

How Far Can We See with Given Lens?

Category	Educational Note
Sub-Category	Video Quality, Application
Camera Model	N/A
Firmware Version	N/A
Software Version	N/A
Publish Date	2009/10/29
Last Review	2009/11/02

Contents

- Introduction
- Definition of Face Recognition
- The Size of Sensor
- Gather Necessary Specifications
- The Graph for Calculations
- Formulas
- One More Example – ACM-4200
- Backwards Calculation
- Lens Selection Table

Introduction

We are often asked, how far you can see with this or that lens. If you tell them the camera has 35x optical zoom lens, they might not understand it easily.

This article introduces a simple method of calculation which can give you the answer in **meters**.

In order to make “how far can see” more specific and meaningful, we have to clarify what we want to see.

Most commonly, we use the zoom in order to recognize faces. So, **our goal will be to find the farthest distance in meters by which we are still able to recognize the face of a person.**

The following calculation method can be applied for zoom lenses (in maximum zoom-in position), vari-focal lenses (in maximum zoom-in positions) and fixed lenses.

Definition of Face Recognition

The smallest unit for presenting an image is pixel. How many pixels of width are sufficient to display a face so that it is recognizable?

The series of practical tests that we conducted led us to the conclusion that **36 pixels** of width are enough to recognize face. The width of face is about **0.2 m**.

36px
↔



This face is
recognizable!

The Size of Sensor

In the datasheets, you find the size of CCD, normally it is either 1/2 inch, 1/3 inch or 1/4 inch. These numbers show the length of the diagonal of the CCD. The following table shows the actual vertical and horizontal size of CCD:

CCD diagonal	Actual width	Actual height
1/2"	6.4 mm	4.8 mm
1/3"	4.8 mm	3.6 mm
1/4"	3.6 mm	2.7 mm

Gather Necessary Specifications

Check the maximum focal length of your zoom or vari-focal lens (if you have fixed lens, then just choose the focal length it has), for example CAM-6630 maximum $f = 119$ mm.

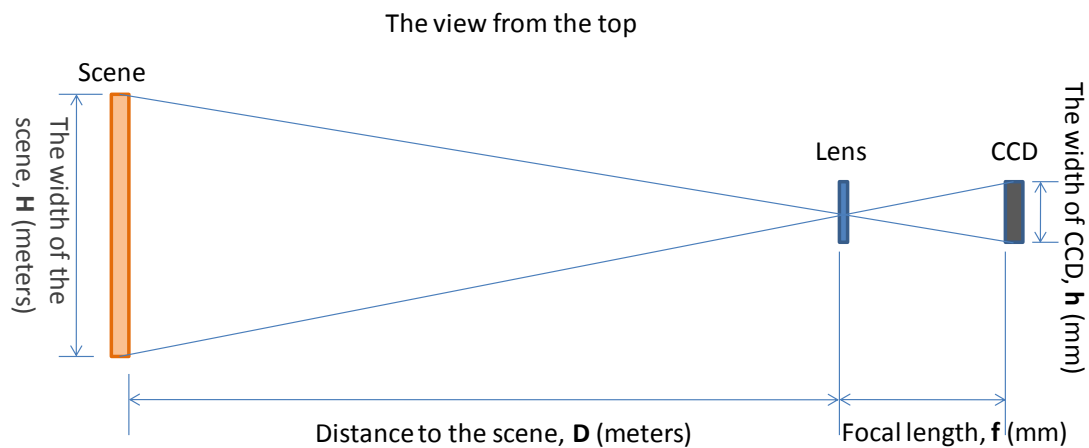
Check the maximum image resolution (width) in pixels, for example CAM-6630P maximum image width = 752 px.

Check the size of CCD, for example CAM-6630 CCD size is 1/4", which means $h=3.6$ mm and $v=2.7$ mm.

The Graph for Calculations

Below there is a graph that illustrates the calculation method. It is the view from the top. The goal is to find:

- The width of the scene – H (meters)
- The distance to the scene – D (meters)



Formulas

The width of the scene:

$$H = 752\text{px} * 0.2\text{m} / 36\text{px} = \mathbf{4.18\text{ m}}$$

The distance to the scene:

$$D = f * H / h = 119\text{mm} * 4.18\text{m} / 3.6\text{mm} = \mathbf{138\text{ m}}$$

The conclusion: With given lens and camera, the face can be recognized as far as from **138 meters!**

One More Example – ACM-4200

Maximum resolution: **1280px**

Focal length of bundled lens: **4.2mm**

CCD size: 1/3", means **h=4.8** and **v=3.6**

$$H = 1280\text{px} * 0.2\text{m} / 36\text{px} = \mathbf{7.11\text{ m}}$$

$$D = f * H / h = 4.2\text{mm} * 7.11\text{m} / 4.8\text{mm} = \mathbf{6.2\text{ m}}$$

If the monitored area is farther than 6.2 meters and you need to recognize faces, then you should consider choosing another lens for ACM-4200, for example 6mm or 12mm vari-focal lens.

Backwards Calculation

In real life applications, you probably have already a given distance and you need to choose appropriate lens that can do the job for this distance.

Let's use the ACM-4200 example again. You have decided to install ACM-4200 and you know it has to be able to recognize faces from 11 meters, because that is the length of the hallway where the camera is to be installed.

