Gocator 2340 Evaluation

This document gives our evaluation of the Gocator 2340. It is based on evaluation of the sensor performed by Stiftelsen Adopticum in a project financed by Kempestiftelserna. For more information about the sensor, please feel free to contact Adopticum.

Introduction

This is a document summarizing properties of the Gocator 2340 laser triangulation smart sensor. The manual for the sensor includes technical data and information (see Software below).

This document, however, focuses on information acquired from our testing with a sensor available and analysing properties of interest. The goal is to make it clearer what kind of measurement cases this sensor would be useful for.

Equipment

The equipment used during testing was:

- Gocator 2340 (to be evaluated), with power and connector (rare/specific) cables from LMI Technologies (sent from Stemmer Imaging).
- Adopticum's conveyor belt.
- Incremental encoder (attached to the conveyor belt). The conveyor belt moving distance and encoder ticks are related as: 0.015152 mm/ticks.
- Test objects for measurement accuracy testing:
    - Checkerboard:
        - Square_size: 23 mm x 23 mm
        - Number of square: 10*7
    - Lego shape (see Figure 1 below).
- Laptop with USB-LAN-port-cable.

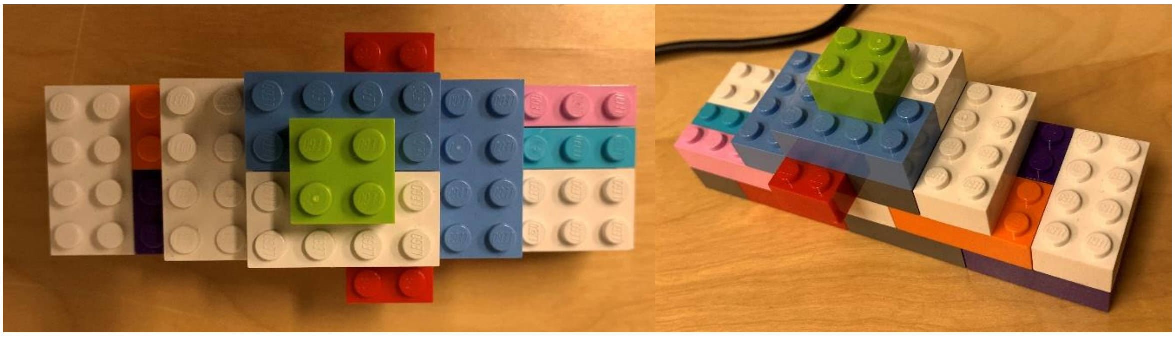

Figure 1: Lego shape used for creating a specific shape with building blocks with a set standardized size.

Software

A web user interface (Firefox and Chrome are recommended for optimal performance) was used for communication with the Gocator. Communication is done through Ethernet.

Startup steps (Windows 10):

Configure the network

- Go to Control Panel -> Network and Sharing Center
- Click on the desired network connection.
- Go to Properties.
- Choose Internet Protocol Version 4 (TCP/IPv4) and click on Properties.
- Choose the option *Use the following IP address*.
- Set the following:
    - IP Address: 192.168.1.5
    - Subnet Mask: 255.255.255.0
- Click OK.

Start the web interface:

- Open a web browser.
- Enter the sensor address http://192.168.1.10

Start the sensor:

- WARNING: Make sure that the sensor is aimed so that no one can accidentally look into the laser light source. If laser class is above class 2, please contact your laser safety officer.
- Select the Manage page in the web GUI and check the upper toolbar.
- Make sure that Replay mode is off (slider set to the left).
- Make sure that the Laser Safety switch is enabled or the Laser Safety input is high.
- Press the Start button to start the sensor and the laser source will then emit a laser lane.
- The sensor is then ready to be configured and used for performing measurements.
- The manual describes how to change settings, like choosing trigger setting using an Encoder and set the mm/tick relation for the conveyor and the encoder. For this information, see https://www.stemmer-imaging.com/media/uploads/vision-systems/lmi/10/106480-Manual-Gocator-2100-2300-2400--2800-Series.pdf.

