







*Become a nut cracker.*  
*Our training programme for your Machine Vision.*



Questions and answers for newcomers  
in Machine Vision



Ingmar Jahr, Head of training, Vision Academy, Erfurt  
[www.vision-academy.org](http://www.vision-academy.org)



## The Vision Academy

- Service provider for the industry
- More than 15 years further education and obtaining of practical technology know-how:
  - destination different groups of users
  - using practical industrial types of problems
  - neutral, effective and interdisciplinary
  - with well-grounded technical background.
- The Vision Academy cares for

**More time!**

We train the knowledge you need.

**More independence!**

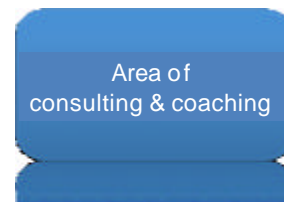
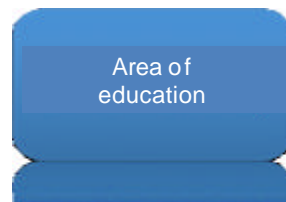
Self-sustaining understanding and control of Machine Vision

**More safety!**

Vision know-how makes sustainable.

## The Vision Academy

- Worldwide first education organization for Machine Vision
- Accompanies companies along the way the successful of use Machine Vision
- 2 areas:



- eight employees ar
- more than 500 part
- own training and laboratory rooms
- worldwide radius of action: Erfurt, in-house, at the customer

## Our customers



## Content

- Machine Vision inside and outside the area of industry
- Industry needs Machine Vision
- Components of Machine Vision
- Which types of problems can be solved?
- Check problem – feasibility – integration
- Keep Machine Vision running
- Limits of Machine Vision
- How to build up Machine Vision knowledge

## Machine Vision is everywhere

- non-industrial applications



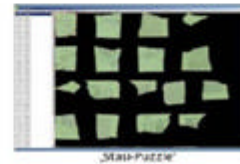
**Extra gentle for the most sensitive skin.**

Start with ultra-sensitive skin, add the chemicals and moisture of urine and stools, and you have diaper rash.

Baby diaper's unique high-absorbency natural-based cotton-pulp padding provides cotton-soft, extra-thick, gel-free protection for your baby's sensitive skin. The chlorine-free materials and soft-care polymers in new tops and inner linings. Clinically and aesthetically recommended for babies with allergies and sensitive skin.

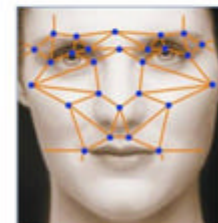
*baby™*

If you get an identical eMail by baby Diapers promotion, you will get your diaper back. Read more about our baby diaper promotion at www.baby.com



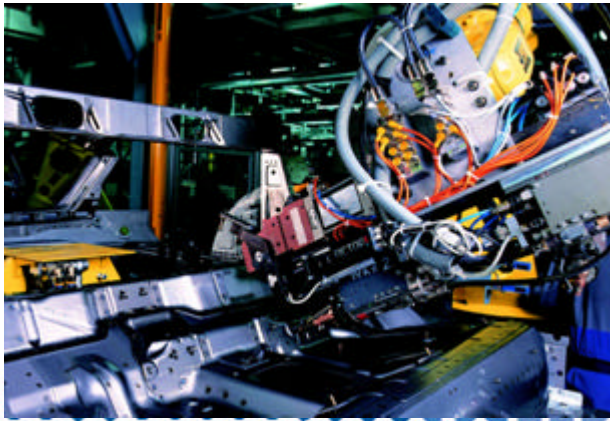
## Machine Vision is everywhere

- non-industrial applications



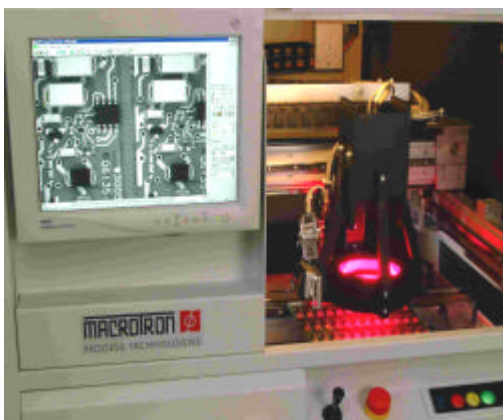
## Machine Vision is everywhere

- industrial applications



## Machine Vision is everywhere

- industrial applications



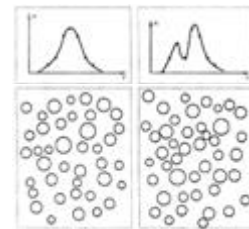
## Industry needs Machine Vision

### Which human weak points are to avoid?

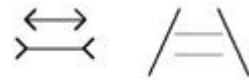
- slow adaption of the eye
- subjective-intelligent post processing
- measurement accuracy? – only qualitative statements
- optical illusions
- limited phase of attention, reliability
- different form on the day („Monday products“)
- not everything is visible
- too slow
- serial processing of inspection jobs
- only one view



