A brand of Balluff

MATRIX VISION

mvBlueGEMINI Technical Manual (EN)

Version: 2.6

Date: 21.11.2019

Table of contents

1 Imprint

1.1 Address

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Given that the documentation is published electronically, the user himself is responsible to update his printouts.

The mvBlueGEMINI smart camera uses embedded Linux/GNU as its operating system. It also makes use of a number of freely available tools that are released under different open source licences. Some of these licences require us to republish the source code used including any modifications that may have been made. Theses sources are published on following website: http://gpl.matrix-vision.com/mvbluegemini/

2 Revisions

Rev.	Date	Description
2.6	21.11.2019	• Updated minimum requirements for browsers.
2.5	18.07.2019	Keine Änderungen.
2.4	08.03.2019	• Updated "Resetting the smart camera".
2.3	25.10.2018	• Updated minimum requirements for browsers.
2.2	25.04.2018	No changes.
2.1	30.11.2017	• Moved chapters "Communication via RS232" and "Communication via UDP" to "mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual (EN)".
2.0	20.07.2017	• Updated "Communication via RS232" and "Communication via UDP".
1.4	30.03.2017	• Added mvIMPACT-CS Service Port in "Communication via UDP". • Added "Resetting the smart camera".
1.3	14.09.2016	• Added "Communication via RS232".
1.2.2	21.07.2016	• Extended description of the LEDs. • Renamed ICS to mvIMPACT-CS • Added "Expert knowledge" in "Find object" and "Check object".
1.2	04.05.2016	• Added Testing the communication.
1.1	31.03.2016	• Added control commands. • Added details about the digital inputs and outputs.
1.02		• Added declaration of conformity.
1.01	11.01.2016	• Added more detail about power supply and scope of delivery. • Added accessories table.
1.0	21.12.2015	• First release

3 Notes, Warnings, Attentions

NOTE

A **note** indicates important information that helps you optimize usage of the products.

WARNING

A **warning** indicates how to avoid either potential damage to hardware or loss of data.

ATTENTION

An **attention** indicates a potential for property damage, personal injury, or death.

All due care and attention has been taken in preparing this manual. In view of our policy of continuous product improvement, however, we can accept no liability for completeness and correctness of the information contained in this manual. We make every effort to provide you with a flawless product.

In the context of the applicable statutory regulations, we shall accept no liability for direct damage, indirect damage or third-party damage resulting from the acquisition or operation of a MATRIX VISION product. Our liability for intent and gross negligence is unaffected. In any case, the extend of our liability shall be limited to the purchase price.

3.1 Declaration of Conformity statement

The manufacturer MATRIX VISION GmbH herewith declares, that this product complies with the provisions of the following European Directives:

CE	**2014/30/EU (EMC Directive)** based on the following harmonized standards *Electromagnetic compatibility (EMC)* • Interference emission EN 61000-6-3 / 2007 • Interference immunity EN 61000-6-2 / 2005

EG-Konformitätserklärung
Declaration of conformity

Der Hersteller
The Manufacturer

Matrix Vision GmbH
Talstraße 16
71570 Oppenweiler
Germany

erklärt hiermit, dass sein Produkt
herewith declares, that his product

Typbezeichnung: **mvBlueGEMINI**
Type: ***mvBlueGEMINI***

mit den Bestimmungen folgender Europäischer Richtlinien übereinstimmt:
complies with the provisions of the following European Directives:

2014/30/EU (EMV-Richtlinie) / *2014/35/EU (EMC Directive)*

auf Grundlage folgender harmonisierter Normen:
based on the following harmonized standards:

Elektromagnetische Verträglichkeit (EMV) / *Electromagnetic compatibility (EMC)*
Störaussendung / *Interference emission*
EN 61000-6-3 / 2007 + A1:2011 + Ber.1:2012

Störfestigkeit / *Interference immunity*
EN 61000-6-2 / 2005 + Ber.1:2005

Oppenweiler, 15.02.2016

i.V. Uwe Hagmaier
Leiter Entwicklung / *Head of Development*

Bitte beachten: Um die Einhaltung obiger Normen sicherzustellen, ist die Verwendung hochwertiger, vollständig geschirmter Anschlusskabel unbedingt erforderlich.
Please note: In order to fulfill the above standards, the use of high-quality, shielded connecting cables is required.

4 About this user manual

Purpose of this manual	This manual provides you with an overview of the smart camera's technical data and the handling of the camera. For a quick summary of the product, we recommend that you read the manual in the specified order.
Content of this manual	In the section entitled "**Proper use**" the camera will be introduced, followed by the camera's technical data and the scope of delivery. The subsequent "**First steps**" section, you will learn how to plug in the camera and how to connect it via your web browser. As soon as you are connected with the camera, you can create an inspection program. Please consult the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**". The next section **Updates** describes, how you can update the software of the smart camera. Technical details are explained in the **Appendix** and **Glossary**.

5 Proper use

The mvBlueGEMINI is a Smart Camera for creating inspection applications for different industrial areas. The camera provides a user interface for connecting the camera via your web browser over network. Furthermore you create and configure inspection programs with the user interface software "mvIMPACT Configuration Studio (mvIMPACT-CS)". You can monitor and analyze the results of the inspection program.

The user interface is kept simple and understandable in order to enable a fast learning process and to allow intuitive working. You will find more details in the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**".

6 Scope of delivery

The scope of delivery includes the following components:

- camera hardware
- already installed configuration software mvIMPACT-CS (**mvIMPACT C**onfiguration **S**tudio)

For connecting the camera, you will need the following accessories:

- a suitable power supply (via suitable power supply unit or via suitable M12 cable conntected to suitable power supply)
- a suitable lens as well as
- a suitablle network cable

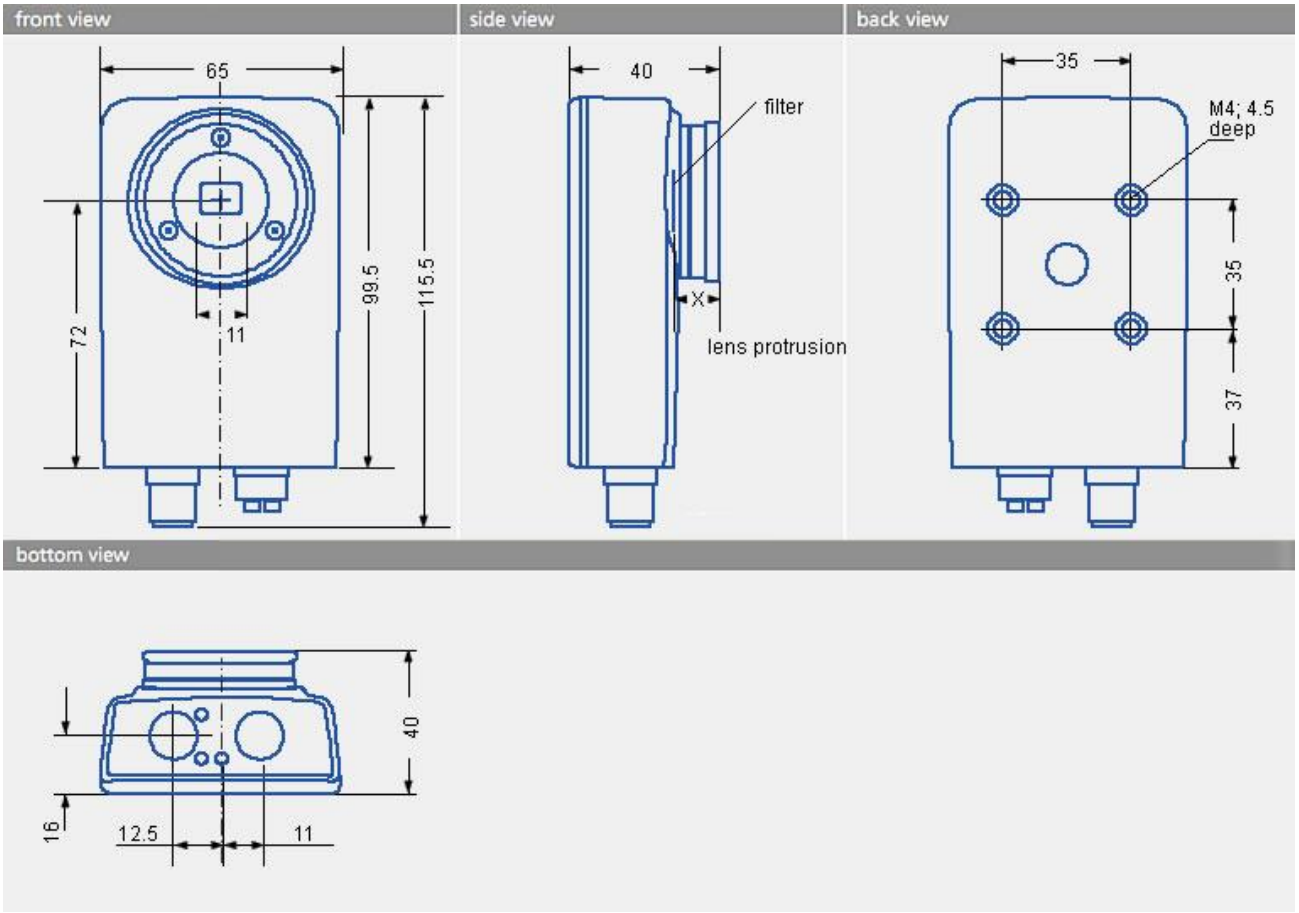
According to the application environment, a separate lighting system could be required.