NOTE! The tests were performed using uniform spacing for the X-coordinate.

Sensor settings

Settings configured from the web GUI can be saved to file and loaded into the sensor at another time. This allows for a quick up-and-running setup for a new test session, a new measurement system installation or when a Gocator needs to be replaced. Also, sensor state, including all settings and currently stored measurement data, can be saved to a support file (.gs) that can be loaded for specific case sensor testing even without a sensor if an emulator is available. For example, such a file can be sent to LMI’s support, allowing for feedback on specific measurement data and sensor settings.

Sensor properties of note

Accuracy

The accuracy and resolution of the sensor can be found in data sheets and have not been analysed extensively. However, measurements have been performed on test objects and the accuracy is deemed to allow for sub-mm-precision. The test objects dimensions could be estimated with about 0.2 mm difference from the known real values, for the depth (Z). X can also measure with sub-mm-precision, but it depends on the distance between the sensor and the objects. Y-precision depends on the relation between encoder ticks and distance travelled by the conveyor, as well as the settings of the camera that affect the profile rate (see Sensor speed below). 0.3 mm per profile (Y) has been achieved during tests.

Data format:

When surface data is written as a csv-file, using the web GUI, the format will be as shown in Table 1 below. The tests were performed using uniform spacing for the X-coordinate.

The First row (excluding the first column) will contain the X-values. The first column (excluding the first row) contains the Y-values. Other parts of all rows and columns contain the Z-data, where every row is data from one profile.

Y/X	-2	-1	0	1	2	3
0	0,424667	0,658994	0,629891	0,136228	0,311252	0,219503
1	0,077336	0,51422	0,239826	0,358966	0,338821	0,713699
2	0,088404	0,93025	0,031702	0,308559	0,124717	0,045567
3	0,988215	0,524437	0,58469	0,630065	0,78113	0,107154
4	0,706782	0,625243	0,228863	0,595645	0,387391	0,683036
5	0,655055	0,430825	0,484236	0,158339	0,565907	0,776361
6	0,510419	0,569843	0,734628	0,33918	0,489585	0,189805

Table 1: The yellow positions are the X-values in mm. The green positions are the Y-values in mm. The grey positions are the Z-values, where every row is data from one profile.

Sensor speed:

The number of profiles per second is affected by several factors. The exposure time for the sensor, naturally, but even with a short enough exposure time many other factors have a big effect on the speed of the sensor but might be desirable enough to justify its use.

- Spacing: The X and Z sub-samplings options might reduce the resolution of the measurements but comes with other benefits. X subsample can reduce the CPU usage, while Z subsampling can increase the sensor speed.
- Tools: Using tools during runtime might reduce the sensor speed.
- Accelerator: Gocator accelerator software can offload work from the sensor to a PC to speed things up (not tested by Adopticum). The accelerator functionality is available from the Gocator Software Development Kit (GoSDK) as well.
- Region of interest: The ROI has a big effect on the speed of the sensor. It is important that a sensor's full field of view will likely not be used if a fast (say >= 1000 profiles/second) speed is needed. There is a functionality called *Tracking window* that allows for the sensor to move the ROI during measurement as it follows the laser line through a larger part of the sensor's active area.

Encoder:

Using an incremental encoder with A-B-ports and TTL-signals, then converted to a differential RS-485 signal, the Gocator could be triggered using the movement of a conveyor belt. Using an encoder as a trigger is simple using the web interface. Simply choose how often, in mm, you want to read the profile measurements. The thing to keep in mind is that if the sensor is triggered too often for the sensor speed to keep up the profile data might include empty profiles.

The encoder ticks to mm-conversion also needs to be handled for accurate measurements. The mm/ticks can be set manually if this is known but it might require test measurements on a well-defined object of known size. The interface can handle automatic encoder calibration if certain calibration objects from the sensor distributor (or self-made objects of the same shape and size) are used.

Align:

Automatic alignment is easy to perform. Perform alignment on a static flat target and a simple coordinate system is put into use with the flat target (for example a conveyor belt) representing a constant zero value (Z=0) with the Z-axis pointing up from the surface.

