# IMAGE PROCESSING AND LASER SENSOR SYSTEMS

## ROBOT-VISION

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THE COMPANY

VMT® provides individual turnkey image processing and laser sensor systems for nearly all industrial fields, ranging from the automotive to the pharmaceutical industry. The members of the VMT team of highly qualified experts have 20 years of experience in industrial image processing.

THE MARKETS

- The whole automotive industry and all the relevant suppliers
- Suppliers of automated industrial facilities, robot manufacturers, and system companies
- Machine engineering and handling equipment suppliers
- Pharmaceutical industry, medical technology, food industry
- Press shops
- Foundries
- Household suppliers

THE SUPPLY PROGRAM

Image processing and laser sensor systems for integration into existing and new assembly facilities.

- 2D and 3D robot vision
- Robot position control
- Robot path correction

THE SERVICE PROGRAM

Experienced engineers, technicians, and mechanics launch your enterprise into operation and provide training for you, your employees and your customers.

We carry out preliminary and field tests, in a professional and qualified manner, thus giving you a solid basis for your investment decisions-making.
CAMERA VERSIONS

Camera in protection case IP65, silicon-free (VMT® Standard)

Swivel/tilting-head camera with a movable sensory head in industry-proof casing

Camera housing with a controllable protective cover in lacquer-proof version

SYSTEM VERSIONS

Vision System, Rittal-case version

Vision System, compact version
Since operation is being kept so simple, two days of training are usually sufficient to be able to operate the system.

Integrated into an automatic sequence VMT IS fulfills its task reliably. In case of irregularities, it is possible, with the aid of statistics and service tools, to analyze the source of the problem and remove the cause.

■ Suitable for bare and cataphoretic varnished car bodies, as well as primed and finish-lacquered bodies
■ Inspection, supervision, type identification and spray checking with one and the same system
■ Simultaneous measuring of several objects with individually calculated object positions for higher processing accuracy
■ Quickly trainable to identify the largest variety of characteristics, thus very adaptable to object modifications
■ Generates correction data in relation to reference position
■ Suitable also for difficult application conditions, such as changing background, etc.
■ Reliable measuring, even if a camera fails or a characteristic is covered up
■ Plausibility check for verification of measuring results and elimination of collisions
■ Measuring of the relative position of components mounted on an object
■ Automatic image storage, thus requiring little time for operation startup and optimization
■ Gap-free logging of all system activities internally and of the interfaces to unit control and to the robot
■ Cyclic measuring of tool geometry on the robot possible (Rob Check)
■ Communication with multiple robots concurrently (standard protocols, all manufacturers)
■ Protected procedures for simple camera calibration and readjustment, without further auxiliaries
■ Optional offline teaching station for preparation of new and optimizing existing models
Some examples of realized applications

The illumination concept used for this application has been specially adapted for the given task and are of substantial importance for the reliability of recognition of the whole system.

APPLICATION OF TAPE ON WINDOW FLANGE

The task:
Covering up a certain area of the window with a tape before lacquer application. Position recognition of the car body to correct the robot path. Cycle time approx. 1 sec per body.

Frame conditions:
- Required accuracy better than ± 1 mm
- Different body colors
- Recognition without hole characteristics

APPLICATION OF ROOF SEAM SEALING

The task:
Application of a sealing material onto the roof seam. Recognition of the roof area to correct the robot path. Cycle time ≤ 1.5 sec per body.

Frame Conditions:
- Different body colours
- Different body types
- Recognition without hole characteristics

Window module before tape application

Roof seam

Camera in special housing with a protection lid

Window module after tape application
APPLYING OF PLATFORM COATING AND STONE PROTECTION

The Task:
Application of platform coating and stone protection. Position recognition of the car body to correct the robot path.
Cycle time approx. 1 sec per body.

Frame Conditions:
- Required accuracy ± 1 mm
- Different types highly differing in length

SEAM SEALING ON THE FLOOR AND INTERIOR OF TRUCK CABINES

The Task:
Application of seam sealing to the platform, in the interior and in the wheel box. Recognition of the body's position to correct the robot path.
Cycle time approx. 1 sec per body.