6.1 Accessories

Article name	Description
KS-RJ45-M12-8X x.xx AL	Network cable, M12 connector, 8-pin X-coded, Cat.6A, length up to 20 m
KS-M12-PWR-IO xx.x	Shielded connection cable mvBlueGEMINI, M12 male connector to prepared wires, UL/CSA, drag chain, up to 20 m
mv-X I/O-BOX	Break-out box for mvBlueGEMINI for connecting the camera and testing of the digital inputs and outputs
MV-TRIPOD ADAPTER GEMINI	Tripod adapter for mvBlueGEMINI
MV-TRIPOD ARM	1/4" Tripod with locking arm and two ball head joints
MV LENS TUBE GEMINI 54	Lens protections tube, IP67, length 54mm
MV-DC2401 GEM IO	Power supply 24V / 1.5 A for mvBlueGEMINI with Dig. I/O on separate cable, length Power 2.0m, I/O 1.0m

7 Technical data

7.1 Dimensional drawing



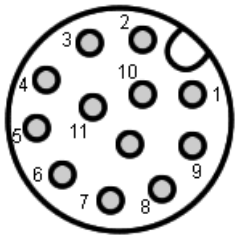
X	12 mm

7.2 Connections

7.2.1 PWR/IO

Manufacturer	Binder
Description	Flanschstecker, M12 x 1, 10,5 mm
Number of contacts	12
Area	M12-A
Order code	09 3491 550 12
	713/763

Figure 1 Power / IO connector



Pin	Signal	Color
1	VIN_L+	brown
2	VIN_L-	blue
3	RS232RX	white
4	RS232TX	green
5	SPSIO1	pink
6	SPSGND	yellow
7	SPSIO0	black
8	SPSIO2	gray
9	SPSIO3	red
10	SPSIO4	violet

Pin	Signal	Color
11	SPSIO5	gray/pink
12	NC	red/blue

7.2.1.1 Pinning of the fitting cable KS-M12-PWR-IO

Pin	Color
1	white
2	brown
3	green
4	yellow
5	gray
6	pink
7	blue
8	red
9	black
10	violet
11	gray/pink
12	red/blue

7.2.1.2 Characteristics of the I/Os

- SPSIO0 - SPSIO5 are digital in-/outputs. Each of them could be used as an input, output, trigger line or for controlling flash lights.
- The inputs switch at approx. 11.3V (supply voltage > 18V; i.e. PLC).
- The inputs switch at approx. 50% of the supply voltage (supply voltage <= 18V).
- Max. output current for each output is 200mA.
- Current limited output (< 450mA)
- 5 µs input filter for spike suppression
- Reverse polarity protection
- Overtemperature protection

Digital input

Delay time	typ. 3.3 µs

Measurement conditions: V_{CC} = 24V

Digital output

Delay time	typ. 6.3 µs

Measurement conditions: V_{CC} = 24V; R_L = 1MΩ

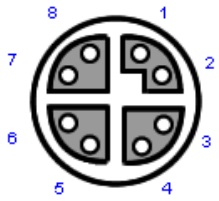
NOTE

Delay time can increase with higher load.

7.2.2 LAN

Manufacturer	Binder
Description	x-coded flange receptacle
Number of contacts	8
Area	M12-D, M12-X
Order code	99 3782 210 08
	Serien 825/876

Figure 2 x-coded flange receptacle



Pin	Signal
1	MDX0+
2	MDX0-
3	MDX1+
4	MDX1-
5	MDX3+
6	MDX3-
7	MDX2-
8	MDX2+

NOTE

The Ethernet signals are galvanically isolated from the camera electronics.

7.3 LED states

7.3.1 PWR (Power)

Color	Description
Green	Power on
Green flashing	FPGA loaded. **Once software is running:** Software is in *Configruation* mode.
Green permanent	Inspection programm is running.
Red flashing	Software updating. **WARNING** DO NOT disconnect from power supply.
Red permanent	Software stalled, please reboot.

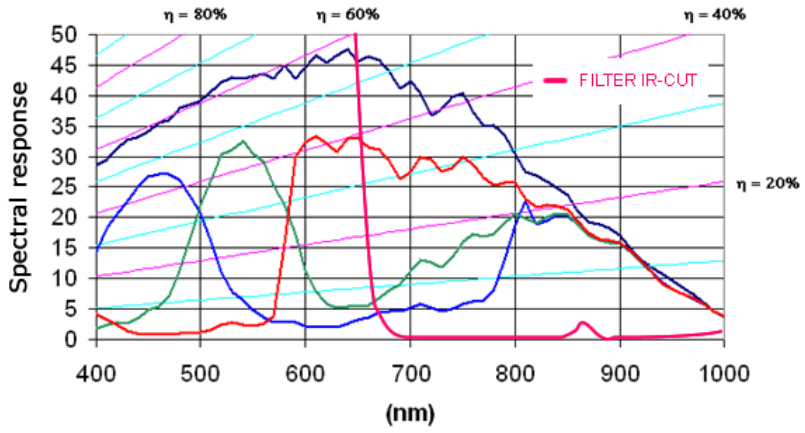
7.3.2 NET (Netzwerk)

Color	Description
Green	Link
Orange flashing	Activity

7.3.3 I/O (Digital inputs and outputs

The LED "I/O" is not implemented in this software version.