Algin can also be used to combine multiple sensors into one coordinate system in a simple and effective way. Where every sensor's active field of view starts can be set manually.

Combining with HALCON:

Not tested by Adopticum but worth noting is that the Gocator communication and data processing (image- and 3D-data) can be handled through HALCON (widely used Machine Vision Software), combining the strengths of both.

Prices

The price range for Gocator-sensors for laser triangulation is about 86 000 SEK for 2320 to 2380 models. The 1400-series has a higher price. About 110 000 SEK.

User cases

- High speed measurement of objects on a limited surface/conveyor belt. Accurate measurements on a relatively small area but with the possibility of extending this area with aligning several Gocators or moving one sensor using mobile robot-parts, although this makes a system that is more expensive and possibly more complicated.
- Speed of >1000 profiles/second is possible for a limited region of interest.
- Simple alignment for combining several sensors in the same coordinate system for measuring multiple sides or larger areas of the same object. Also, simple flat surfaced conveyor belts are easily aligned and the conveyor surface itself easily excluded from the measurements, simplifying identification of objects to measure by using only the built-in tools for the Gocator.
- Several tools for different automatic measurements are available as build-ins for the Gocator:
    - Get basic measurements automatically for full objects (called surface) or separate profiles (3D-bounding box, object area/volume, intersection points and angles and more)
    - Identify shapes and defects (locate holes/circles/ellipses, cracks, subparts)
    - Built-in tools are most suitable for objects with small variation (a uniform base unit) between units (circuit boards for instance).

Summary

The Gocator laser triangulation sensors are easy to set up and have several built-in tools that can make the sensor a measurement system on its own, very well fit for manufacturing of parts that should be identical to each other. Limited range can be a problem, but several sensors aligned/calibrated together can solve that problem. The built-in tools seem mostly fit for a simple conveyor belt with a flat surface where it is well suited for delivering data and performing measurements only when an object of interest passes by. Setting up the whole system is easy thanks to the relatively user-friendly web user interface. The sensor has many tools for measurements on both complete objects and for single profiles. This means that you can get a lot of functionality "for free" when you know what kind of predefined common shapes or defects you are looking for.

The pre-calibrated camera and laser system that the Gocators provide simplifies calibration effort and time considerably and is easy to replace if a sensor needs to be replaced. It does make the use of filters, the resolution and accessible field of view limited in a way a system with separated laser and camera are not. This needs to be considered against the cost/time-loss of performing a potentially more time-consuming and cumbersome calibration process for systems where the camera and laser are separated and need to be recalibrated when adjustments or component replacements are made.

When the objects to measure can differ wildly in size or shape, the built-in tools aren't always enough, and the raw profiles or surfaces need to be analysed using other software. For example, Gocator and HALCON can be used together for very flexible solutions, that Gocator itself can't easily handle, like estimating the curvature of an object.

If the Gocator tools can't easily solve a measurement problem and the Gocator's effective alignment functionality isn't needed, the Gocator doesn't necessarily need to be the sensor of choice. For bigger measurement targets or a need for a bigger field of view in general, or for objects of very different sizes or shapes another sensor might as well be used. The speed of other sensors seems to be above the level the Gocator can handle if speed is the most important factor and the software handling the data processing for extracting measurements is not from the Gocator toolset but from other software. Again, HALCON and Gocator can be a good match, but for Adopticum there would remain a lot of work to get HALCON running with Gocator communicaton. HALCON also has a price for licensed use, which increases the costs.

Regarding the cost, the sensors' prices at 86 000 SEK or higher for ONE sensor is high if the built-in tools, one of the big advantages of a smart-sensor like this, will not be used and the acquiring of raw profiles is what it is to be used for. There are other sensors that can be used for this that are a bit cheaper. And if a Gocator's laser emitter burns out and the whole sensor needs to be replaced, it means that the replacement costs will be higher than for other systems where the light source and the camera are separated.

The Gocator 2340-sensor can thus be a good and time-saving solution when the application suits the built-in functionality that the sensor provides.