Frame Conditions:
- Required accuracy ± 1 mm
- Different types highly differing in length

PALE ASSEMBLY ON REAR DOORS

The Task:
Installation of glasses in rear doors. Position recognition of the left and right rear door and glass to correct the robot before assembly.
Cycle time approx. 2 sec per Window.

Frame Conditions:
- Required accuracy ± 0.4 mm
- Different vehicle types (length, height) on one and the same assembly line.
- Complete color spectrum of lacquered doors

Hand camera controlled robot during pane assembly
SEAM SEALING IN THE INTERIOR OF AUTOMOBILE BODIES

The Task:
Application of seam sealing in the interior of automobile bodies. Recognition of the body’s position to correct the robot path.
Cycle time approx. 1 sec per body.

Frame Conditions:
- Required accuracy ± 1 mm
- Different body types on same assembly line
- Multiple robots working concurrently

CAVITY PRESERVATION AT VANS

The Task:
Preservation of cavities in sills and in the rear, on doors and hoods. Position recognition of the body, lids, as well as side doors to direct the robot correctly.
Cycle time approx. 2 sec per body.

Frame Conditions:
- Required accuracy ± 1 mm
- 3 different vehicle lengths
- Complete color spectrum

RECOGNITION OF BODY POSITION

The Task:
Application of seam sealing to the platform and in the wheel box. Recognition of the body’s position to correct the robot path.
Cycle time approx. 1 sec per body.

Frame Conditions:
- Required accuracy ± 1 mm
- 4 different body types on same assembly line
Wheel assembly using 3D position recognition with 3 cameras

The Task:
Automatic application of type plates on engine blocks. Recognition of the engine's position to correct the robot.
Cycle time approx. 3 sec per engine block.

Frame Conditions:
- Required accuracy ± 1 mm
- 3D position identification using hand camera from 2 positions (stereo vision)
- Over 12 engine type variants

Platform Sealing at Vans

Recognition of the body's position

The Task:
Application of seam sealing to the platform and in the wheel house. Recognition of the body's position to direct the robot correctly.
Cycle time approx. 1 sec per body.

Frame Conditions:
- Required accuracy ± 1 mm
- Different vehicle types on same assembly line

Automatic Wheel Assembly

Wheel assembly using 3D position recognition with 3 cameras

The Task:
Automatic assembly of the wheels on a vehicle. Position recognition of the brake disk to correct the robot. Identifying the rotation of the holes for precise screwing in of the wheel bolts.
Cycle time approx. 1 sec per wheel.

Frame Conditions:
- Required accuracy ± 0.5 mm
- Different vehicle types on same assembly line
- Model-dependent size and type of brake disk
Hardware
■ Industrial PC in 19” 4-HE or compact version
■ Pentium processor; min. 512 MB Main Memory; AGP graphics card
■ PCI framegrabber card for usage with up to 6 cameras
■ Up to 24 cameras using expansion cards
■ CCD cameras from 768 x 572 to 1620 x 1220 image resolution, as well as progressive scan for moving objects or swivel/tilting head cameras built into housing.
■ Lens with fixable iris and focus
■ Application-specific illumination
■ Digital input/output card for communication with PLC units
■ Other interfaces: Profibus, Interbus, serial, Ethernet, I/O, CAN-Bus

Software
■ Operating system Windows 2000, XP
■ Application software VMT 3D
■ Process control
■ Test plan and task management
■ Recording software
■ Automatic data protection (network-wide)
■ Result logging with image saving
■ System check, e.g., measuring and position recognition data
■ Password management with user report
■ Version management
■ Access recording and process logging
■ Approved automated calibration and referencing procedures
■ Statistical recording, saving and evaluation
■ All standardized protocols to current robot controls
■ Multilingual user interface
■ Teach module for simple creation of models and classifiers
■ Test module for images and classifiers for recognition assessment
The core of the system is a neuron network that can be trained to recognize characteristics with the aid of models and trial characteristics. The system's sensors are therefore able to identify liberal characteristics or contour elements.

By adding further appearance variants, the system achieves maximum recognition capability possible. Fluctuations in the surrounding conditions and varying image backgrounds may therefore be easily optimized.