Simultaneous contrast



Lack of accuracy



Optical illusions

## Industry needs Machine Vision

### What can camera eyes see different?

	camera	eye
resolution	> 25 MPixel	ca. 130 M"Pixel"
grey values	> 1 Mio. ( $2^{20}$ )	$2^6 \dots 2^7$
hue	> 16 Mio.	> 7 Mio. (depends on gender!)
speed	> 1 kHz possible	> 5 fps not to resolve
3D	limited	very good
complex information	limited to process	very good to process
robustness against variation	partial	general extremely good
accuracy	quantitatively good	qualitatively good
constancy	long lasting	decreasing
running costs	high, if small output volume	high, if large output volume

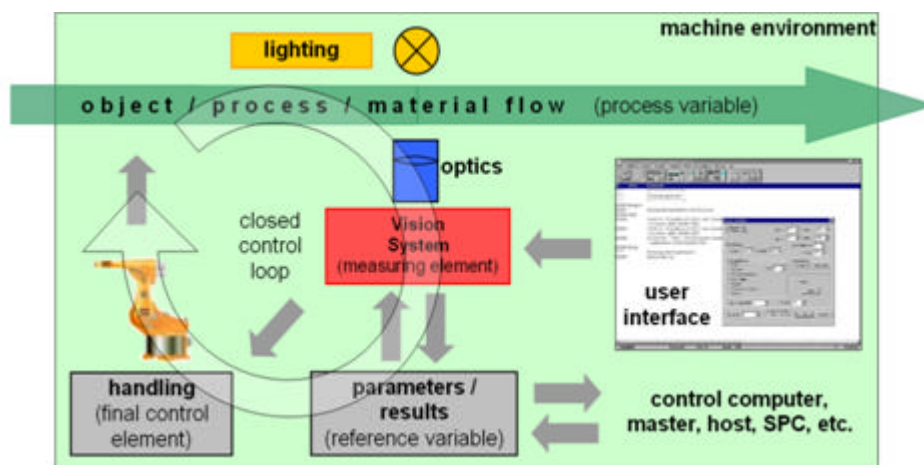
## Industry needs Machine Vision

### What is the benefit of Machine Vision?

- Continuous automated solutions
- Products with documented quality
- No added value to bad products
- Avoid from follow-up costs
- Better operating rate of the machine
- Optimization of production / control of technological processes
- Fast 100%-inspection
- Linking up with other technology
- pervious commodity flows
- Products are better salable



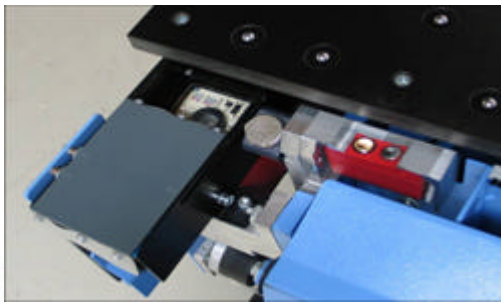
## Basic principle and components are always similar ...



## ... but solutions are different

**Standard solutions?** Yes and no!

- Individual solutions are always new.
- Machines in series: standardized and optimized solutions.
- Check problem, test object and environment determine the structure.



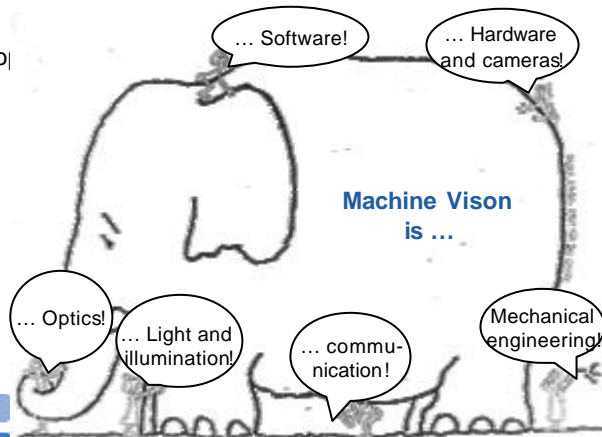
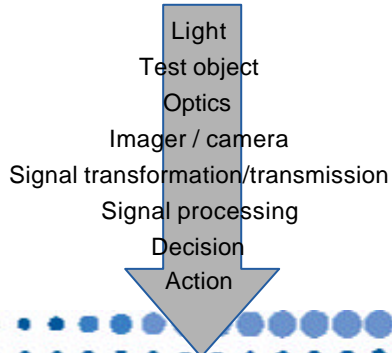
Standardized solution for tool adjustment of saw machines (Source: Holzmat)



