filter, including its name, category, inputs and outputs.
- **Invoke** – defines the routine that transforms inputs into outputs.

When creating *a filter with state* (storing information from previous invocations) the class is going to have some data fields and two additional methods have to be overridden:

- **Init** – initializes the state variables, invoked at the beginning of a Task parenting the instance of the filter, may be invoked multiple times during filter instance lifetime. Always remember to invoke base type **Invoke()** method.
- **Stop** – deinitializes the state variables, including releasing of external and I/O resources (like file handles or network connections), may not affect data on filter outputs, invoked at the end of a Task parenting the filter instance (to pair every **Init** call).
- **Release** – releases output variables memory, invoked at the end of a Task macrofilters marked to release memory.

When a user filter class is created it has to be registered. This is done in the *RegisterUserObjects* function which is defined at the bottom of the sample user filters' code. You do not need to call it manually, it's called by Aurora Vision Studio while loading filters from the .dll file.

Structure of *Define* Method

Use the *Define* method to set the name, category, image (used as the icon of the filter) and tooltip for your filter. All of this can be set by using proper *Set...* methods.

The *Define* method should also contain a definition of the filter's external interface, which means: inputs, outputs and diagnostic outputs. The external interface should be defined using *AddInput*, *AddOutput* and *AddDiagnosticOutput* methods. These methods allow to define name, type and tooltip for every input/output of filter. For inputs a definition of the default value is also possible.

Aurora Vision Studio uses a set of additional attributes for ports. To apply attribute on a port use *AddAttribute* method. Example:

```
AddAttribute(L"ArraySync", L"inA inB");
```

List of attributes:

Attribute Name	Description	Example	Comment
ArraySync	Defines a set of synchronized ports.	`L"inA inB"`	Informs that arrays in inA and inB require the same number of elements.
UserLevel	Defines user level access to the filter.	`L"Advanced"`	Only users with Advanced level will find this filter in Libraries tab.
UsageTips	Defines additional documentation text.	`L"Use this filter for creating a line."`	This is instruction where this filter is needed.
AllowedSingleton	Filter can accept singleton connections on input	`L"inA"`	User can connect a single value to inA which has Array type.
FilterGroup	Defines element of filter group.	`L"FilterName<VariantName> default ## Description for group"`	Creates a FilterName with default element VariantName. More detailed description in "Defining Filters Groups"
Tags	Defines alternative names for this filter.	`L"DrawText DrawString PutText"`	When user types "DrawText" this filter will be in result list.
CustomHelpUrl	Defines alternative URL for this filter.	`L"http:\\adaptive-vision.com"`	When user press F1 in the Program Editor alternative help page will be opened.

Defining Filters Groups

Several filters can be grouped into a single group, which can be very helpful for user to change variant of very similar operations.

To create filter group define attribute L"FilterGroup" for default filter with parameters. **L"FilterName<VariantName> default ## Description for group"**. Notice "default" word. Text after "##" defines the tooltip for whole group.

If default filter is defined you can add another filter using L"FilterGroup" with parameter **L"FilterName<NextVariant>"**

Example usage:

```
// Default filter FindCircle -> Find: Circle
AddAttribute(L"FilterGroup", L"Find<Circle> default ## Finds an object on the image");
...

// Second variant FindRectangle -> Find: Rectangle
AddAttribute(L"FilterGroup", L"Find<Rectangle>");
...

// Third variant FindPolygon -> Find: Polygon
AddAttribute(L"FilterGroup", L"Find<Polygon>");
...
```

As result a filter group Find will be created with three variants: Circle, Rectangle, Polygon.

Using custom user filter icons

Using methods `SetImage` and `SetImageBig` user can assign a custom icon for user filter. Filter icon must be located in this same directory as output output user filter DLL file.

There are four types of icons:

- **Small Icon** - icon with size 16x16 pixels used in Libraries tab, set by `SetImage`, name should end with "_16"
- **Medium Icon** - icon of size 24x24 pixel, created automatically from Big Icon,
- **Big Icon** - icon of size 48x48 pixel, set by `SetImageBig`, name should end with "_48",
- **Description Icon** - icon of size 72x72 used in filter selection from group, name is created by replacing "_48" from `SetImageBig` by "_D". For given `SetImageBig` as "custom_48.png" a name "custom_D.png" will be generated.