Through combining approved special sensory procedures on the subpixel level, it is possible to achieve the highest accuracy subsequent to the reliable recognition of characteristics.

The unit is operated with a modern user interface that allows intuitive working. No knowledge of programming at all is required to operate the unit.

Since operation is being kept so simple, two days of training are usually sufficient to be able to operate the system.

Integrated into an automatic sequence VMT 2D fulfills its task reliably. In case of irregularities, it is possible, with the aid of statistics and service tools, to analyze the source of the problem and remove the cause.

- Position-dependent control of machining units
- Recognition of objects in liberal rotation (360°) and position. Position identification up to 0.1 mm also with large workpieces with multiple cameras from different perspectives
- Multilevel sensory procedures offer the highest recognition capability, precision and reliability possible
- Recognition of characteristics is trainable for the widest range of object characteristics, object variants and different backgrounds
- Automatic image memorizing, therefore short operation startup and time optimizing, as well as error documenting
- The number of the characteristics of a workpiece, for the purposes of recognition and inspection, may be liberally expanded and combined
- The applications are realized with the aid of stationary cameras or robot hand cameras
- Standardized protocols for all current robot controllers
- Fully automated process of robot-aided camera calibration and workpiece referencing
- Validation of workpiece geometry (recognition of inadmissible deviations from characteristics)
- Measuring up to 6 degrees of freedom through combination of several measuring levels
Some examples of realized applications

The illumination concept used for this application has been specially adapted for the given task and are of substantial importance for the reliability of recognition of the whole system.

POSITION AND TYPE RECOGNITION OF CASTINGS

The Task:
Type recognition of bathroom fittings (mixed operation) and information about the type and position of the casting to the robot which subsequently directs the component to a machining station.

Special Features:
- Liberal position of the workpiece (360°) and different side positions
- Mixed operation with integrated type recognition
- Stationary camera
- Roughest surrounding conditions
- Background texture and sand particles
- Different glossiness on casting surface

Type recognition of castings under rough conditions
POSITION RECOGNITION OF FLOOR TILES FOR STAMPING CONTROL

The Task:
Position recognition of floor tiles before stamping and cutting with the aid of tile pattern or outer contour.

Frame Conditions:
- The largest variety of tiles (knotting, pattern)
- Liberal tile color
- Recognition accuracy 0.1 mm
- Outer edge inspection with calendered goods for inadmissible indentations
- Time for position recognition and contour inspection: 230 ms
- Correction values are transmitted to stamping control

DEPALLETIZING OF CRANK CASES

The Task:
Crank cases are taken off pallets by a robot and placed on a conveyor belt. Near the gripper is a camera that recognizes the position, orientation and the interim position of the workpiece. The vision system transfers the correction values to robot control by means of a field bus interface.

Frame Conditions:
- Hand camera robot
- 8 different crank case types
- Recognition of wooden floor inserts
- 5 stack-up layers
POSITION RECOGNITION OF LACQUERED VEHICLE BODIES FOR DOOR DISMOUNTING

The Task:
2.5D position recognition of lacquered bodies for accurate guidance of dismounting grippers. Tact time approx. 500 ms per body.

Frame Conditions:
- High precision requirement of 0.3 mm in order to approach the screwed-on unit safely to eliminate damaging it
- Measuring 4 degrees of freedom (X,Y,Z, rotY)
- Liberal body color

TYPE AND POSITION RECOGNITION OF AUTOMOBILE BODIES TO INSTALL SPARE WHEEL TRAY

The Task:
Example: Control task with characteristics in a platform area

HANDLING OF FINISHED PARTS IN THE PRESS SHOP

The Task:
Automatic stacking up upon removal from the end of line

The Task:
Position recognition of finished tin parts for stacking up in transport containers in the press shop or for lifting up finished parts upon finishing.

Frame Conditions:
- Measuring of 4 degrees of freedom (X,Y,Z, rotZ) over 8 characteristics in 5 cameras in the floor area
- Precision of 0.3 mm
- Verification of the body type
- Checking the fitting area for foreign particles
The Task:
Before coming to the press, blanks go through a washing and oiling station, where they are shifted and rotated. In order to bring the blanks back into position on arrival at the press line, the position and orientation must be identified.