## MV is cooperation of different components

**What knowledge do I need?**

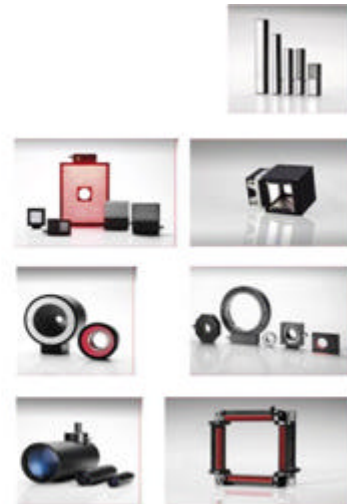
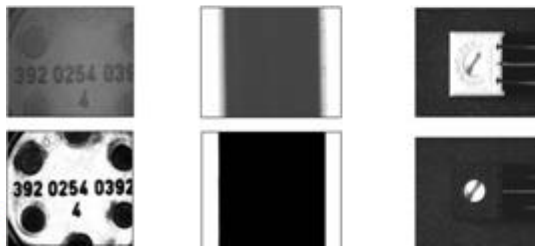
- Pay attention to signal path! (error pro)



## The most important thing: illumination

### Is a ,lamp' enough?

- More than 2/3 of the solution are lighting!
- Create contrast!
- Consideration: 1000 EUR for a lighting component against 4 weeks fruitless software development?
- Different techniques and components

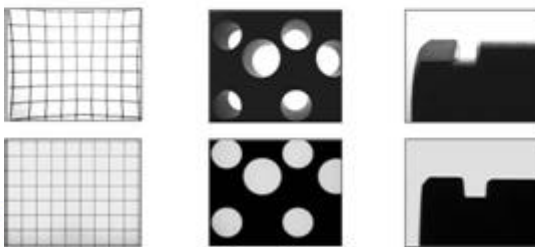


Source: Vision & Control

## Optics – more than a piece of glass

### The optics differs so much in the price - why?

- Shaping the light information, adaption to the environment
- Avoid aberrations, know them, take into account
- entocentral / telecentral objectives (measurement)
- Fragility  $\leftrightarrow$  industrial proofed construction!



Source: Vision & Control

## Different Vision Systems

### Can I choose the performance of the Vision System?

- Vision Sensors Between light barrier and Smart Camera  
Simple operation – all in one  
Fixed, reduced Functionality  
Starting Machine Vision
- Smart Cameras Free definable jobs in one view  
Separation of processing and operation  
Good connection to the process  
Flexible adaption
- Multi camera systems Complex jobs in 2+ views  
Maximal performance  
Colour / bw, line / matrix, low res / high res  
Partially extensive programming



Source: Vision & Control

## Different Vision Systems

	Vision Sensor	Smart Camera	Multi camera system
Complexity of check problem	small	medium	high
Solvable problems	special	universal	universal
Software adaption	no	different levels: worker, master, programmer	
Flexibility for other parts	bad	good	good
No. of inspection positions	1	1	1 to >8
Connection to the process	no	yes	maximal
Typical speed [parts/s]*	10 to 15	to 100	> 100 <small>* depends on problem</small>
Component costs	< 2.000 EUR	> 2.000 EUR	> 5.000 EUR
Costs for integration	small	medium	medium to high
Costs maintenance	small	small	small to medium
Necessary knowledge	small	considerable	extensive

## Software – key to the functionality

### What type of software do I need?

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>• Software libraries</li> </ul>        | <p>Flexible and universal<br/>Tested, development of versions, bugfixes<br/>Experiences / Programming in MV<br/>Each application is newly programmed</p> |
| <ul style="list-style-type: none"> <li>• Preconditioned programmes</li> </ul> | <p>Purpose-oriented fast way in to MV<br/>Time effective and simple<br/>Makes complex solutions possible<br/>Extensions difficult</p>                    |
| <ul style="list-style-type: none"> <li>• Component based approach</li> </ul>  | <p>Uses Microsoft object model<br/>Standardized flow / data exchange<br/>only for Windows<br/>Knowledge in Windows programming</p>                       |