Structure of *Invoke* Method

An *Invoke* method has to contain 3 elements:

1. **Reading data from inputs**

   To read the value passed to the filter input, use the *ReadInput* method. This is a template method supporting all Aurora Vision Studio data types. *ReadInput* method returns the value (by reference) using its second parameter.

2. **Computing output data from input data**

   It is the core part. Any computations can be done here

3. **Writing data to outputs**

   Similarly to reading, there is a method *WriteOutput* that should be used to set values returned from filter on filter outputs.

   Data types that don't contain blobs (i.e. *int*, *avl::Point2D*, *avl::Rectangle2D*) can be simply returned by passing the local variable to the *WriteOutput* method. Output variables with blobs (i.e. *avl::Image*, *avl::Region*) should be declared at least in a class scope.

```
class MyOwnFilter : public UserFilter
{
 int Invoke()
 {
  int length;
  // ... computing the length value...
  WriteOutput("outLength", length);
 }

 // ...
}
```

   All non-trivial data types like Image, Region or ByteBuffer should be defined as a filter class filed.

   This solution has two benefits:

   1. Reduces performance overhead for creating new objects in each filter execution,
   2. Assures that types which contains blobs are not released after the filter execution.

   For the sake of clarity it is good habit to define all filter variables as class members.

```
class MyOwnFilter : public UserFilter
{
 private:
          // Non-trivial type data
  avl::Image image;

 int Invoke()
 {
  // ... computing image ...
  WriteOutput("outImage", image);
 }

 // ...
}
```

Invoke has to return one of the four possible values:

- **INVOKE_ERROR** - when something went wrong and program cannot be continued.
- **INVOKE_NORMAL** - when everything is OK and the filter can be invoked again.
- **INVOKE_LOOP** - when everything is OK and the filter requests more iterations.
- **INVOKE_END** - when everything is OK and the filter requests to stop the current loop.

For example the filter ReadVideo returns **INVOKE_LOOP** whenever a new frame is successfully read and **INVOKE_END** when there is the end. **INVOKE_NORMAL** is returned by filters that do not have any influence on the current loop continuation or exiting (for example ThresholdImage).

All filter outputs should be assigned by WriteOutput before filters return status. Missing assigned may result random data access in complex program structure. On INVOKE_END result filter should set up output values as last iterations of filter.

In case of error also exceptions can be thrown. User *atl::DomainError* for signaling problems connected with input data. All hardware problems should be signaled using *atl::IoError*. For more information please read Error Handling

Using Arrays

User filters can process not only single data objects, but also arrays of them. In Aurora Vision Studio, arrays are represented by data types with suffix *Array* (i.e. IntegerArray, ImageArray, RegionArrayArray). Multiple *Array* suffixes are used for multidimensional arrays. In C++ code of user filters, *atl::Array<T>* container is used for storing objects in arrays:

```
atl::Array< int > integers;
atl::Array< avl::Image > images;
atl::Array< atl::Array< avl::Region > > regions2Dim;
```

For more information about types from *atl* and *avl* namespaces, please refer the documentation of *Aurora Vision Library*.

Diagnostic Mode Execution and Diagnostic Outputs

User filters can have diagnostic outputs. Diagnostic outputs can be helpful during developing programs in Aurora Vision Studio. The main purpose of this feature is to allow the user to view diagnostic data on the Data Previews, but they can also participate in the data flow and can be connected to an input of any filter. This type of connection is called a diagnostic connection and makes the destination filter to be executed in the *Diagnostic* mode (filter will be invoked only in the *Diagnostic* mode of program execution).

When a program is executed in the *Non-Diagnostic* mode, values of the diagnostic outputs shouldn't be (for performance purposes) computed by any filter. In user filters, you should use the **IsDiagnosticMode()** method for conditional computation of the data generated by your filter for diagnostic outputs. If the method returns *True*, execution is in the *Diagnostic* mode and values of the diagnostic outputs should be computed, otherwise, the execution is in the *Non-Diagnostic* mode and your filter shouldn't compute such values.

Filter Work Cancellation

Aurora Vision Studio allows to stop execution of each filter during the time consuming computations. To use this option function **IsWorkCancelled()** can be used. If function returns value *True* the long computation should be finished because user pressed the "Stop" button.