The width of the scene does not change: $H = 1280px * 0.2m / 36px = 7.11 m$

$D = f * H / h = f * 7.11m / 4.8mm = 11 m$

$f = 11 * 4.8 / 7.11 = 7.4 mm$

The conclusion: For the given camera and with the requirement of face recognition from 11 meters, the ACM-4200 camera has to have a lens with the focal length of **7.4mm** or more. For that case please refer to the ACTi lens selection table to choose a fixed or vari-focal lens that has a maximum focal length 7.4mm or more.

Lens Selection Table

From the cross table below you can find the available lenses and the cameras they can be applied for. The numbers behind each camera model represent **the maximum distance in meters at which the face can be recognized** with given lens.

Please note that only the black numbers represent currently available combinations of camera and lens while the grayed figures are for theoretical reference only.

Lens Name	PLEN-0101	PLEN-0102	PLEN-0103	PLEN-0104	PLEN-0105	PLEN-0106	PLEN-0107	PLEN-0108	PLEN-0109	PLEN-0110	PLEN-0111	PLEN-0112	PLEN-0201	PLEN-0202	PLEN-0203	PLEN-0204	PLEN-0205
Old Name	LEN-101	LEN-102	LEN-106	LEN-107	LEN-108	LEN-109	LEN-112	LEN-113	LEN-114	LEN-115	LEN-117	LEN-118	LEN-201	LEN-205	LEN-207	LEN-209	LEN-210
Size	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/3"	1/2"
Mount	CS	CS	CS	CS	CS	CS	CS	Board	Board	Board	Board	Board	CS	CS	CS	CS	C
Type	IR	IR	Normal	Normal	IR	IR	Normal	IR	IR	IR	Normal	Normal	Normal	IR	IR	IR	IR
IRIS	Fixed	Fixed	Auto	Auto	Auto	Auto	Manual	Fixed	Fixed	Fixed	Fixed	Fixed	Manual	Manual	Auto	Auto	Auto
Aperture (F)	1.8	1.8	1.0	1.4	1.0	1.3	1.4	1.8	1.8	1.8	2	2	1.2	1.6	1.3	1	1.6
Focal Length (mm)	4.2	8	3 8	5 55	3 8.5	7.5 50	3.5 8	3.6	6	12	2.4	2.4	2.4 6	2.8 12	2.8 12	2.9 8.2	8 80
Field of View (HOR)	75	40	36.8 94.3	61 5	94.2 33.5	90.5 33.6	106 43.2	85	50	25	116	116	111.3 47.1	102.2 23.7	102.2 23.7	95 35.6	46.6 4.7
CAM-5201 CAM-5301	3.5	6.7	6.7	45.8	7.1	41.7	6.7	3.0	5.0	10.0	2.0	2.0	5.0	10.0	10.0	6.8	66.7
CAM-5221 CAM-5321	3.5	6.7	6.7	45.8	7.1	41.7	6.7	3.0	5.0	10.0	2.0	2.0	5.0	10.0	10.0	6.8	66.7
ACM-3001	3.1	5.9	5.9	40.7	6.3	37.0	5.9	2.7	4.4	8.9	1.8	1.8	4.4	8.9	8.9	6.1	59.3
ACM-3401	6.2	11.9	11.9	81.5	12.6	74.1	11.9	5.3	8.9	17.8	3.6	3.6	8.9	17.8	17.8	12.1	118.5
ACM-3601 ACM-3603	3.1	5.9	5.9	40.7	6.3	37.0	5.9	2.7	4.4	8.9	1.8	1.8	4.4	8.9	8.9	6.1	59.3
ACM-3701 ACM-3703	6.2	11.9	11.9	81.5	12.6	74.1	11.9	5.3	8.9	17.8	3.6	3.6	8.9	17.8	17.8	12.1	118.5
ACM-4000 ACM-4001	3.1	5.9	5.9	40.7	6.3	37.0	5.9	2.7	4.4	8.9	1.8	1.8	4.4	8.9	8.9	6.1	59.3
ACM-4200 ACM-4201	6.2	11.9	11.9	81.5	12.6	74.1	11.9	5.3	8.9	17.8	3.6	3.6	8.9	17.8	17.8	12.1	118.5
ACM-5001	3.1	5.9	5.9	40.7	6.3	37.0	5.9	2.7	4.4	8.9	1.8	1.8	4.4	8.9	8.9	6.1	59.3
ACM-5601	6.2	11.9	11.9	81.5	12.6	74.1	11.9	5.3	8.9	17.8	3.6	3.6	8.9	17.8	17.8	12.1	118.5
ACM-5611	6.2	11.9	11.9	81.5	12.6	74.1	11.9	5.3	8.9	17.8	3.6	3.6	8.9	17.8	17.8	12.1	118.5
ACM-5711	3.5	6.7	6.7	45.8	7.1	41.7	6.7	3.0	5.0	10.0	2.0	2.0	5.0	10.0	10.0	6.8	66.7
ACM-5801 ACM-5811	3.5	6.7	6.7	45.8	7.1	41.7	6.7	3.0	5.0	10.0	2.0	2.0	5.0	10.0	10.0	6.8	66.7
TCM-4301	6.2	11.9	11.9	81.5	12.6	74.1	11.9	5.3	8.9	17.8	3.6	3.6	8.9	17.8	17.8	12.1	118.5
TCM-5311	6.2	11.9	11.9	81.5	12.6	74.1	11.9	5.3	8.9	17.8	3.6	3.6	8.9	17.8	17.8	12.1	118.5