Special Features:
- Total measurement range with the aid of 2 cameras up to 2.5 m x 4.5 m at a precision of ≤ 2.5 mm
- Measuring time of 250 ms for identification of 4 corners using 2 cameras
- Different blank sizes and forms; large number of types
- Different surface textures (steel, zinc-coated and aluminum blanks, different degree of oiling)
- Simple teaching of new types and referencing to the robot

The Task:
Home appliances on a conveyor line are fitted with cardboard lids and several labels, using a robot. In order to ensure the required precision, cameras measure the relevant freedom degrees and corrections to the robot program are made.

Frame Conditions:
- Measuring of 4 degrees of freedom (X,Y,Z, rotZ) using 2 stereo sensors
- The area of the characteristics is lacquered in different colors
POSITION RECOGNITION OF NON-VIBRATION MATS

The Task:
Home appliances are fitted with non-vibration mats, using a robot. In order to ensure the required precision, cameras measure the relevant freedom degrees and corrections to the robot program are made.

Frame Conditions:
- Measuring of 3 degrees of freedom (X, Y, rotZ) using 2 cameras

SYSTEM DESCRIPTION

Hardware
- Industrial PC in 19” 4-HE or compact version
- Pentium Processor; min. 512 MB working memory; AGP graphics card
- PCI frame grabber card with up to 6 camera terminals
- Up to 24 cameras using expansion cards
- CCD cameras from 768 x 572 to 1620 x 1220 image resolution, also as progressive scan for moving objects or swivel/tilting head cameras built into housing
- Lens with adjustable iris and focus
- Application-specific illumination
- Digital input/output card for communication with PLC units
- Unit interfaces: Profibus, Interbus, serial, Ethernet, I/O, CAN-Bus

Software
- Operating system Windows 2000, XP
- Application software VMT 2D
- Process control
- Test plan and task management
- Recording software
- Automatic data protection (network-wide)
- Result recording with image saving
- System check, e.g., measuring and position recognition data
- Password management with user report
- Version management
- Access recording and process logging
- Approved fully automated calibration and referencing procedures
- Statistical recording, saving and evaluation
- All standardized protocols to current robot controls
- Multilingual user interface
- Teach module for simple model creation and classifiers
- Test module for images and classifiers for secure recognition assessment
By means of the VMT BK system for path correction, the robot can accurately follow the actual workpiece contour.

The nominal robot path with its support points is applied to a reference workpiece whose contour is designated as nominal. If a new workpiece is introduced, its contour does not match the nominal robot path anymore. By measurement on the actual workpiece contour, the path support points are matched to the actual contour. By using the path support points, corrected in this manner, the robot can accurately follow the actual workpiece contour.

In order that the robot is able to measure the workpiece contour, there is a suitable sensor installed on its hand. The robot "sees" the workpiece edge with the help of this sensor and can thus determine its relative position on any path support point.

**TYPICAL APPLICATIONS**

- Seam sealing
- Edge processing
- Soldering and welding
- Processing workpieces

The system can be used, for example, for the seam sealing on bodies-in-white.

**METHOD**

- **Measuring run:**
  In the first step, the processing contour on the workpiece is measured. To this end, the robot guides a sensor along the processing contour.

- **Path correction:**
  Every single support point on the path is corrected on the basis of the measured values.

- **Application run:**
  The robot processes the workpiece using the corrected path.

**OFFLINE PATH CORRECTION**

Many processing tasks require a robot path that is individually adjusted to the workpiece. Not only the position of the workpiece, but each individual processing point on the workpiece must be measured and the robot path correspondingly corrected. The VMT BK system measures the geometry and the position of the seam/joint/edge with an accuracy of 0.1 mm or better and corrects every individual support point of the robot path.

The robot can thus carry out its processing tasks with the highest accuracy.

**INTEGRATION INTO THE PRODUCTION PROCESS**

- Measuring and processing in one station. Advantage: saves space in the line.

- Separate stations for measurement and processing. Advantage: No soiling of the measuring equipment, application tool does not need changing.

The VMT BK program was developed in such a way that it works alone, but if required, can work together without any problems with the VMT IS program for 3D-position recognition.

In a typical application, in a first step, the workpiece position is determined with VMT IS, in order to balance out the position tolerances that are initially present. The measured workpiece displacement is transferred to the robot and there, used as the base displacement of all subsequent movements.
TECHNICAL CONSTRAINTS

The VMT BK system is a PC-based software, with the help of which a robot can match the processing (working) path on a step-shaped workpiece edge in the path support points to the real contour of the workpiece. Shape tolerances of the workpiece can thus be compensated.

The system uses a laser triangulation sensor or light intersection sensor for acquiring the workpiece edge. This sensor is located on the hand of the robot and is so positioned on the workpiece that it can acquire the relevant contours properly.

Implementation with robots
KUKA, other manufacturers possible using standardised interfaces

Machine interfaces
Interbus, Profibus, serial, I/O, further interfaces on request

Edge sensor
Laser triangulation, sensor-protection housing can be closed pneumatically

YOUR BENEFITS

- Measurement and processing are decoupled
- Highest possible local processing accuracy
- Consistently high manufacturing quality, even for shape fluctuations
- Low consumption of materials for seam sealing
- System is compatible with the VMT 3D position detection unit (see page 4)

PERFORMANCE FEATURES

- Can also be used for processes that are sensitive to soiling because of the delay between measurement and processing
- Fine adjustment of the processing path of the robot is possible without influencing the measuring path
- Measurement of edges with a laser triangulation sensor: robust with respect to variable illumination, surface properties and the background
- Autonomous learning of the correct path points and automatic sensor calibration
- Generation of correction values at each support point on the path within the cell or vehicle coordinate system
- Generation of relative correction values with respect to a reference object
- Extensive validation checks for reliable measurement results
- Separate specification of tolerances for each point on the path is possible
- Continuous logging of all system activities internally and at the interfaces to the machine controller and to the robot
- Simple logging for communication with all common industrial robots
- Quality control of the local edge geometry can be carried out at the same time
- Controlling of several robots with one system computer
- Referencing of the object’s edge to an arbitrary point: outer corner, inner corner, centre of sheet, etc.
- Reliable calculation of the edge, even if damaged or soiled
- Self-calibrating after sensor replacement without any additional aids
- Optional: compatible with the VMT 3D position detection unit on the same system computer (see page 4)
VMT RP makes it possible to position a robot gripper equipped with sensors in a defined position with respect to an object, for example, a chassis.

In contrast to the single-step measurement systems, the robot position is adapted continuously with the help of the sensor signals that are recorded.

VMT RP evaluates the sensor signals recorded on the current object and corrects the robot position till the sensor measurement values once again conform to the values of the learning position on the reference object. The robot gripper then once again has the exactly identical relative position to the current object that it had at the time of setting up to the reference object.

**TYPICAL APPLICATIONS**

- Body-in-white attachments:
  - Absolute positioning (form and pierce),
  - Relative positioning (gap/transition)
- Assembly tasks
- Parts removal
- Joining parts through online regulation of the robot
- Precise positioning

This system can be applied, e.g. for guiding stamping tongs for STFP plants.

**ACTIVE POSITIONING**

In most processing steps, an add-on piece or a tool must be positioned relative the workpiece.

The constant relative reference point is crucial for successful processing.

The choice of detection points on the workpiece and the robust conversion of this information into a position correction of the tool are crucial for accurate positioning.

**METHOD**

The relative position between the workpiece and a robot gripper is continuously determined using a suitable sensor system.

The sensor data are converted into a position correction value using a mathematical compensation procedure.

A position controller continuously guides the robot gripper until the correct relative position is reached.

**YOUR BENEFITS**

- Fast positioning through continuously measuring sensors
- Constant manufacturing quality, even for component ageing and temperature fluctuations
- Best possible manufacturing quality for shape tolerances
- Lower cycle times
- Simplest implementation
- Lower setting up, operation, and maintenance times
- Complete process control and documentation
- If necessary, dynamic following of a moving workpiece (optional).
PERFORMANCE FEATURES

■ Complete correction of all static positioning errors of the robot.
■ Highly accurate positioning is better than the reproducibility.
■ Best possible relative possible if the shape of workpiece deviates.
■ Complete control of the workpiece and positioning tolerances.
■ Rapid positioning using continuously measuring sensors.
■ Laser distance sensors have a high robustness for variable illumination and critical surface properties
■ Not sensitive to external light
■ Calculation of the position correction from the data measured by the sensor using a weighted best-fit procedure
■ Redundant sensor arrangement that allows production to continue even if the sensor fails
■ Integrated check of the deviation in the workpiece shape safeguards against incorrect processing
■ Automatic checks for mechanical changes in the sensor mounting
■ Reliable robot movement by specification of limiting values for the control speed and movement range during guidance
■ Control of up to six degrees of freedom
■ Positioning accuracies that are well below the reproducibility of the robot and which remain stable over a long period
■ Short positioning times depending on the final accuracy preset in the system
■ Fine adjustment of the relative position on the workpiece always possible, even after the system has been setup

TECHNICAL CONSTRAINTS

The system is installed in a separate switch cabinet of its own. The software runs on a standard industrial PC, which is equipped for operation by the user with a monitor as well as a keyboard and mouse.

The program can activate the robot during the position control over the Ethernet interface with the help of the RTCI protocol. The clock time in case of activation of the robot by the PC is about 12 ms and is essentially determined by the robot controller.

Implementation with robots
KUKA, other manufacturers on request

Interfaces
Ethernet to the robot, further interfaces Interbus, Profibus and others on request

Distance sensors
Laser triangulation, analogue output 4–20 mA, further sensors available on request
“Bin picking” is one of the systems with highest interest of the industry, in order to automate the production process, to increase the capacities and to lower the costs.

**3D Position Recognition with Laser Measurement**

Partial solutions exist using classical sensor technology (inductive or ultrasonic sensors) or with the initial stages of image processing.

However a lot of systems have failed in the face of the complex requirements and problematic site conditions. Thus the challenge for VMT consisted of finding a concept that unites the advantages of the individual sensor technologies specifically for each application.

The VMT IS system enables very different sensors or sensor systems to be combined and to extract the necessary information by means of proven evaluation procedures, so that reliable systems can be offered, which ensure the highest possible availability.

The system is based on 3D evaluation by means of camera technology and/or a height image for the controlling the robot grippers generated by measuring the runtime of the light. However a minimum organization of parts to be recognized and detailed, individual case studies remain absolutely necessary, if the high requirements for the installations availability and profitability are to be ensured.

The requirements for palletizing and depalletizing items from containers or pallets and the handling of parts and various bundles are very complex.

The substantial challenges of these tasks are:

- Item complexity and variability
- The very different surfaces of the objects to be processed
- Recognition of containers, intermediate layers, where applicable, and also foreign objects and disruptive contours
- Exclusion of external light interference
In order to fulfill all demands for trouble-free operation and a process-stable system, VMT also decided, in addition to proven image processing systems, on the use of laser light-section and laser time-of-flight sensor technology. This kind of sensor technology provides not only significant freedom from external light interference for the testing process but also the requisite speed, and fulfills the requirements for accuracy. Additional information is also available for determining, for example, the stack height and recognizing foreign objects; this is often not available when using traditional image processing. The VMT system provides the capability of linking the most appropriate sensors for the variety of individual requirements to the VMT software, in order to generate the optimum solution for the problem. In addition to the image-processing sector (typically surface and line cameras), it also covers triangulation and laser light-section sensors and laser time-of-flight sensors and the latest generation of ultrasonic sensor technology.

### APPLICATION EXAMPLES

- Robot-supported unloading of untreated brake disks
- Depalletizing of unsorted types of rims
- Container, barrel and bag unstacking
- Tire depalletizing
- Gripping unfinished castings, such as cylinder heads and engine casings

### THE VMT IMAGE-PROCESSING SYSTEM

The image-processing computer is based on a high-performance industrial PC with the Windows XP operating system. Since it can be coupled to robotic control and SPS, the VMT system offers all the usual interfaces employed in the industry. These include Profinet, digital I/Os, serially, Interbus, Profibus, TCP/IP and CAN bus. The complete system including visualization on a TFT screen is built into a PC cabinet, in accordance with the customer requirements.
Reading of characters and symbols of all kinds, such as plain text, matrix code and bar code.