Using Dependent DLL

User filter libraries are often created as wrappers of third party libraries, e.g. of APIs for some specific hardware. These libraries often come in the form of DLL files. For a user filter to work properly, the other DLL files must be located in an accessible disk location at runtime, or the user gets the error code 126, *The specified module could not be found*. MSDN documentation specifies possible options in the article Dynamic-Link Library Search Order. From the point of view of user filters in Aurora Vision Studio, the most typical option is the one related to changing the PATH environment variable – almost all camera manufacturers follow this way. For local user filters it is also allowed to add dependent dll in the same directory as the user filter dll directory.

Alternatively, it is possible to create a new directory for a global user filter library: `Documents\Aurora Vision Studio 5.3 Runtime\Filters\Deps_x64`, after which the user filter's dependent DLL files can be stored inside of it.

Advanced Topics

Using the Full Version of AVL

By default, user filters are based on *Aurora Vision Library Lite* library, which is a free edition of Aurora Vision Library Professional. It contains data types and basic functions from the 'full' edition of Aurora Vision Library. Please refer to the documentation of Aurora Vision Library Lite and Aurora Vision Library Professional to learn more about their features and capabilities.

If you have bought a license for the 'full' Aurora Vision Library, you can use it in user filters instead of the Lite edition. The following steps are required:

- In compiler settings of the project, add additional include directory `$(AVL_PATH5_3)\include` (*Configuration Properties* | *C/C++* | *General* | *Additional Include Directories*).
- In linker settings of the project, add new additional library directory `$(AVL_PATH5_3)\lib\$(Platform)` (*Configuration Properties* | *Linker* | *General* | *Additional Library Directories*).
- In linker settings of the project, replace `AVL_Lite.lib` additional dependency with `AVL.lib` (*Configuration Properties* | *Linker* | *Input* | *Additional Dependencies*).
- In source code file, change including `AVL_Lite.h` to `AVL.h`.

Accessing Console from User Filter

It is possible to add messages to the console of Aurora Vision Studio from within the *Invoke* method. Logging messages can be used for problems visualization, but also for debugging. To add the message, use one of the following functions:

```
bool LogInfo   (const atl::String& message);
bool LogWarning(const atl::String& message);
bool LogError  (const atl::String& message);
bool LogFatal  (const atl::String& message);
```

Generic User Filters

Generic filters are filters that do not have a strictly defined type of the data they process. Generic filters have to be concretized with a data type before they can be used. There are many generic filters provided with Aurora Vision Studio (i.e. ArraySize) and user filters can be generic as well.

To create a generic user filter, you need to define one or more ports of the user filters as generic. In the call of *AddInput* method the second parameter (data type) has to contain < *T* >. Example usage:

```
AddInput ("inArray", "<T>Array", "", "Input array");
AddInput ("inObject", "<T>", "", "Object of any type");
```

In the *Invoke* method of a user filter, the *GetTypeParam* function can be used to resolve the data type that the filter has been concretized with. Once the data type is known, the data can be properly processed using the *if-else* statement. Please see the example below.

```
atl::String type = GetTypeParam(); // Getting type of generic instantiation as string.
int arrayByteSize = -1;

if (type == "Integer")
{
    atl::Array< int > ints = GetInputArray< int >("inArray");
    arrayByteSize = ints.Size() * sizeof(int);
}
else if (type == "Image")
{
    atl::Array< avs::Image > images = GetInputArray< avs::Image >("inArray");
    arrayByteSize = 0;
    for (int i = 0; i <  images.Size(); ++i)
        arrayByteSize += images[i].pitch * images[i].height;
}
```

Creating User Types in User Filters

When creating a User Filter add to the project an AVTYPE file with a user types description. The file should contain type descriptions in a format the same like the one used for creating User Types in a program. See Creating User Types. Sample user type description file:

```
enum PartType
{
 Nut
 Bolt
 Screw
 Hook
 Fastener
}

struct Part
{
 String  Name
 Real Width
 Real Height
 Real Tolerance
}
```

In your C++ code declare structures/enums with the same field types, names and order. If you create an enum then you can start using this type in your project instantly. For structures you must provide *ReadData* and *WriteData* functions overrides for serialization and deserialization.

In these functions you should serialize/deserialize all fields of your structure in the same order you declared them in the type definition file.