Source: [www.mvtec.com](http://www.mvtec.com)



Source: [www.vision-control.com](http://www.vision-control.com)



Source: [www.siemens-imaging.us](http://www.siemens-imaging.us)

## What tasks can be solved?

### Measurements

#### *geometric*

- coordinates
- length (width, height, distance)
- angle / orientation
- surface area
- centre of gravity
- straight-, roundness
- shape / contour

#### *photometric*

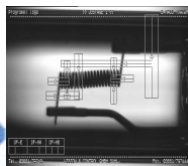
- brightness, intensity

#### *colorimetric*

- colour, wavelength

#### *thermometric*

- temperatures



### Gauging

#### *all task from 'measurement' plus:*

- presence / completeness
- attributive tests
- position / orientation
- surface inspection
- structure-, texture recognition
- print control
- pattern matching
- object recognition / part identification
- read codes and characters
- numbers, quantities

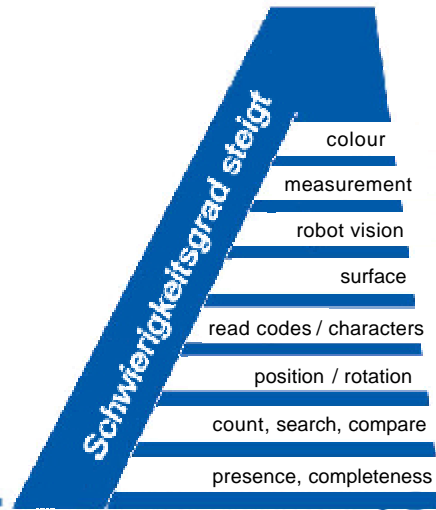
...



## The check problem

### What is easy? What is difficult?

- Complete, exact terms of reference!  
(description part, environment, interfaces)  
→ use checklists
- Describe test features clearly! → catalogue  
(kind, place, relevance, critical size of defects  
examples for good parts)
- Desire and reality. Are all partial problems solvable?
- Conditions for testing have to be fixed (environment)
- Do we speak the same language?  
(100% testing, reject rate,  
pseudo rejects, error rate in ppm)



## The feasibility

### Can all my demands be fulfilled?

#### Technical feasibility:

- Clarification of technical possibilities, advantages, disadvantages
- Study (use services)
- If necessary separation in different tasks
- Look ahead: How much MV do I need in the future (upcoming parts)?

#### The own feasibility study:

- Make or buy?
- Clarification of necessary know-how, collection or partners



## Offer and price

### Are different offers comparable? Is the price too high?

- The reason: Single outstanding data stay in mind.  
(especially introductory price of Vision Sensors)
- The problem: Limited function does not fit to the application.
- Clarification: Does the budget fit to the scope of the application?
- Clarification : What shall contain the offer? (make or buy)
- Range:
  - components
  - Consulting + own solution
  - common solution MV-provider and user
  - turn-key integration
  - complete solution
  - Machines in series with MV
- Make = collect knowledge + do it yourself - Buy = pay for services



## Specifications are standardized

### How do I put the check problem into words?

- VDI guidelines support (in English too):
  - 2628: Automated optical inspection – description of the check problem
  - 2632: Guideline for the preparation of specifications for Vision Systems
  - 3694: Specifications for the use of automation systems

ICS 01.040.37, 35.240.50	VDI/VDE-RICHTLINIEN	November 2011
VEREIN DEUTSCHER INGENIEURE VERBAND DER ELEKTROTECHNIK ELEKTRONIK INFORMATIONSTECHNIK	Industrielle Bildverarbeitung Leitfaden für die Erstellung eines Lastenhefts für Bildverarbeitungssysteme	VDI/VDE 2632 Blatt 2

## The integration

### How do I get the solution?

- Clarification: Make or Buy? (you or a service provider)
- „Machine Vision is much mechanical engineering“ (engineering, adjustments, setting, handling)
- Handling of varieties of interfaces (mechanical, electrical, IT)
- Problem of changed boundary conditions to the offer:
  - Test object
  - Test environment (positioning, illumination, time, ...)

The dilemma:

- MV provider has expertise in Machine Vision
- User has expertise concerning product, production method, industrial sector
- → use provider with knowledge of the trade

## Keep Machine Vision running

### Who cares for the machine after starting up?

- MV needs care!
- Somebody in the company has to be responsible for MV
- Changes in the production method instantly become evident:
  - changes in part properties
  - changes in checking method (changes, additional check criteria), speed
  - changes in environmental conditions
- Do the operators accept the new technology? → job for the management
- Are the employees able to work with MV? → improve MV qualification

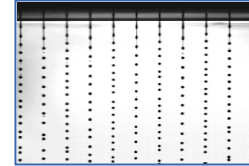
## Are there limits?

