GEOMETRIC / LOCAL / GLOBAL

1.) Name the three classes of operators dealing with machine vision, the key features, and at least one example.

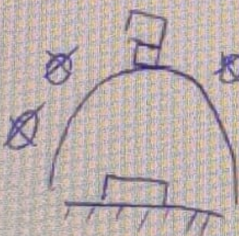
[10] —

Offline: - complex algorythms - no camera - image analysis - Test-phase Matlab	Interactive: - ~~smat~~ - smart sensor - rapid prototyping - doesnt need special personal (can be done by amateurs) LabView	fully automated - close to hardware - real time - feature recognition - Open CV (Python) - HVAC (C++)

2.) Diffuse illumination/shade projection: **A)** Draw a sketch for both of them. **B)** What are the main applications these are used for (include reasoning)?

[10] 10

A)



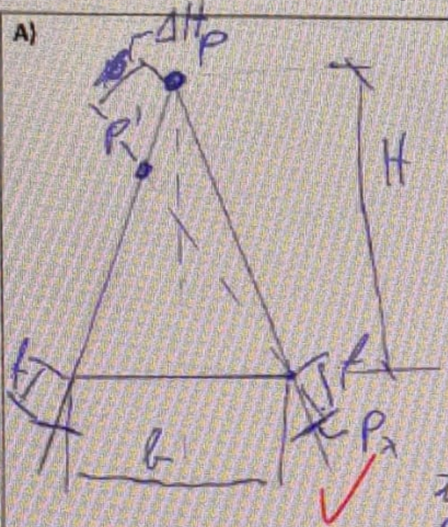
Diffuse illumination => no shadows
Is mainly used for 3D-Objects
Since there are no shadows it is easier to extract all features and measure precisely ✓

B)

Here the shadow of the object is measured. Is used when the background and the Object have similar grey levels. ✓

3.) **Stereography - depth resolution: A) How is the definition (words/sketch/formular)? B) Select a proper lens out of available ones (f = 6/8/12/16/25/50/200 mm) (including reasoning/calculation) to fulfill the following application: There are two capturing devices with a distance of 60 mm; the distance to the object is 2.0 m; the pixel grid is 5.6 µm; the depth resolution has to be <= 5 mm.** [15] 15

A)



$$\Delta H = \frac{P_x \cdot H^2}{f \cdot b}$$

ΔH = depth resolution

Descripes how far an object can move along ~~as~~ the optical axes of a ~~camera~~ camera, bevore ~~it is visible at~~ it changes the Pixle in the other camera

b ... Base line

P_x ... Pixle size

B)

$$\Delta H = \frac{P_x \cdot H^2}{b \cdot f}$$

$$\frac{P_x \cdot H^2}{b \cdot f} \leq 5$$

$$f \geq \frac{P_x \cdot H^2}{b \cdot 5} = \frac{5{,}6 \cdot 10^{-3} \cdot 2000^2}{60 \cdot 5}$$

$$\underline{f \geq 74{,}6\,mm} \Rightarrow \underline{f_{chosen} = 200\,mm}$$

4.) Convolution filter: Set the kernel elements for a Prewitt-filter for horizontal edges? [5] 5

Filter matrix

-1	-1	-1
0	0	0
1	1	1

5.) A) State the key features of a lens (at least three); B) which values/descriptions will these features take approximately? [5] 5

A)

- Focal Distand f
- f-number
- ~~[illegible]~~
- fit sensor format
- lense style/type
- fits sensor?

B)

fnumber: in theorie from $1 \to \infty$

in practice 1; 1,2; 1,4; ... 2; 6; 8

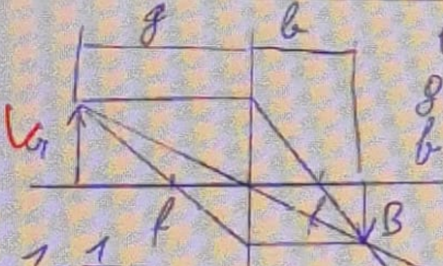
lense style: - telecentric lense: only parallel beams from object

- fishe eye: wide field of view
- Macro-lense: short distances → object near lens

focal Distand/Brenn~~punkt~~ -weite: If the only Barallel beams hit the lence then this is the point where they cross at other side. Influences f-number etc.