7.4 Image sensor

CMOS	
Model[1]	G / C
Resolution	1280 x 1024
MPixel	1.3
Shutter type	Pipelined / Global
Sensor size	1/1.8"
Unit cell size [µm]	5.3 x 5.3
Exposure time	10 µs - 1 s
ADC resolution / output	10 bit (10-8 companding) → 8 bit
SNR	41 dB
DR (normal / HDR)	62 dB / -
Trigger (HW / SW)	yes / yes
Spectral densitivity	
Sensor manufacturer	E2V
Sensor name	EV76C560

[1] G = Gray scale, C = Color

7.5 Hardware

- FPGA/SoC with Dual-Core Cortex-A9 each with 800 MHz
- 1 GB DDR3 SDRAM memory
- 4 GB NAND Flash
- *Connections:*
  - 1 GBit Ethernet LAN,
  - 6 digital in-/outputs (valid modes: input, output, trigger, flash)
- Size without lens (B x H x L): 65 x 40 x 99.5 mm
- IP67
- Power consumption less than 5W
- Power supply: 12V to 24V DC +/- 10%
  - Power consumption: 360mA @12V or 180mA @24V
  - Reverse polarity protection
- Permissible ambient temperature
  - Operation: 0 °C .. +55 °C, without airflow
  - Storage: -25 °C .. +70 °C
- RoHS

7.6 Software

- Operating system: Linux®
- Configuration software mvIMPACT Configuartion Studio (mvIMPACT-CS) with modern and intuitive user interface

8 First steps

8.1 Connect the smart camera

Figure 3 Connector side

- Connect the smart camera with the local network using the **NET** (2) connector .
- Power the camera using the connector **PWR/IO** (1).
- Now, the smart camera will start which will take approx. 30 seconds.
- The smart camera will load the most recently opened inspection program and will continue with the most recently used operating mode (active/inactive).

8.2 Connect with the smart camera

- The smart camera is configured via PC, tablet or smartphone. It is assumed that the device used for this purpose
  - has **a minimum resolution of 1024 x 768 pixels**,
  - has **an supported web browser and**
  - **is connected to the same network** as the smart camera. In Windows, you need to apply the setting **"Obtain an IP address automatically" (DHCP)** for the network adapter for the PC or smart camera.

Supported web browsers are:

- Google Chrome version 32.0 and above
- Mozilla Firefox version 24.0 and above
- Microsoft Internet Explorer version 11 and above

- Microsoft Edge version 40 and above

NOTE

JavaScript must be enabled in the web browser.

NOTE

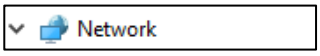
If you connect the smart camera to your PC or laptop directly and cannot access the smart camera via the web broser, then you have to switch of your Wi-Fi or internet connection. Some internet service providers forward local address requests, which they do not know, to own addresses.

- Access is then via the web browser. To go to the configuration software page,
  a. open the web browser,
  b. enter the address or URL of the device on which mvIMPACT-CS is running.

     For the mvBlueGEMINI smart camera, this may look something like: "*http://gemini-000110*".
  c. Confirm your entries.
     Please replace *000110* with the serial number of the used smart camera (without "MS"). You will find the serial number on the rear side of the camera printed on a label (starting with "MS").
- If there are other smart cameras in the network, you can also connect to them.

  If you are connected to the smart camera correctly, you will see the homepage of mvIMPACT Configuration Studios (mvIMPACT-CS).

Alternatively, you can use Windows Explorer to find the smart camera or the PC in the network. To do this,

- select the network folder 

to display all connected network devices or
- press **Windows + R** and enter the address of the smart camera (e.g. *gemini-000110*\).

As soon as you have chosen a smart camera, the shared folders of the smart camera are displayed:

- *images*
  Here you can drop **.bmp* images, which can be opened using the camera simulation ("File Device") (see chapter "Tool Box" → "Image capturing tools" → "Set up camera" → "Active camera" in the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**").
- *logs*
  Here you can find the log files of the smart camera (see chapter "User Interface" → "System

Menu" → "System Settings" → "System" in the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**").

- *updates*
  For updating the smart camera drop the update file in this folder (see chapter "Updates").

NOTE

If you cannot access the shared folders, please have a look a the appendix "Troubleshooting Table" → "Accessing the shared folders is not possible".

8.2.1 If you wish to access ICS in another subnetwork ...

- Subnetworks have been explicitly created to arrange computers into various networks, with these boundaries restricting access.
- Refer to your IT administrator to set up access to the smart camera or PC. You can find useful tips in the appendix "Notes about network connections".

8.3 How to continue?

You are connected to the smart camera via browser and the homepage of mvIMPACT Configuration Studios (mvIMPACT-CS) is displayed. Now, you can create your first inspection program with mvIMPACT-CS. For this, please consult the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**".

9 Updates

9.1 Update software

Periodically, we publish software updates on our website. The updates contain bug fixes, performance optimization, or functional extensions.

NOTE

We recommend updating the smart camera from time to time to derive maximum benefit from the smart camera.

Please follow these steps to update the smart camera:

1. Download the latest update file from our website (https://www.matrix-vision.com/) and save it locally on your computer.
2. Press the keys **Windows + R**, enter the address of the update directory (e.g. *gemini-000110**updates*), and confirm with **Enter**.

   NOTE

   In order to access this folder you have to use the following credentials:

   - Login: *expert*
   - Password: *expert*

   NOTE

   If you cannot access the shared folders, please have a look a the appendix "Troubleshooting Table" → "Accessing the shared folders is not possible".

3. Copy the update file into the folder *updates*. The update process will start automatically, which can take up to 5 minutes. The LED status indicator "PWR (Power)" will flash red during the update process and the smart camera is not available.

   ATTENTION

   Do not switch off the smart camera during the update process. This may cause irremediable damage to the smart camera.

4. After a few minutes, the update is finished and the LED status indicator "PWR (Power)" will change to green. The smart camera is then ready to use.

10 Resetting the smart camera

10.1 Making a factory reset

In case you want to reset the smart camera, MATRIX VISION provides a factory reset script, which is available online.

Factory reset means, that

1. all inspection programs and
2. all log files will be deleted,
3. the color scheme and
4. all system settings (Network, I/O direction, FTP server, NTP server, etc.) will be reset.

NOTE

After the reset of the network, the camera is configured with DHCP, without gateway or static IP address.

WARNING

Save your data like inspection programs, images, etc., before you start to reset your smart camera. As soon as the reset process is running, you cannot recover your data.

Please follow these steps to reset the smart camera:

1. Download the factory reset script file from our website (https://www.matrix-vision.com/) and save it locally on your computer.
2. Press the keys **Windows + R**, enter the address of the update directory (e.g. *gemini-000110**updates*), and confirm with **Enter**.

   NOTE

   Please note the correct entry of the characters ****.

   NOTE

   In rare cases, the username (address of the smart camera, e.g. *gemini-000110*) and the corresponding password (blank password) will be requested.

3. Copy the factory reset script file into the folder *updates*. The reset process will start automatically, which can take up to 5 minutes. The LED status indicator "PWR (Power)" will flash red during the update process and the smart camera is not available.

   WARNING

   Do not switch off the smart camera during the reset process. This may cause irremediable damage to the smart camera.

4. After a few minutes, the update is finished and the LED status indicator "PWR (Power)" will change to green. The smart camera is then ready to use.

10.2 Resetting user passwords

NOTE

The following passwords will be reset to default values:

- User password
- Technician password
- Expert password
- Administrator password

All other passwords like the FTP password for exporting reports will remain unchanged.

Should you forget your user passwords, you can reset them to default values with a specific reset packet. Additionally, password protection will be disabled. All other settings and inspection programs are not affected by this reset.

To use the password reset packet, please follow the same instructions as given for the factory reset, but use the password reset packet instead (password_reset_MV.sh).

NOTE

The password protection will be disabled after the reset has been performed. You have to enable password protection again and supply new passwords if you want to have access control.