### Extreme applications

- Measurement of stamping parts:  
50 liftings / s, feed 2 m / s, 0,08 mm accuracy
- Surface inspection endless material, speed 120 km/h
- Control of foundry crane at 450°C environmental temperature
- Surface cracks at injection valves < 300 nm

### Recognition is limited by:

- Wavelength of the light (< 1 µm only statistical)
- Quality of the components
- Accuracy of the algorithms
- Cycle time (car body: 100 s/part, stamping parts: 20 ms/part)
- Accessible accuracies depends on application
- Repeat accuracy in industrial environment < 10 µm almost impossible

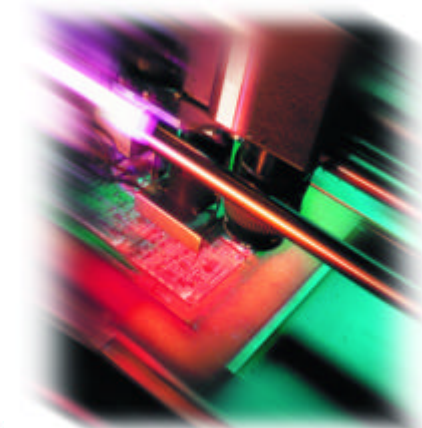


Measurement of ink drops in flight  
Speed 8 m/s  
(Field of view 0,6 x 0, 8 mm²)



## Are there limits?

- **Adverse, unstable environmental conditions:**  
vibrations, variations of temperature, dust,  
dirt, humidity, aerosols, heat, oil film, ...
- **Changing part properties / products:**  
sizes, optical properties (e.g. corrosion,  
colour deviations), adverse part geometry, ...
- **Too much features to check:**  
„challenge cups“,  
optical 3D measurement not always possible



## Are there limits?

### Human influences:

- unrealistic expectations of the user  
comparison of single / spectacular advantages previous measuring methods
- today's and all future products with still unknown properties shall be auditable
- unqualified / sabotaging operators:  
convincing the staff from the benefit of MV is first duty of management
- Management does not exempt personal resources for MV

### Pay attention!

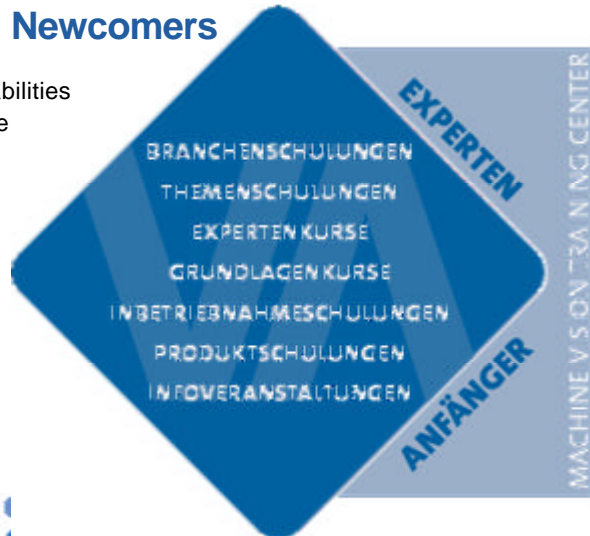
- MV intervenes strongly in social-technical systems
- increasing efficiency is only one side of the coin.
- Technology shall make easier the work of men.
- If technology is a threat it will be declined.

## Summary

- Today Machine Vision is omnipresent.
- Possibilities / capabilities against human inspection are increasing steadily.
- Variety of solvable check problems demands knowledge.
- Approach for newcomers: From simple to difficult.
- To find a solution and conversion into reality is a question of make or Buy.
- MV needs care!
- MV does not work whatever happens.
- MV can be learned!

## Obtain MV-knowledge for Newcomers

- **Training** for practically applicable capabilities
- Way in with different level of knowledge
- Step by step start up
- modular concept
- Worldwide available
- Dates: [www.vision-academy.org](http://www.vision-academy.org)
- **Coaching:**
  - Coaching for newcomers
  - Coaching for component selection
  - Coaching for complete solutions
  - feasibility studies
  - procurement of solution partners



More under [www.vision-academy.org](http://www.vision-academy.org).

## Crack with us the hard nuts!

- Use your voucher to build up know-how, for coaching, for ... !
- Learn more under [www.vision-academy.org](http://www.vision-academy.org)!

**Ask now!**