To support structure *Part* from the previous example in your source code you should add:

Structure declaration:

```
struct Part
{
 atl::String  Name;
 float   Width;
 float   Height;
 float   Tolerance;
};
```

Structure deserialization function:

```
void ReadData(atl::BinaryReader& reader, Part& outPart)
{
 ReadData(reader, outPart.Name);
 ReadData(reader, outPart.Width);
 ReadData(reader, outPart.Height);
 ReadData(reader, outPart.Tolerance);
}
```

Structure serialization function:

```
void WriteData(atl::BinaryWriter& writer, const Part& inValue)
{
 WriteData(writer, inValue.Name);
 WriteData(writer, inValue.Width);
 WriteData(writer, inValue.Height);
 WriteData(writer, inValue.Tolerance);
}
```

Enum declaration:

```
enum PartType
{
 Nut,
 Bolt,
 Screw,
 Hook,
 Fastener
};
```

It is not required for custom serialization / deserialization of enum types.

The file with user type definitions has to be registered. This is done in the *RegisterUserObjects* class constructor which is defined at the bottom of the user filter code. You need to add there a registration of your file as *RegisterTypeDefinitionFile("fileName.avtype")*. The file name is a path to your type definitions file. The path should be absolute or relative to the User Filter dll file.

You can use types defined in a User Filter library in this User Filters library as well as in all other modules of the project. If you want to use the same type in multiple User Filters libraries then you should declare these types in each User Filters library.

The following Example Program: "User Filter With User Defined Types" demonstrates usage of User Types in User Filters.

Troubleshooting and Examples

Upgrading User Filters to Newer Versions of Aurora Vision Studio

When upgrading project with User Filters to more recent version of Aurora Vision you should manually edit the User Filter vcxproj file in your favorite text editor e.g. notepad. Make sure to close the solution file in Microsoft Visual Studio before performing the modifications. In this file you should change all occurrences of *AVS_PROFESSIONAL_SDKxx* (where is xx is your current version of Aurora Vision) to `AVS_PROFESSIONAL_SDK5_3`, save your changes and rebuild the project.

After successful build you can use your User Filter library in the new version of Aurora Vision.

During compilation you can receive some errors if you use in your code function which has changed its interface. In such case, please refer the documentation and release notes to find out how the function was changed in the current version.

Remarks

- If you get problems with PDB files being locked, kill the *mspdbsrv.exe* process using Windows Task Manager. It is a known issue in Microsoft Visual Studio. You can also switch to use the *Release* configuration instead.
- User filters can be debugged. See Debugging User Filters.
- A user filter library (in .dll file) that has been built using SDK from one version of Aurora Vision Studio is not always compatible with other versions. If you want to use the user filter library with a different version, it may be required to rebuild the library.
- If you use Aurora Vision Library ('full' edition) in user filters, Aurora Vision Library and Aurora Vision Studio should be in the same version.
- A solution of a user filter library can be generated with example filters. If you're a beginner in writing your own filters, it's probably a good idea to study these examples.
- Only compiling your library in the release configuration lets you use it on other computer units. You cannot do so if you use a debug configuration.

Example: Image Acquisition from IDS Cameras

One of the most common uses of user filters is for communication with hardware, which does not (fully) support the standard GenICam industrial interface. Aurora Vision Studio comes with a ready example of such a user filter – for image acquisition from cameras manufactured by the IDS company. You can use this example as a reference when implementing support for your specific hardware.

The source code is located in the directory:

```
%PUBLIC%\Documents\Aurora Vision Studio 5.3 Professional\Sources\UserFilters\IDS
```

Here is a list of the most important classes in the code:

- **CameraManager** – a singleton managing all connections with the IDS device drivers.
- **IDSCamera** – a manager of a single image acquisition stream. It will be shared by multiple filters connected to the same device.
- **IDS_BaseClass** – a common base class for all user filter classes.
- **IDS_GrabImage**, **IDS_GrabImage_WithTimeout**, **IDS_StartAcquisition** – the classes of individual user filters.

The CameraManager constructor checks if an appropriate camera vendor's dll file is present in the system. The user filter project loads the library with the option of Delay-Loaded DLL turned on to correctly handle the case when the file is missing.

Requirement: To use the user filters for IDS cameras you need to install IDS Software Suite, which can be downloaded from IDS web page.

After the project is built in the appropriate Win32/x64 configuration, you will get the (global) user filters loaded to Aurora Vision Studio automatically. They will appear in the Libraries tab of the Toolbox, "User Filters" section.

Example: Using PCL library in Aurora Vision Studio

This example shows how to use PCL in an user filter.

The source code is located in the directory:

```
%PUBLIC%\Documents\Aurora Vision Studio 5.3 Professional\Sources\UserFilters\PCL
```

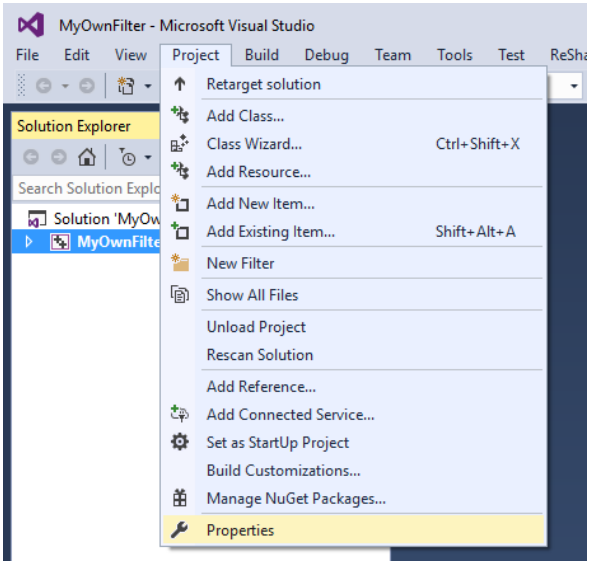
To run this example PCL Library must be installed and system PCL_ROOT must be defined.

Debugging User Filters

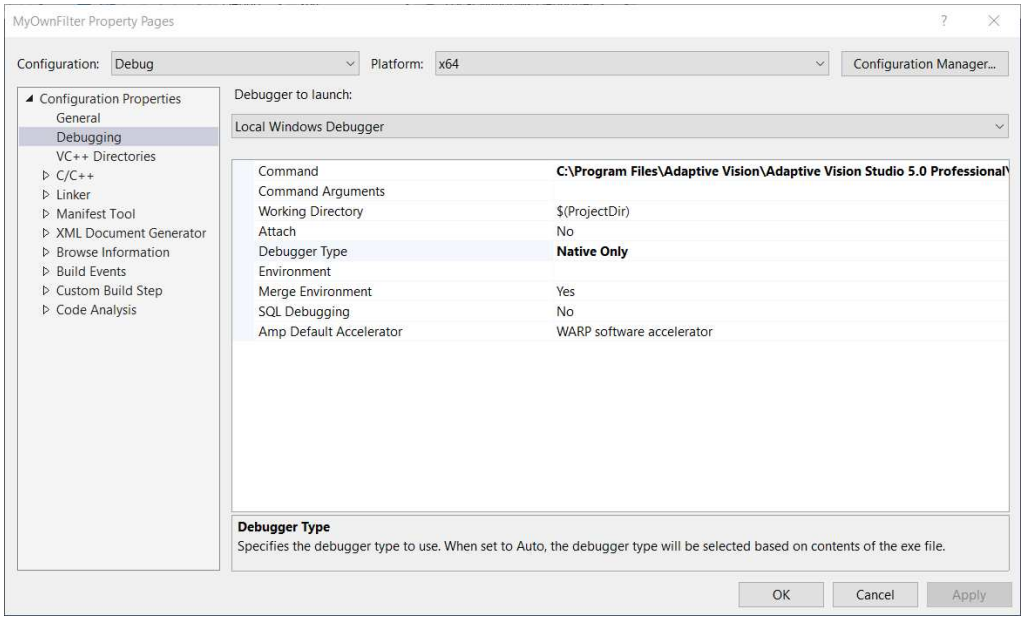
Debugging User Filters with Aurora Vision Studio Running

To debug your user filters, follow the instructions below:

1. If the Microsoft Visual Studio solution of your user filter library is not opened, open it manually. For global user filters it is typically located in *My Documents\Aurora Vision Studio Professional\Sources\LibraryName*, but can be located in any other location that you have chosen while creating the library. For local user filters, you can check the location of the solution file in the Project Explorer task pane.
2. Make sure that Aurora Vision Studio is not running.
3. Select *Debug* configuration.
4. Go to the project properties:



5. Go to *Debugging* section:

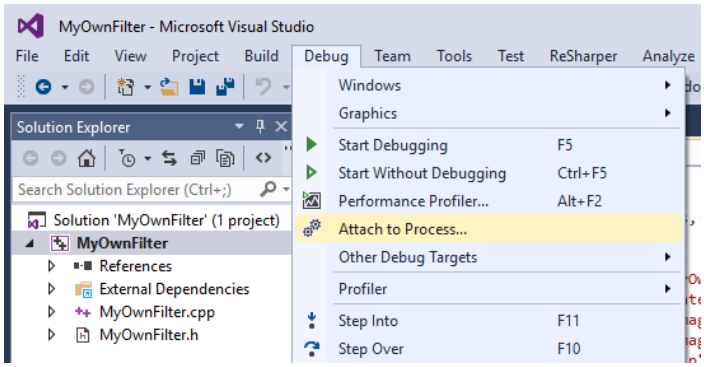


6. Set *Command* to the executable of Aurora Vision Studio.
7. Set *Debugger Type* to *Native Only*.
8. Set a breakpoint in your code.
9. Launch debugging by clicking *F5*.
10. Have your filter executed in Aurora Vision Studio. At this point it should get you into the debugging session.

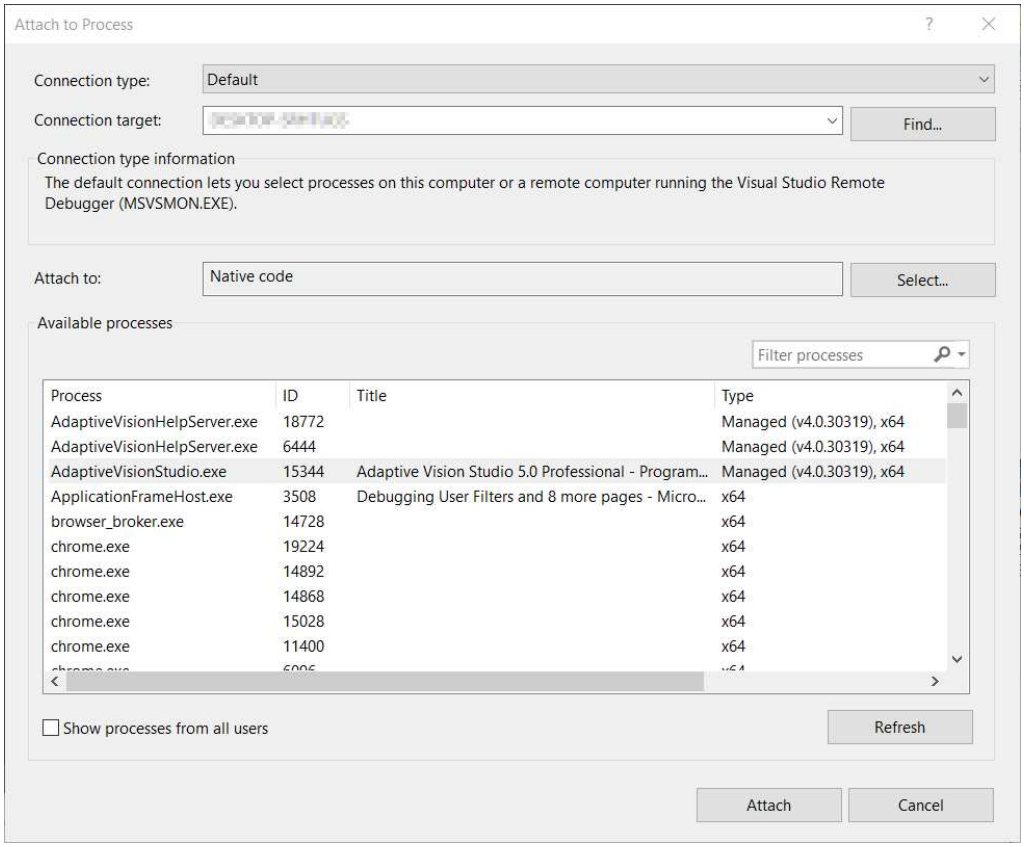
Debugging User Filters by attaching to Aurora Vision Studio process

You can attach the Microsoft Visual Studio debugger to a running process. Follow the instructions below:

1. Run Aurora Vision Studio and load your project.
2. Load solution of the User Filter in Microsoft Visual Studio.
3. From the *Debug* menu, choose *Attach to Process*.



4. In the *Attach to Process* dialog box, find AuroraVisionStudio.exe process from the *Available Processes* list.
5. In the *Attach to* box, make sure *Native code* option is selected.



6. Press *Attach* button.
7. Set a breakpoint in your code.
8. Have your filter executed in Aurora Vision Studio. At this point it should get you into the debugging session.