6.) **A)** Describe the Model of Thin Lens (sketch, essential beams of radiation, parameters, formular). **B)** What is the relation between opening diameter of the iris and depth of sharpness? [10] 10

A)



f... focal Distance
g... object to lens (length)
b... distance ~~Object~~ lense to imaging plane
G... Object B... Image

$$\frac{1}{f}=\frac{1}{g}+\frac{1}{b}$$

$$\boxed{\frac{B}{G}=\frac{b}{g}}$$

For the thin lense it is assumed, that it is so thin, that Beams of light only bend in the middle.

B)

D gets smaller => f-number gets bigger => depth of sharpness gets bigger / and vice versa f number $= \frac{f}{D}$

7.) Homography: **A)** Name the three hierarchical levels of the homographic projection and state the differences (sketch/formula). **B)** Camera calibration: what are the three essential transformations (name; which parameters are included by each of these transformations? [10] 7

sketches on page 8.

A)

euclidian rotation $\begin{bmatrix} \cos & -\sin & 0 \\ \sin & \cos & 0 \\ 0 & 0 & 1 \end{bmatrix}$, translation $\begin{bmatrix} 1 & 0 & d_x \\ 0 & 1 & d_y \\ 0 & 0 & 1 \end{bmatrix}$

He

distances and angles preserved

Affine (includes euclidian) scaling $\begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$, shearing $\begin{bmatrix} 1 & S_y & 0 \\ S_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

$H_a = H_e \cdot H_{aff}$. preserves parallel lines

Homography (includes others) only where lines cross is preserved

→ rectify image → from one plane into another

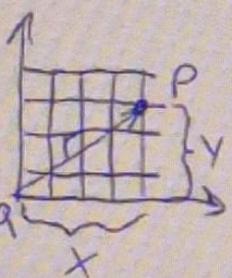
B)

Rectification is used to project geometry into another plane; uses homography.
also see A)

B) EXTRINSIC
PERSPECTIVE
INTRINSIC

8.) Discrete mathematics: **A)** What is the meaning of distances; which are the different formulars (sketch)?
B) Why are there different types? [10] 10

A)



Euclidean: $D = \sqrt{(Q_x - P_x)^2 + (Q_y - P_y)^2}$
≙ length of arrow r

Block Manhattan: $D = |Q_x - P_x| + |Q_y - P_y|$
~~ChessBo~~ ≙ would be x+y

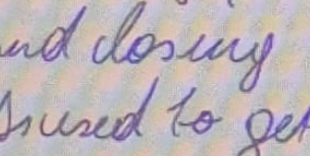
Chess Board: $D = \max(|Q_x - P_x|, |Q_y - P_y|)$
≙ would be x

B)

Euclidean is the most accurate but has high computational cost. Both others are not as accurate but 20x faster.

9.) Morphology – erosion: Describe the operation by text and sketch; name an example of an application. [10] 10

~~The~~ Used on binary images. If one of the pixels in its kernel is not set, the point to be calculated is also not set. => ~~The~~ Lines / Objects get thiner or circles can be opened.
=> Used together wit dilitation for opening and closing
=> Is used to get rid of small distortions



~~sta~~ sorry for bad sketch ·̈

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10.) CCD vs. CMOS: **A)** What does CCD stand for? **B)** Which capturing steps have to be fulfilled by the CCD and the photodiode sensor? **C)** What characteristics do these two different sensor types have/what are the underlying physical processes? [15] 15

A) Charge Coupled Device ✓

B) CCD:

1) Discharge ✓
2) Expose (0,5 → 20 ms)
3) Stop Exposure
4) read out (Shift registers)

photo diode:
here the readout is continuos
=> can always be exposed ✓

C) CCD: Has small capacitores, which are charged by luminous flux. Than charges are shifted to read them out ✓ at one single point.
Can have transistor as well (CMOS)
- needs shutter
- brightness corelates to charge
- Fillfactor: CCD = 90% → higher pixeldensity
CMOS = 30%

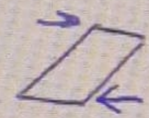
Photodiode: The photo diode changes its resistance when hit by electrones. Has transistor
=> can controll sensitivity. Back current ✓ is measured => high noise (small current)
=> continuos readout
- fill factor ~ 30%

7.A) rotation:

translation:

scaling:

sheer:



homography: