Laboratory automation solution with USB and GigE industrial cameras from IDS

Higher throughput

Laboratories are increasingly required to deliver scientific findings faster and more easily than before, while simultaneously reducing costs and labor. There is a growing need for automated solutions, and the constantly increasing numbers of specimens and simultaneous drive to shorten process times are making robot-based analysis increasingly attractive in bio-analysis technology. This is also the case when it comes to automating high throughput processes. The Karlsruhe Institute for Technology (KIT) has developed a modular laboratory robot system to perform monotonous manual activities. The detection and analysis work normally carried out by humans is performed by IDS industrial cameras combined with LabView and state of the art machine vision technology.

High-throughput processes are hugely important in bio-analysis technology. They play a role in decoding biological processes and their control mechanisms, in toxicological analyses as part of drug approval processes, and in analysis of substances for harmfulness. These processes all involve a sequence of individual activities to be carried out in turn. Normally, the specimens are prepared in analysis vessels at the beginning of the analysis. The actual analysis is then carried out by adding substances or exposure to chemical or physical influences that trigger a reaction in the specimens. The specimens are then inspected, and there is a final analysis of the processes.

The specimens used are mainly model organisms such as zebrafish. The embryos of this 5 cm long fish have a range of characteristics that make them ideal as model organisms.

They are not expensive to keep, they regularly lay a large quantity of eggs, they develop outside the mother, they are transparent, and they are large enough to perform a range of classic biological experiments on. Findings obtained can easily be applied to humans.

Current studies involving zebrafish, as with other model organisms, have a very limited throughput due to the number of operations to be carried out manually. As a result, there is demand for automation solutions for biological analyses that will contribute to increasing efficiency and simultaneously cutting costs. As part of a development project at the Karlsruhe Institute for Technology (KIT), Dr. Alexander Pfriem came up with a new concept for a fully automatic high throughput analysis involving zebrafish, which completely eliminates manual interventions and significantly increases throughput.

The embryos of the zebrafish have a range of characteristics that make them ideal as model organisms.

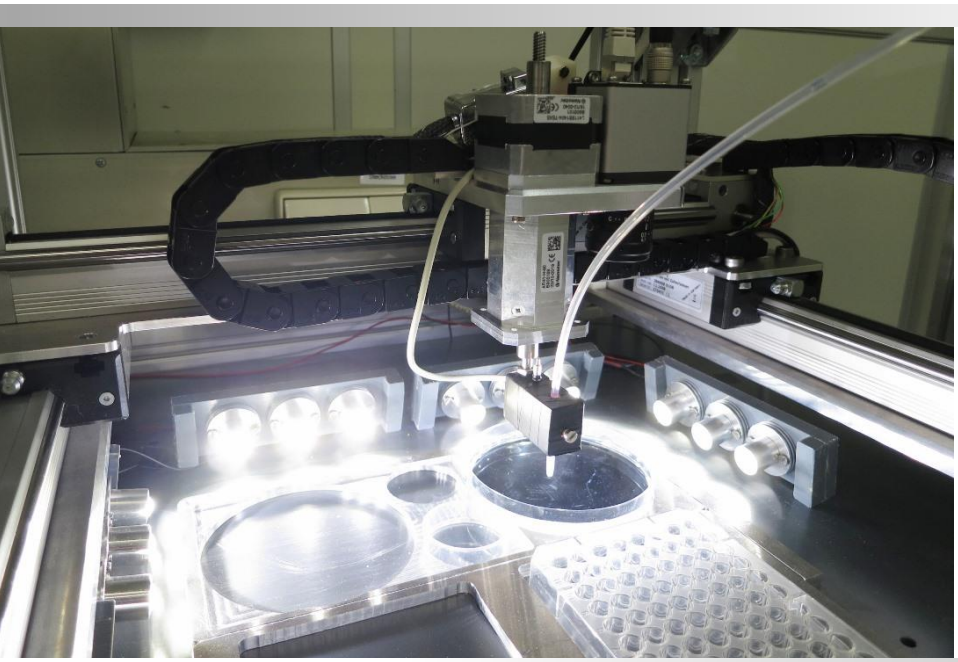
In his modular system concept, the sub-processes of the analysis are automated using four laboratory robots. Depending on the analysis method, these stations can be used as a stand alone solution or combined as required. The individual stations are linked by a transport system that transfers microplates from one robot to another. These plastic plates contain isolated chambers that hold the specimens. The automatic operation of the process chain is made possible by high performance cameras and corresponding machine vision software. Detection and analysis operations, such as evaluation and assessment of specimen conditions, no longer have to be performed by laboratory staff, which takes a long time.

The system uses industrial cameras from the SE series with a USB or GigE connection from IDS. The cameras in this series are genuine all-rounders: small, compact and robust, and available with a wide range of sensors and resolutions.

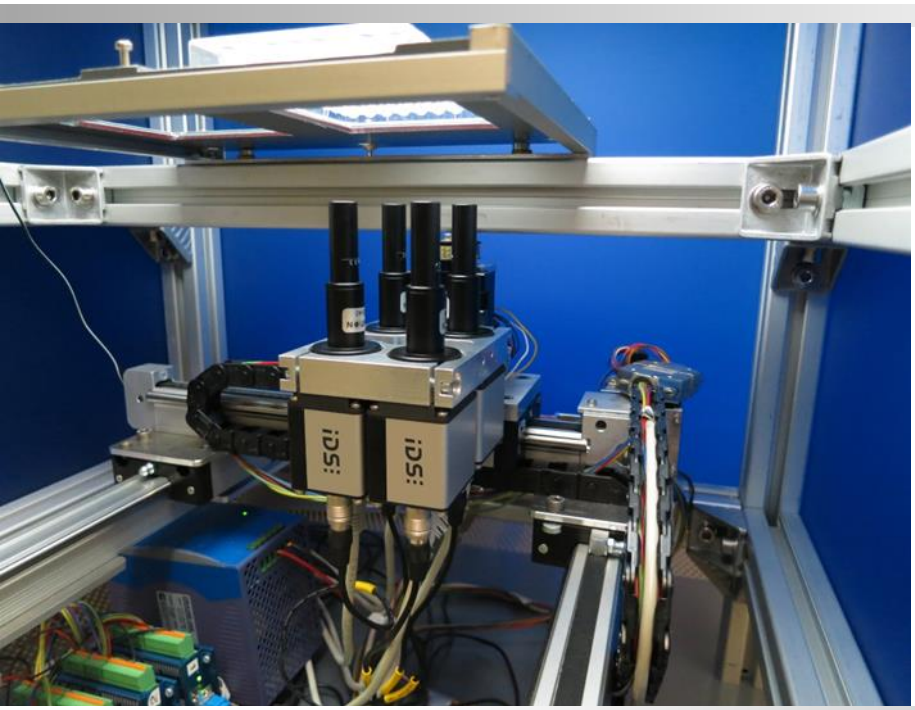
Because the camera housings have a screw-on fitting, they can be easily fitted almost anywhere. In addition to the screw-on RJ45 connector, they have a 6-pin Hirose connection for the power supply and digital inputs/outputs for trigger and flash control. These are optically decoupled and can process signals up to 30 V, making the models ideal for use in automation.

Dr. Alexander Pfriem summarizes the requirements for his particular application: “The cameras need to be compact so that they can be used in very tight spaces in the gantry robots. When used with the appropriate lenses, the resolution must be able to reproduce very small structures of 0.3 to 3 mm in sufficient detail at a working distance of just 5 to 15 cm.”

The automated analysis begins with a fish sorter. This involves transferring fish larvae randomly distributed in a petri dish into a microplate using a pipette. This is captured by a camera. The images are captured by the UI-5480SE industrial camera model from IDS.



Fish sorter in research lab



Parallel microscope with four compact GigE industrial cameras

This camera has a Gigabit Ethernet interface and is equipped with an ON Semiconductor CMOS sensor with 5 megapixel resolution.

The microplate is then transferred to the next station, where further analyses can be performed automatically. A parallel microscope, a heartbeat microscope, and a fluorescence module are available. On the parallel microscope, four cameras capture the fish larvae in the chambers of the microplate, enabling an exceptionally fast preliminary analysis to be carried out with a large number of specimens.

The UI-6240SE type cameras – also with a GigE interface – have a resolution of 1.3 megapixels (1280 x 1024 pixels). “The parallel microscope and the four cameras allow a large number of microplates to be captured quickly using single images or image sequences”, says Pfriem, outlining the key benefits of the station. “The module requires around 30 seconds to capture 96 images – all 96 chambers on a microplate. Conventional high resolution laboratory microscopes take over two minutes, and also generate an unnecessarily large volume of data.”

The subsequent heartbeat microscope is equipped with two UI-5480SE GigE cameras. The first camera captures a chamber of the microplate containing the fish larva. The machine vision system determines the position of the fish larva’s heart.

The second camera is positioned precisely underneath the fish larva and produces a sequence of significantly enlarged images to capture the heartbeat. Once again, considerable efficiency gains are achieved here. Manually aligning 96 larvae to capture individual short videos generally takes several hours. By comparison, according to Dr. Alexander Pfriem the heartbeat microscope needs just 18 minutes to produce the sequences of six images per chamber for all 96 chambers on the microplate.

The fluorescence module selects specific zebrafish with a particular fluorescence emission pattern. Thanks to the exceptional light sensitivity of the 1.3 megapixel CMOS sensor from e2V, the compact USB 2.0 version of the SE camera series is used. To reduce the data volume, only gray scale images are imported from the cameras.

State of the art machine vision software extracts the required information from the images and decides on the subsequent process based on its algorithms. Image analysis is carried out with the well-known standard software LabView, which is also used to control the robots. The industrial cameras are connected using a plug-in specially developed by IDS for LabView.

This plug-in includes a collection of “virtual instruments”, which enable the cameras to be easily configured and incorporated into the LabView programming. The LabVIEW Vision Development Module is ideal for convenient development of image recognition and machine vision applications and includes a library of powerful functions. This allows more complex evaluations of image material to be carried out.

Image supplied by a camera on the heartbeat microscope enables the position of the fish larva’s heart to be determined using image analysis

The new concept for an automatic process chain based on robot systems contains a total of eight IDS industrial cameras. They support imaging analysis in this automated, modular laboratory robot system by capturing images more easily and quickly. This increases the throughput of imaging laboratory analysis, improves efficiency, and cuts costs.

Client:

Karlsruher Institute for Technologie (KIT), Dr.-Ing. Alexander Pfriem

USB 2 uEye SE – particularly powerful, sensitive sensor with outstanding sensity

Interface:	USB 2.0
Model:	UI-1240SE
Sensor type:	CMOS
Manufacturer:	e2v
Frame rate:	25.8 fps
Resolution:	1280 x 1024 Px
Shutter:	Global Shutter, Global Start Shutter, Rolling Shutter
Optical class:	1/1.8”
Dimensions:	34 x 32 x 41,3 mm
Mass:	65 g
Connector:	USB 2.0 Mini-B, screwable

GigE uEye SE - All-round camera, broad sensor portfolio, many different versions, special sensor seal

Interface:	GigE
Model:	UI-5480SE
Sensor type:	CMOS
Manufacturer:	ON Semiconductor
Frame rate:	14.1 fps
Resolution:	2560 x 1920 Px
Shutter:	Global Start Shutter, Rolling Shutter
Optical class:	1/2”
Dimensions:	34 x 44 x 49,8 mm
Mass:	102 g
Connector:	GigE RJ45, screwable