i-CS lenses

Intelligent lenses improving camera performance

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Summary

An i-CS lens holds information about its own optical properties and has motors for remote control of zoom, focus, and iris opening. When mounted on a camera, the camera reads the lens's information and controls the lens's motors to optimize the image quality of the optical system. i-CS lenses can be used with cameras that have support for this type of lens.

It is possible for the camera to, for example, read out data about the geometrical distortion and perform barrel distortion correction (BDC). The camera can also use data from the lens in order to stabilize the image automatically by means of electronic image stabilization (EIS).

An i-CS lens has no physical setting rings for zoom or focus. When you install a camera that uses an i-CS lens, you just make sure that it captures the desired field of view and the rest of the setup can be done remotely. This optimizes camera installation and setup in terms of cost, effort, and time, which is especially important if you have many cameras.

Table of Contents

1 Introduction

An i-CS lens is an intelligent CS-mount lens that holds information about a number of relevant optical properties and has motors for remote control of zoom, focus, and iris opening. By reading the information about the optical properties and using the motors of the lens, a camera can optimize the entire optical system in the same way as with a built-in lens.

Figure 1. This lens can be identified as an i-CS lens by the marking on its label.

Axis cameras with support for i-CS lenses communicate using an open protocol. Thanks to the information from the lens and the use of the protocol, the camera can optimize its image quality at all times. It is possible for the camera to, for example, read out data about the geometrical distortion and perform barrel distortion correction (BDC). The camera can also use data from the lens in order to stabilize the image automatically by means of electronic image stabilization (EIS).

This white paper provides a brief overview of how i-CS lenses work and their main benefits.

2 The CS-mount standard

The mount standards C-mount and CS-mount are used for lenses that can be exchanged. Both standards are compatible with Axis fixed box cameras.

C-mount and CS-mount look the same. They both have a one-inch thread and a pitch of 32 threads per inch (TPI). CS-mount, which is more common than C-mount, is an update to the C-mount standard and reduces manufacturing cost.

The difference between CS-mount and C-mount is the flange focal distance (FFD), that is, the distance from the mounting flange to the camera's image sensor when the lens is mounted on the camera.

- CS-mount: FFD=12.526 mm ($\approx$ 1/2 in).

- C-mount: FFD=17.526 mm ($\approx$ 11/16 in).

This means that the only difference between a CS-mount lens and a C-mount lens is that the CS-mount lens is positioned 5 mm closer to the camera sensor.

3 Open protocol

i-CS lenses are an industry standard and the result of a joint development between Axis and the lens manufacturer Computar®. The open protocol is freely available from Axis or Computar®. The serial bus used for the communication between the camera and lens is an I^{2}C bus. The open standard means that

lens manufacturers can develop and manufacture their own i-CS lenses with different features, and these lenses will be interchangeable.

4 Characteristics of an i-CS lens

An i-CS lens contains data about its characteristics:

- Type of model and the manufacturer

- Geometrical distortion

- Focal length at a given zoom and focus position

- F-number at a given zoom and iris position (f-number is the ratio of the focal length to the diameter of the entrance pupil)

- Trace (data describing the required position of the focus lens in relation to the zoom lens to get a sharp image of an object at a certain distance)

- Vignetting (the manner in which the light that passes through the lens is reduced depending on the distance from the center of the lens)

- Modulation transfer function (MTF) (describes the resolution of the lens at different zoom and iris positions)

- Operating temperature range (the lens has a built in temperature sensor)

Axis cameras with support for i-CS lenses make use of all these characteristics, except vignetting.

5 Motor control

The three built-in motors in the lens enable automatic and remote control of the lens's features. Being able to remotely control the zoom, focus, and iris opening is a great advantage during camera installation and maintenance. It also provides support for features like BDC and EIS.

Remote motor control of the generic features makes the lens versatile because you can use the same lens for different purposes. For example, in one scenario the lens can be used on a camera where focus and iris opening are automatically controlled, and in another scenario the same lens type can be used on a camera where the zoom needs to be readjusted regularly. This is possible thanks to the open protocol that enables an i-CS lens to be used on various cameras with different capabilities.

6 Communication between camera and lens

To use an i-CS lens, the camera must have support for this type of lens. It is not possible to connect an i-CS lens on a camera without support, since its cable contact does not match the camera connector.

The camera communicates with the lens through the cable connection and thereby finds out exactly which type of i-CS lens it is.

7 Lens adjustments

Most adjustments in an i-CS lens are automatic. Initially, you set the required zoom remotely and fine tune the focus, and then the camera automatically adjusts the iris opening. Since the camera has information about the setup of the i-CS lens, it can optimize the iris opening for all light conditions. If you have enabled BDC or EIS, the camera adjusts these features automatically.

7.1 Electronic image stabilization

With electronic image stabilization (EIS), a camera provides smooth video even if it is subject to vibrations. A typical example is the vibrations of a pole-mounted camera in strong winds. EIS is a feature that can be enabled in the camera's web interface.

For EIS to work properly, it is important that the camera knows the focal length of the lens. A camera with an i-CS lens reads the focal length directly from the lens, thereby eliminating the need for tricky, manual settings.

7.2 Barrel distortion correction

No lens is perfect. All lenses create some form of aberration or image defects as a result of its limitations. One of the aberrations is barrel distortion, which causes straight lines to curve out. Since the i-CS lens holds information about its geometrical distortion, the camera can compensate for barrel distortion by reading that information. Barrel distortion correction (BDC) is a feature that is supported by many Axis cameras and can be enabled via the camera's web interface.

8 Easy installation, use, and maintenance

An i-CS lens has no physical setting rings for zoom or focus. When mounting a camera that uses an i-CS lens, you just make sure that it captures the desired field of view and everything else can be done remotely. This optimizes the installation process in terms of cost, effort, and time, which is especially important if you have many cameras.

Quick and easy installation is even more advantageous for outdoor installations. This is because they often have cameras placed in enclosures and mounted on hard-to-access locations. Installation might require that areas are temporarily closed down, such as busy highways or intersections. If your cameras use i-CS lenses, you can install the cameras in the enclosures beforehand and then mount them directly in the planned location without needing to open any hatches to set zoom and focus. This saves time and effort and keeps the cameras dry and dust free.

Remote control of the lens functions also makes camera setup easier. The camera is factory-focused on infinity. When you set the zoom level in the camera's web interface, the camera retains focus on infinity. You may fine-tune focus by, for example, choosing an area where focus should be kept at all times. If you click the autofocus button the camera sets the best possible focus, but if you want to focus on something else, manual refocusing in the web interface is possible. You can always manually set focus at the desired distance. When you change the zoom level, the camera keeps focus at that same distance, thanks to the i-CS lens.

In time, zoom or focus might need to be readjusted. With the remote zoom and focus capability of an i-CS lens, you can control these operations remotely without needing to drive to the location, close roads or climb ladders, or even open hatches to access the camera.

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Axis has around 4,000 dedicated employees in over 50 countries and collaborates with technology and system integration partners worldwide to deliver customer solutions. Axis was founded in 1984, and the headquarters are in Lund, Sweden

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