11 Appendix

11.1 Troubleshooting Table

Error	Cause	Action
No connection to the camera possible	Incorrect network configuration	Check and implement the measures defined in the "Notes on network connections" chapter. Alternative access to the camera (direct connection): 1. Disconnect the camera's power supply. 2. Use a PC/laptop with an Ethernet port. 3. Disconnect the PC from all networks by removing all network cables and disabling the WLAN (if present). 4. Establish a direct connection between the PC and the camera by connecting the camera's network cable directly to the PC's Ethernet port. Do not use any switches/routers/hubs. 5. Restore the camera's power supply. 6. The camera now starts up and establishes a network address with the connected PC. This may take up to 5 minutes. 7. Follow the sequence mentioned in the "First steps" chapter under "Connecting with the smart camera" 8. Open the system settings and check the camera's network configuration. In case of doubt, consult an IT expert.
No connection to the camera possible	Incorrect configuration of PC - Wrong IP address	If you cannot get an connection to the camera as described before, it could be possible, that your PC/laptop doesn't find the camera because it doesn't negotiate an IP address with the camera. Please ensure that your PC retrieves it's IP address automatically (DHCP): 1. Open the settings of your network adapter and there the settings of the internet protocoll (TCP/version 4) 2. Set the IP address to *automatically* 3. Inside the tab alternative configuration also set the IP address to *autmatically*

Error	Cause	Action
		4. Close the windows and restart the PC 5. Retry the previously described way
No connection to the camera possible	Incorrect configuration of PC - NetBIOS name (*http://gemini-nnnnnn*) of the smart camera is not dissolved	If you still cannot get an connection to the camera as described before, it could be possible, that your PC/laptop cannot dissolve the NetBIOS name (*http://gemini-nnnnnn*) of the smart camera. Please check the "Node Type" of your PC: 1. Open the command promt of your system. 2. Enter *ipconfig /all*. You will find the entry "**Node Type**" in "**Windows IP Configuration**". Here should be "**Hybrid**". Otherwise, change the entry in the following way: https://msdn.microsoft.com/en-us//library/cc757386(v=ws.10).aspx If you still cannot connect to the camera, using Intel network cards, try to install the driver without "*Intel PROSet for Windows Device Manager*" and without "*Advanced Network Services*" or to deinstall both options.
No connection to the camera possible (especially with laptops)	Incorrect configuration of PC - NetBIOS name (*http://gemini-nnnnnn*) of the smart camera is not dissolved because of a WiFi connection	Because of a WiFi connection, the DNS server of your internet service provider is used to resolve the NetBIOS name (*http://gemini-nnnnnn*) of the smart camera. The DNS server, of course, does not know the address *http://gemini-nnnnnn* and responds with an error messsage. Please 1. turn off the WiFi module and 2. reboot the laptop. Now, you can check, if the camera was resolved using the Windows shell: 1. Click on the Windows start button and 2. enter *cmd*. 3. Enter *nbtstat -c*. All resolved NetBIOS names will be listed and you should find the smart camera there:

Error	Cause	Action
		C:\Users\war>nbtstat -c Ethernet: Node IpAddress: [0.0.0.0] Scope Id: [] No names in cache Local Area Connection: Node IpAddress: [169.254.93.40] Scope Id: [] NetBIOS Remote Cache Name Table Name Type Host Address Life [sec] --- --- GEMINI-NNNNNN <20> UNIQUE 169.254.4.9 540 GEMINI-NNNNNN <00> UNIQUE 169.254.4.9 549 You can also reach the camera with the IP address directly (in this sample 169,254.4.9).
Connection to the camera possible, however a dialog appears, that the connection to the camera was lost	Firewall active	Please add *http://gemini-** as trusted web addresses to your firewall settings.
Action menu "Monitor": No fluent display or freeze of the browser	Display device is too weak	Deactivate the live image diplay: 1. Change to the action menu "Configuration". 2. Select the Tool "Get image". 3. Deactivate the checkbox "outImage" in the result table. 4. Repeat this step for every used "Get image" and "Find object" tool.

Error	Cause	Action
Not every inspection result is transferred to the FTP server.	Connection to the FTP server is too slow.	Possible approaches: 1. Export only reports without images. 2. A faster connection to the FTP Server. 3. Cycle reduction. 4. Reduce the number of monitored images.
Accessing the shared folders is not possible.	Your Windows 10 installation does not allow a guest access to the shared folders (mvIMPACT-CS releases <= 2.3.0 and >= 2.2.2); sometimes also with error code **0x80070035**	Update mvIMPACT-CS to a version > 2.3.0, which allows accessing the shared folders with following credentials: • Login: *expert* • Password: *expert* If Windows does not prompt for the login and password please use this command in a terminal window, replacing the host name with the correct value for your camera: `cmdkey.exe /add:gemini-000110 /U:expert /P:expert`

11.2 Notes on network connections

11.2.1 Background information

The user would like to connect to the smart camera with their client via web browser. For this to work,

1. the smart camera's IP address or host name must be known or found, and
2. a data packet route to this IP address or host name must exist.

Point 2 is relatively simple, as only a single route has to exist between the client and the server. Routers (and routing tables) as well as port forwarding are available for this purpose. However, for point 1, conveniently locating the smart camera, the mDNS broadcasts must be available, which is normally suppressed by routers. The server essentially publishes its settings via Avahi and mDNS. The client can initially use the host name printed on the smart camera.

Different problems need to be overcome with different solutions depending on the network topology. These are discussed below.

11.2.2 Terms (simplified description)

- **Switch** is a simple distributor of network packages in a subnet. Both mDNS packages as well as packages directly on another computer are permitted.
- **Router** separates subnets, i.e. a router can forward queries from one subnet to another subnet. NAT is generally used, i.e. the router replaces the querying IP address with its own. This means that external access to the computer behind the router is not possible. mDNS broadcasts are also not transmitted.
- **Firewall** behaves in a similar manner to a router, but it also filters the content of the network packages.

11.2.3 Server and client not separated by a firewall

11.2.3.1 Server and client live in the same subnet (e.g. DHCP or fixed IP)

The server now has the problem of having to find the IP address. The possible solutions are:

- In the case of DHCP, the IP address can be read out in the DHCP server, but requires read rights to the DHCP server.
- Start the delivered script and display an overview of the smart camera. Select a smart camera and access its URL via web browser.
- Start a local instance of the mvIMPACT-CS server (offline version) and connect with "localhost" via web browser. Then select the desired smart camera in the browser.
- Call up a central but local instance in the intranet. This is where a small web server is running, which identifies all smart cameras in the local network via Avahi and makes them available for selection.

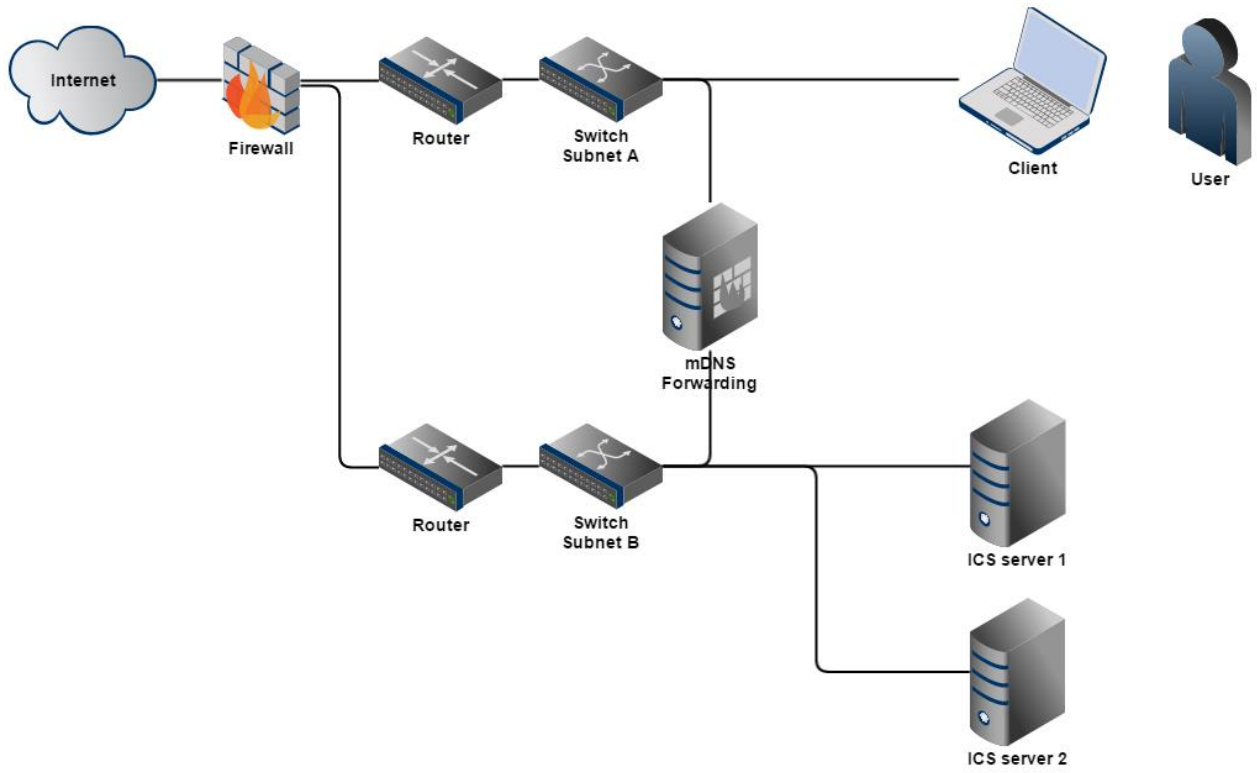
11.2.3.2 Server uses a Zero-Conf address and a fixed IP in an external subnet

The client then also has to use a Zero-Conf address (set "dynamic IP address" under Windows with no DHCP server in the network). This can be achieved by connecting the camera directly to the client PC. The second or third solution from *"Server and client live in the same subnet (e.g. DHCP or fixed IP)"* can then be used.

11.2.3.3 Server and client live in different IP subnets

The mDNS packages are not transmitted beyond subnet boundaries as standard. The possible solutions are:

- An additional (Linux) computer, which connects both subnets, i.e. has access to both subnets and is configured so that it forwards mDNS queries to the other subnet (=Avahi reflector), is required.

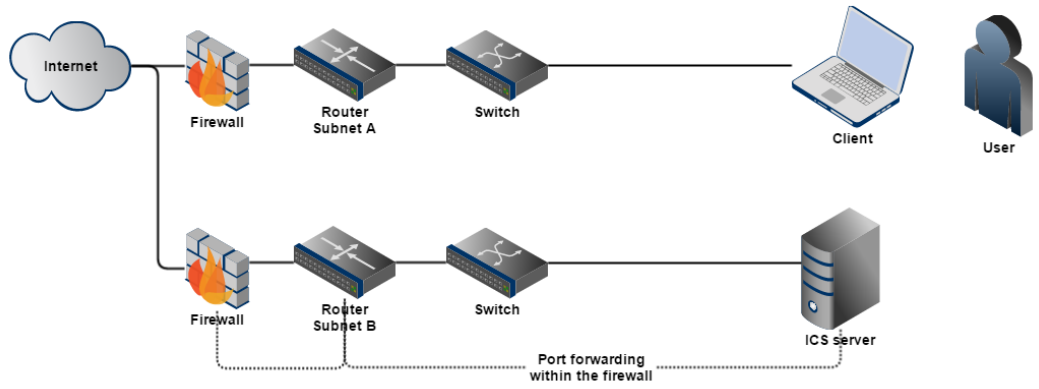


11.2.4 Server and client separated by a firewall

In this case, the server and client are in different IP subnets without loss of generality.

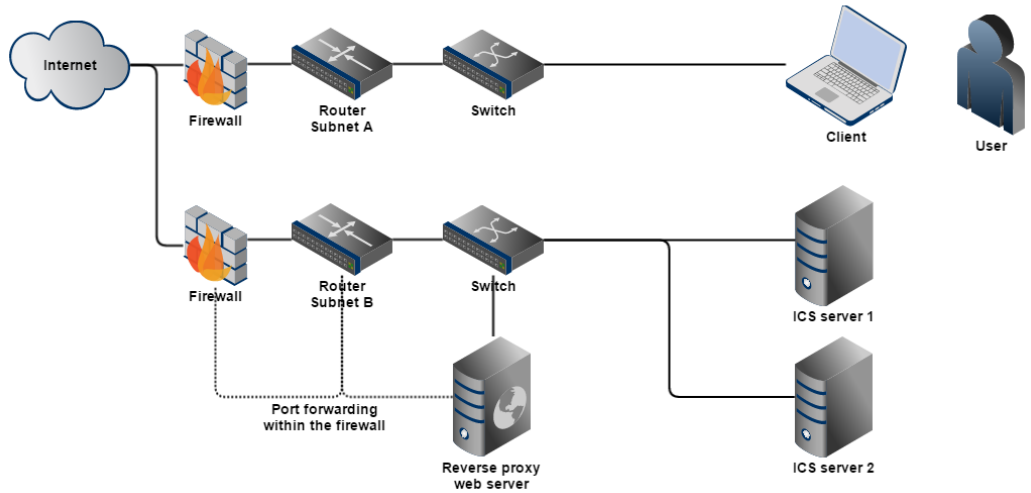
11.2.4.1 Static port forwarding

The easiest access to a smart camera behind a firewall is established by port forwarding. In this case, the firewall forwards all queries on one of its ports to a specific smart camera port, i.e. this forwarding must be manually configured for every smart camera. The Avahi service is not used. The client accesses the open firewall port externally.



11.2.4.2 Reverse proxy with dynamic subdomains

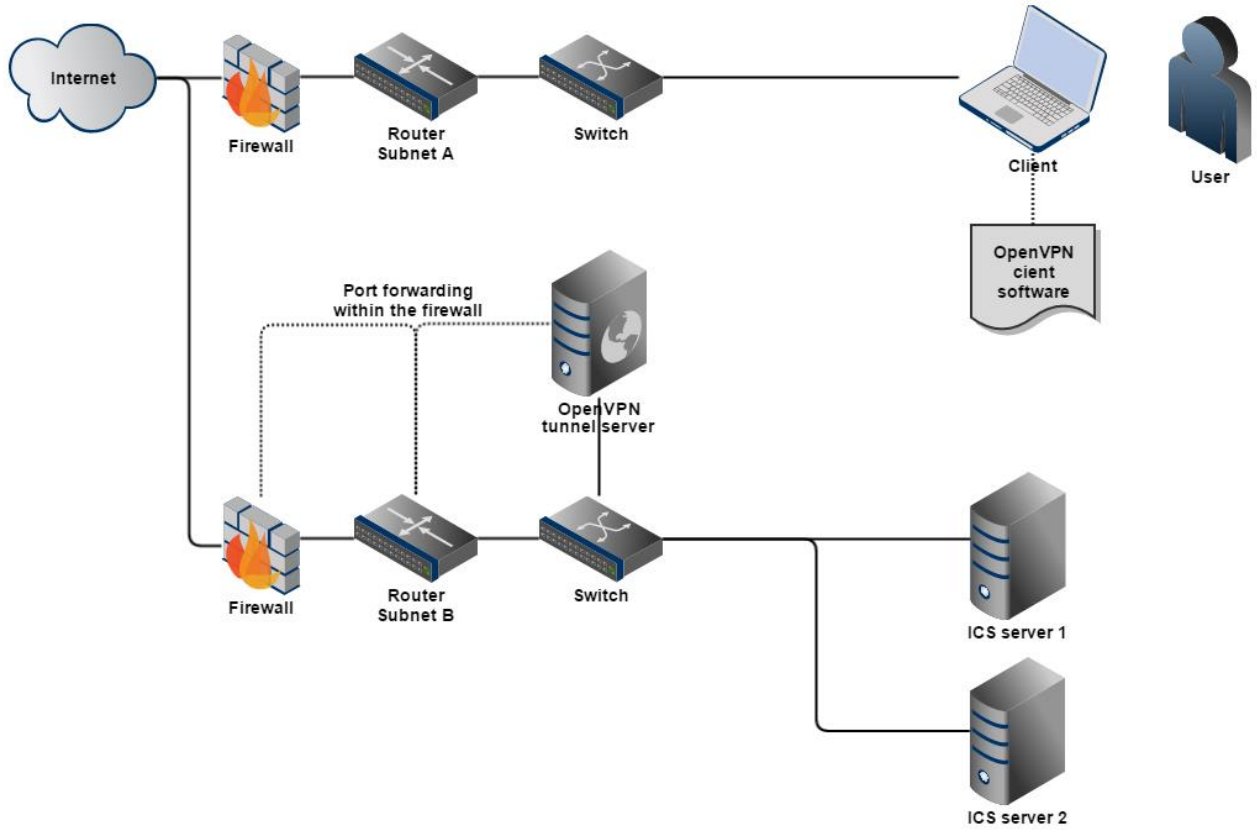
An Avahi service is also running on the reverse proxy web server, which automatically publishes all smart cameras as subdomains and makes these available in its function as a reverse proxy. The reverse proxy also requires port forwarding to be set up in the firewall.



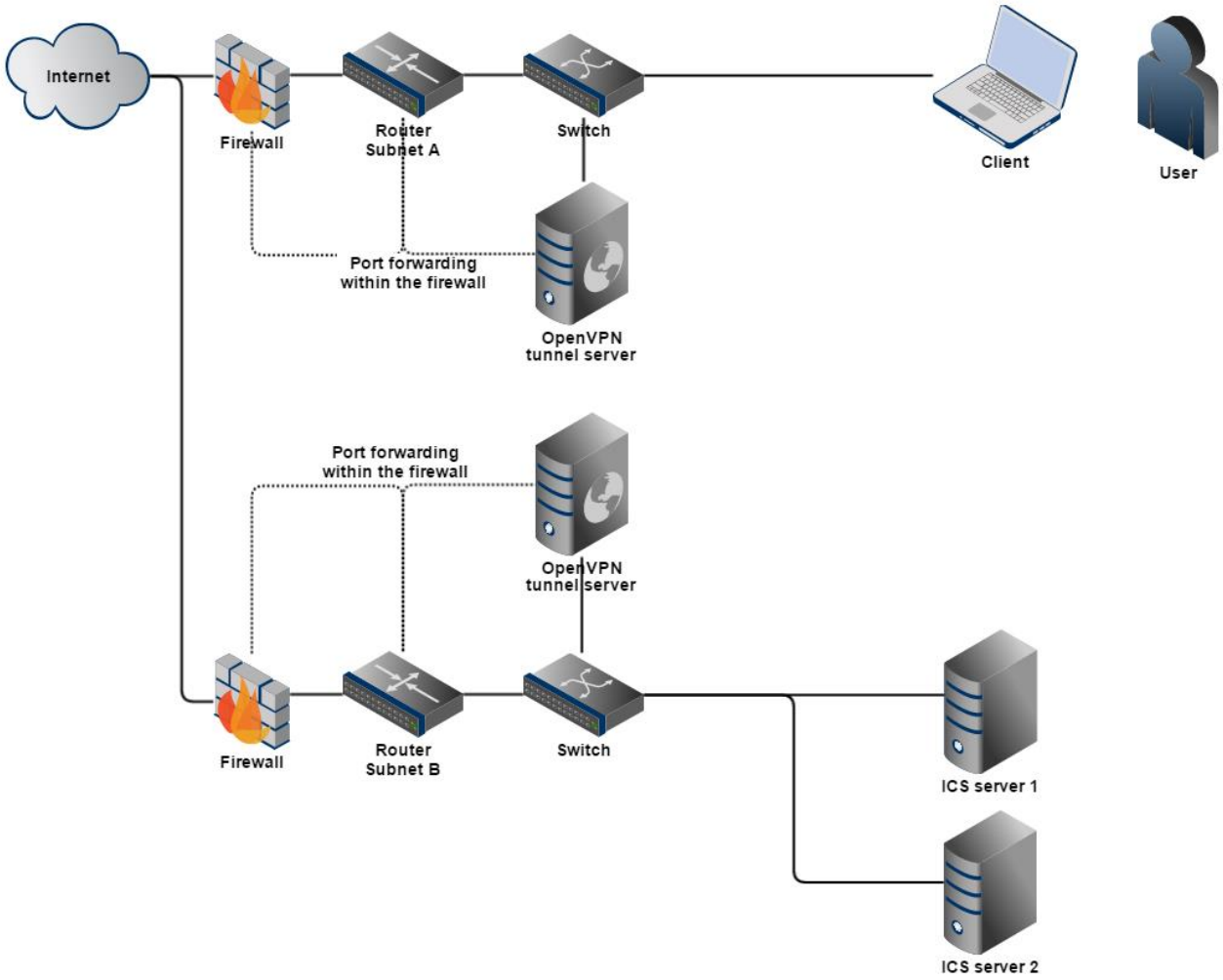
11.2.4.3 OpenVPN as a bridge between two subnets

An OpenVPN server functions as a bridge and connects two subnets (see http://www.heise.de/netze/artikel/Bridge-Modus-224072.html and https://docs.openvpn.net/how-to-tutorialsguides/virtual-platforms/site-to-site-layer-2-bridging-using-openvpn-access-server/). In this case, the two Open VPN servers must be configured so that they transmit direct network packages as well as mDNS broadcasts. This either takes place by establishing forwarding as is the case in "Server and client live in different IP subnets" or configuring the VPN so that the client and server are located in the same subnet.

Versions with OpenVPN client



Versions with OpenVPN bridge



11.3 Choice of the right lens and lighting system

11.3.1 Find the correct lens

Lenses are the starting point of the image processing signal path and shape the light information. The better the optics and the more time you've invested in this issue, the better the source material for the image processing. In the following you will find an overview of the essential properties, sizes and contexts.

11.3.1.1 Limits and settings of a lens

Image field size

With the image filed sizes you can extract first information about the boundary conditions of an image. Here, the focal length of a normal lens corresponds to the diagonal of the image field.
For example, an 8 mm lens behaves like a wide angle lens in combination with a 1 inch sensor. In contrast, the same lens behaves like a telephoto lens in combination with a 1/4 inch sensor. For industrial purposes, sensor sizes from 1 inch and smaller are common.

	Image field	Diagonal
4/3 inch	17.3 mm * 13.0 mm	23 mm
1 inch	12.8 mm * 9.6 mm	16 mm
2/3 inch	8.8 mm * 6.6 mm	11 mm
1/1.8 inch	6.7 mm * 5.4 mm	8.61 mm
1/2 inch	6.4 mm * 4.8 mm	8 mm
1/3 inch	4.8 mm * 3.6 mm	6 mm
1/4 inch	3.2 mm * 2.4 mm	4 mm

Components of a lens

Using a lens, the **focal length** defines the image angle and for this reason the scale between object and image.
You can adapt two properties of the lens:

- **Focus**
  - a sharp image is possible even with different object distances
  - a scale on the lens indicates distance between object and image (from the minimum distance to infinity)
  - a closer focus is possible using spacers

- **Aperture**
  - an opening through which light travels (narrow aperture = less light)
  - a scale indicates the f-number (high value = narrow aperture)
  - has direct impact on the imaging quality (determines resolution and depth of field).

Calculate the image

Using the formula for a single lens is the easiest way to calculate an image. At least, it is possible to indicate the boundary conditions for a test setup's concept.
The accuracy of measurement specifies how many measuring points are needed in the object. With it and setting the image detail, you can determine the camera.

Example: If an accuracy (M) of 0.1 mm is needed, you have to use twice as many resolution points (F; according to the sampling theorem), which results in a measurement resolution (A) of 0.05 mm:

```
M = F * A
A = M / F => A = 0.1 / 2 = 0.05
```

The sensor of the mvBlueGEMINI has a pixel size (P) of 0.0053 mm (5.3 µm), which will lead to an image scale of approx. 1/10:

```
A = V * P
V = A / P => V = 0.05 / 0.0053 = 9.43 (~ 10)
```

With the sensor size of 6.7 mm * 5.4 mm (1/1.8 inch), you can view an object of 67 mm * 54 mm in an image.
Example of further such correlations:

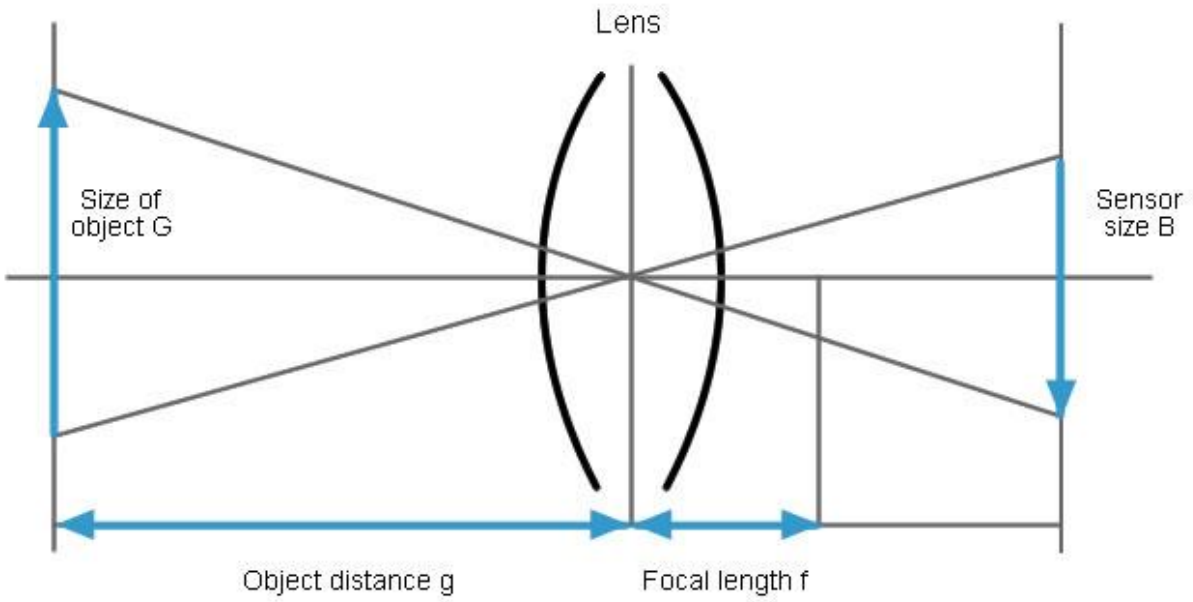
Accuracy of measurement Resolution	Number of points	Object field Size of the object
2 µ 1 µ	4000 x 2600	4 mm * 2.6 mm
20 µ 10 µ	4000 x 2600	40 mm * 26 mm
40 µ 20 µ	4000 x 2600	80 mm * 52 mm
200 µ 100 µ	4000 x 2600	400 mm * 260 mm

With these considerations you can check, if you can image the object with the **camera**'s **sensor**.

Choice of the lens

You can calculate further parameters using the following formula (the focal length with the given object distance, or with the given focal length the object distance):

Figure 4 Focal length formula




```
f = g * B / (G + B)
```

If the size of the sensor (B), the size of the object (G), and the object distance (g) are known, you can calculate the needed focal length.

For a rough calculation a swift procedure is enough. If the object distance is noticeably larger than the focal length, you will have the image scale immediately.

```
f / g = B / G                    # if G > 10 * B
```

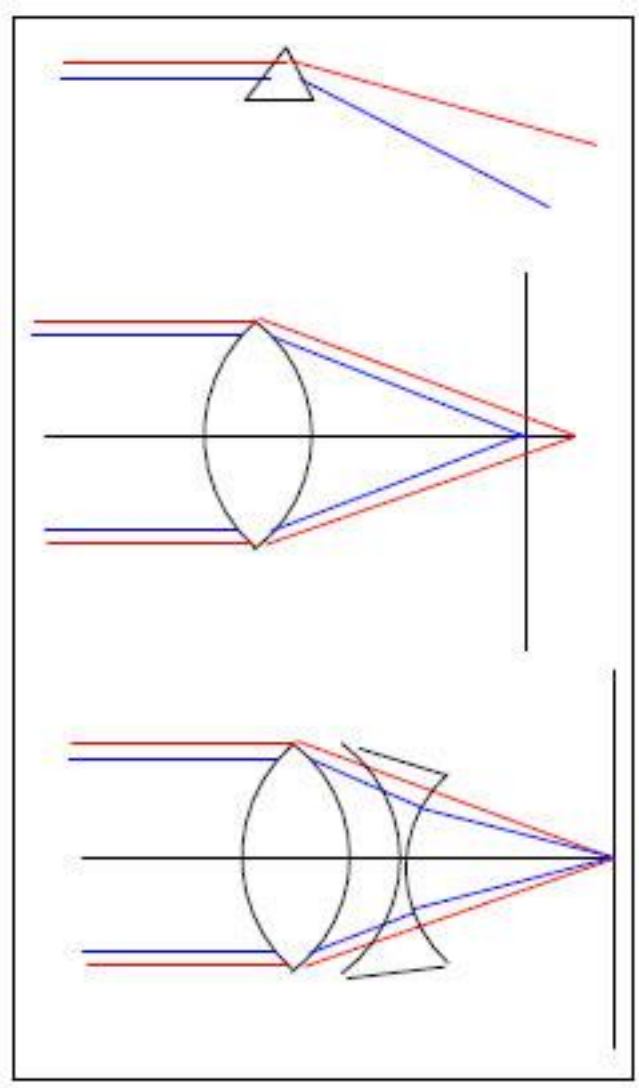
On our website, we offer a lens calculator:

https://www.matrix-vision.com/lens-calculator.html	

Because single lenses have strong aberrations, several lenses are used to compensate these errors.
The wavelength of the light has a great influence on the image. For each wavelength, the image quality is good and/or is sharp in different spots.
By the use of the mentioned corrections with several lenses, it is tried to consolidate these levels.

An **achromatic lens**, for example. is a lens **with two corrected colors**. Other wavelengths vary from it a bit.
An **apochromatic lens** is a lens which is optimized for three wavelengths.

Figure 5 Lens correction



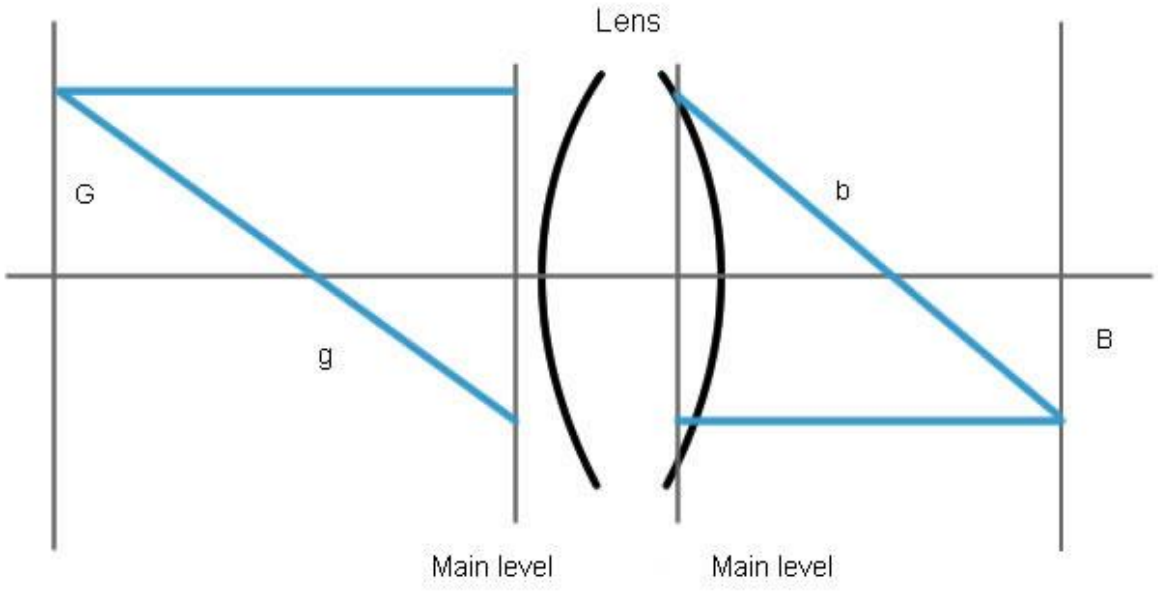
Zoom lenses often consist of 10 or more lenses.