Debugging Tips

- User filters have access to the Console window of Aurora Vision Studio. It can be helpful during debugging user filters. To write on the Console, please use one of the functions below:
  - ```
    bool LogInfo (const atl::String& message);
    ```
  - ```
    bool LogWarning (const atl::String&amp; message);
    ```
  - ```
    bool LogError (const atl::String& message);
    ```

  Functions are declared (indirectly) in the *UserFilter.h* header file that should be used in every file with user filters source code.
- To write messages on the Output window of the Microsoft Visual Studio, please use standard *OutputDebugString* function (declared in *Windows.h*).
    ```

Creating User Types

In Aurora Vision Studio it is possible for the user to create custom types of data. This can be especially useful when it is needed to pass multiple parameters conveniently throughout your application or when creating User Filters.

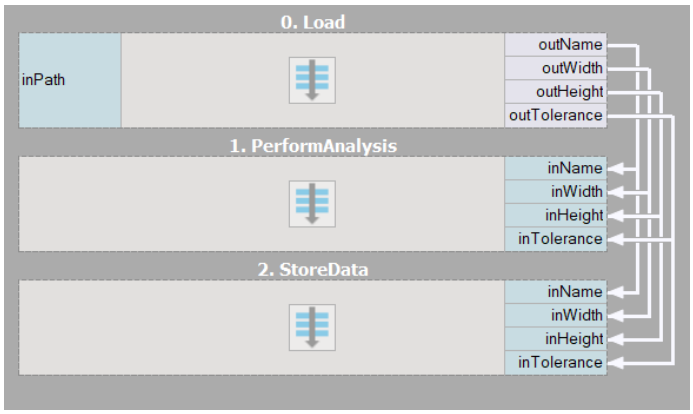
The user can define a structure with named fields of specified type as well as his own enumeration types (depicting several fixed options).

For example, the user can define a structure which contains such parameters as: *width, height, value* and *position* in a single place. Also, the user can define named program states by defining an enumeration type with options: *Start, Stop, Error, Pause,* etc.

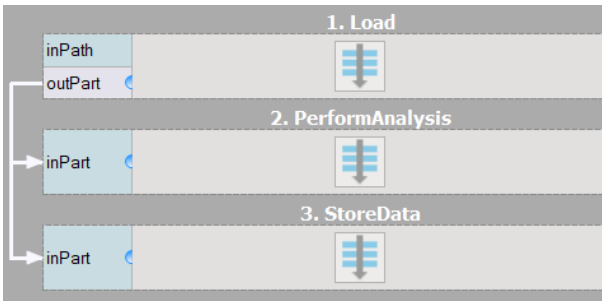
Usage

In an example project information such as: part name, part width, part height and its tolerance is needed for checking product quality. All this data elements must be accessed during image analysis.

This problem can be solved without user defined types, but creating a lot of connections can make the program structure too complex. The pictures below show a comparison between working with a user's structure and passing multiple values as separate parameters.



A solution without user types – more connections, less readable.

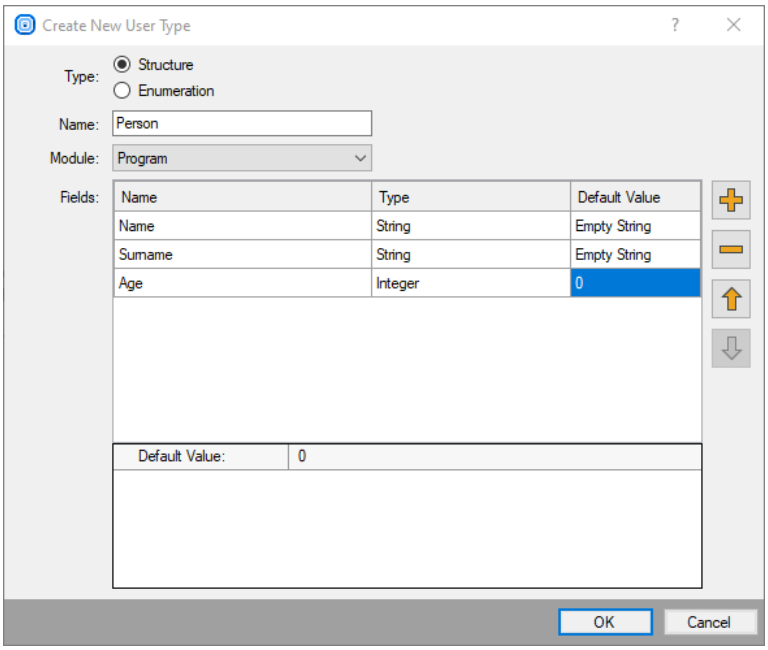


A solution with user types – fewer connections, more readable.

Creating User Types in a Program

User types are created with a graphical editor available through the Project Explorer window.

Use this icon to open the graphical editor.

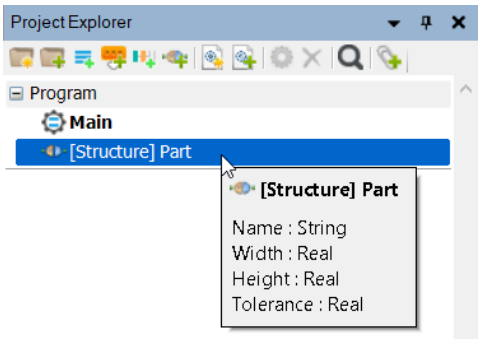


Graphical user type editor.

Alternatively, you can save your project, open the main AVCODE file (e.g. with Notepad++) and at the beginning of the file enter a type declaration:

```
struct Part
{
 String  Name
 Real Width
 Real Height
 Real Tolerance
}
```

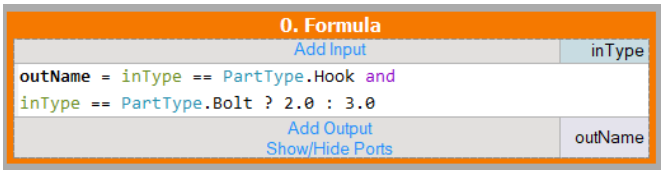
Save your file and reload the project. Now the newly created type can be used as any other type in Aurora Vision Studio.



After reloading the project the custom made type is available in Aurora Vision Studio.

Also custom enumeration types can be added this way. To create a custom enumeration type add the code below to the top of your AVCODE file.

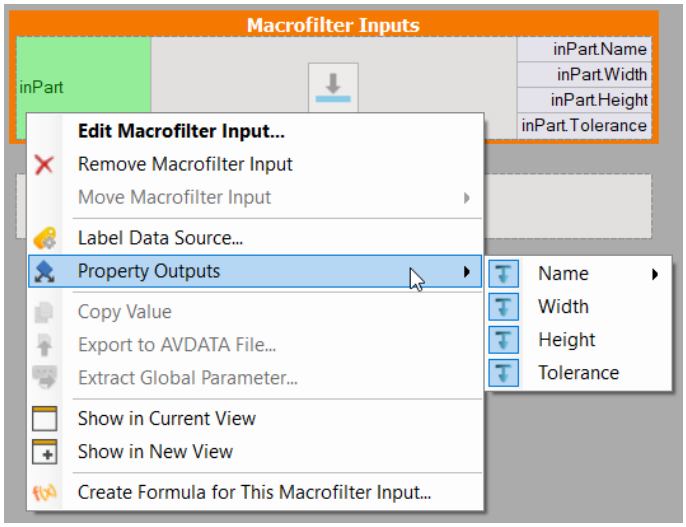
```
enum PartType
{
 Nut
 Bolt
 Screw
 Hook
 Fastener
}
```



Custom enumeration types can be used like other types.

Accessing Structure Fields

To access information contained in a user structure its fields must be expanded. The picture below shows how to expand a type on an input of a macrofilter.

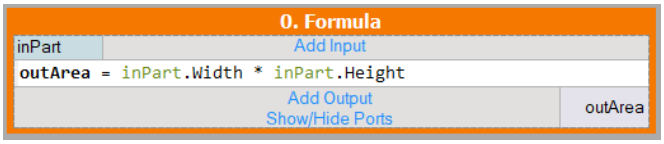


User type fields expanded on a macrofilter's inputs.

User type objects can be created with the CopyObject filter.

User type fields expanded on the CopyObject input.

User defined types can also be accessed with formulas.



Computation using the user defined type.

Saving User Types

User defined types work in Aurora Vision Studio, so filters such SaveObject, WriteToString, WriteToXmlNode or Tcplp_WriteObject can be used to store and transfer user data.

Related Program Examples

User defined types can be studied in the following Program Examples: Brick Destroy, User Defined Types, User Filter With User Defined Types.

Zebra
Aurora™ Vision

This article is valid for version 5.3.4