Real lenses have an entrance pupil and an exit pupil. The parameters b and g are calculated starting from these levels. If the distance of the levels equals h (also called main level), the total setting distance e is between object and image.

```
e = g + h + b
```

h equals 0 with a single lens.

Figure 6 Setting level



The parameter h is usually not known. With lenses, normally used in combination with the mvBlueGEMINI, h is usually very small.
For this reason, the formula without h is used in test setup concepts.

It should be possible to set every lens to infinity. In this case, the

```
Distance between lens and image = focal length
```

Therefore, each lens should be fixed in a different way. To avoid this, camera classes have fixed distances, called **flange focal distance**. C-mount lenses, for example, have a flange focal distance of 17.5 mm, which is independent from the focal length (CS-mount = 12.5 mm). With the help of adapters, lenses with longer flange focal distances can be mounted on cameras with shorter distances. This will not work vice versa because you will not reach infinity then.

The resolution - a little physics

Actually, you have to consider the **wavelength of the light**, because the light makes the image. The wavelength of the visible light is between 0.4 µm and 0.6 µm.
The smallest imaged point results from the aperture which will never be smaller than 0.5 µm. Realistic figures are between 2 µm and 5 µm.

```
B = 1.22 * 2 * λ * F / D

B = Diffraction disk or point image
F = Focal length
D = Aperture diameter
```

Example with green light and λ = 0.5 µm

F-number F/D	Diameter diffraction disk
1	1.25 µm
4	5 µm
16	20 µm

11.3.2 Find the correct lighting system

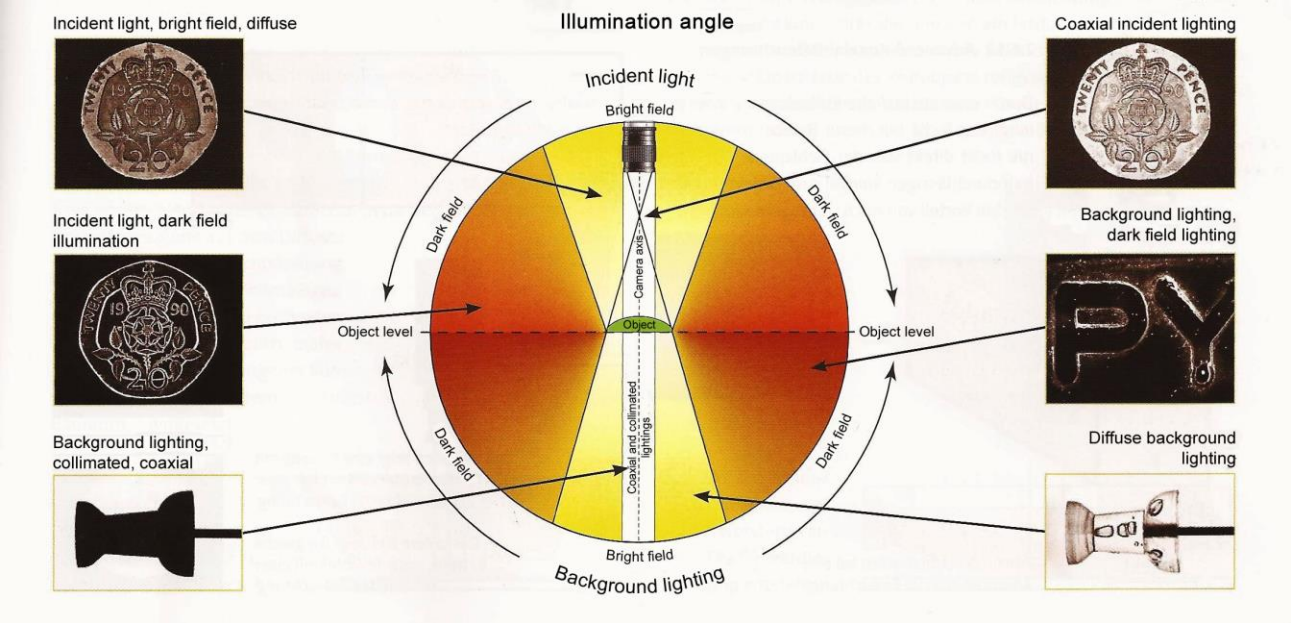
Besides optics, the illumination is an important point, which is critical for good results in the image processing. The golden rule is: create contrast.

A lighting system can be homogeneous or structured. Following table shows the effects and the characteristics of lighting systems:

	Effects	**Light specifications**
Without structure	• light on object • light as a contrast to the object • no information by the light • information from the object	• must be homogeneous • must be time stable • must be broadband in color
With structure	• underlines specific characteristics • color changes contrast of details • projected lines perform a coordinate transformation • usually disturbing reflections become information	• is definied structured • is limited to light bands

11.3.2.1 Direction of the light

Figure 7 Direction of the light



Source: https://wiki.zimt.uni-siegen.de/fertigungsautomatisierung/index.php/Beleuchtungstechniken_f%C3%BCr_die_industrielle_Bildverarbeitung

According to the direction, there are different possible uses:

Direction	Angle	Applications	Specialty
Background lighting	Bright field	• transparent and opaque as well as flat or spatial parts • often in combination with diffuse or telecentric lighting • suitable for testing bore holes • Preferred lighting system for presence monitoring (binary image)	• uniformly bright, high-contrast image • almost binary attributes
	Dark field	• Transparent test objects like glass or plastics • Very small distance between test objects and lens possible	• surface characteristics as light details on a dark background
Incident lighting	Bright field	• suitable for transparent and opaque parts (glass, metal, plastics)	• uniformly bright, well-contrasted image

Direction	Angle	Applications	Specialty
		• also suitable for rough, poorly reflecting surfaces	• possible with coaxial mirror lighting
	Dark field	• emphasizing shapes, scratches, cracks, etc. • determines both, engraved and raised structures • suitable for transparent and opaque parts • particularly suitable for surface inspections, also highly reflective parts	• difficult with dirt

11.3.2.2 Lighting structure

Besides homogenous light there are following lighting structures:

Dimensions	Illuminant	Procedure	Specialty
0	Light point	Triangulation	• light beam is sent to the surface obliquely • if the object's distance changes in front of the lens, the point where the light passes the lens will move laterally • the lateral movement will be displayed and measured • the lateral offset of the image is a measure for the change in distance
1	Light line	Light section method	• oblique projection • translate depth information in image coordinates (e.g. z in x) • expand the triangulation principle to many parallel measurements (here the Y coordinate)
2	Light grid	Grid projection method	• phase shift process returns dense spatial information

11.3.2.3 Further factors

Further factors of lighting systems are:

- **wavelength**
  - color
- **type of lamp**
  - incandescent lamp
  - discharge lamp
  - LED
- **long-term behavior**
  - aging
  - pollution
- **short-term behavior**
  - AC/DC supply
  - radio-frequency operation
  - flash