The core of the system is a neuron network that can be trained to recognize characteristics with the aid of models. This network is trained to recognized model characteristics and symbols, enabling the system to read a liberal number of characteristics.

By adding further appearance variants, the system achieves maximum recognition capability possible. Fluctuations in the surrounding conditions and varying image backgrounds may therefore be easily optimized.

The system is an equally effective tool for the end user and the OEM customer in terms of optimized production procedures, process controlling and documenting, thus reducing need for additional and follow-up work.

The unit is operated with a modern user interface that allows intuitive working. No knowledge of programming at all is required to operate the unit.

Through simple movement of the mouse, the user may call up new models and test tasks, change testing plans, or follow trained recognition. Since operation is being kept so simple, two days of training are usually sufficient to be able to operate the system.

Integrated into an automatic sequence VMT OCR fulfills its task reliably. In case of irregularities, it is possible, with the aid of statistics and service tools, to analyze the source of the problem and remove the cause.

Suitable also for difficult application conditions, such as changing backgrounds, etc.

Trainable for a high variety of fonts, characteristics and symbols

Suitable also for fast moving objects and high tact rates

Automatic image memorizing, allowing short operation startup and time optimizing, as well as error documenting

Accurate recognition of relevant areas through preset position definition of objects and script drafts

The highest recognition certainty possible through use of preset knowledge of character positions or expected characters, e.g., through use of negative examples and blanking out of irrelevant areas.

The system is validable for applications in the pharmaceutical and medical industry. Conformity to 21 CFR Part 11, according to FDA Standards.
Some examples of realized applications

The illumination concept used for this application has been specially adapted for the given task and are of substantial importance for the reliability of recognition of the whole system.

**READING MANUFACTURER NUMBER ON A TELEPHONE CARD**

The Task:
Reading the serial number on a telephone card.
Tact time ≤ 300 ms per card.

Frame Conditions:
- Changing background printing
- Character quality inconsistent
- Character visible under UV light only

**READING CHASSIS NUMBER ON VEHICLE BODIES**

The Task:
Reading an engraved chassis number on the platform and verification with data in the system.
Tact time approx. 1 sec per vehicle.

Frame Conditions:
- Different number quality
- Position variations and deviations due to tolerances of the conveyor
- Chassis number on lacquered metal in all color variants
- Different vehicle types

**READING REFERENCE NUMBERS ON TYPE PLATES**

The Task:
Reading of stamped numbers on the type plate and transmitting the number to the master control computer.
Tact time approx. 300 ms per vehicle.

Frame Conditions:
- Type plate very shiny
- Soiled with oil and dust
- Different quality of stamping
- High position variations and deviations due to tolerances of the conveyor
- Rechecking of the recognition results by means of the integrated test character
- 24-hour operation (non-stop)
- Separate terminal in the control room

**READING SERIAL NUMBER ON ID CARDS**

The Task:
Reading the serial number on ID cards.
Tact time ≤ 300 ms per card.

Frame Conditions:
- Changing background printing
- Character quality inconsistent
- Different font types (international)
READING RELEASE NUMBERS ON CDs

The Task:
Reading of release numbers on CDs, saving in memory and sorting of the recognized numbers. 
Tact time ≤ 300 ms per CD.

Frame Conditions:
■ Critical, strongly reflecting surface
■ Characters in circular form
■ Undefined turning position of the Characters
■ Preset position identification for follow-up of the reading range
■ Saving all the numbers read in a VMT OCR database for subsequent evaluation

VERIFICATION OF LOT NUMBERS ON PHARMACEUTICAL PACKAGES

The Task:
Reading and verifying lot numbers as well as position identification on the bags. 
Tact time approx. 300 ms per package.

Frame Conditions:
■ Glossy foil, wavy
■ Validated according to 21 CFR Part 11

READING NUMBERS ON PARTS FOR THE GEAR BOX

The Task:
Reading of needle-engraved numbers on a part of the gear box and transmitting the number to the master control computer. 
Tact time approx. 500 ms per component.

Frame Conditions:
■ Various character appearance due to needle stamping
■ Background disturbance due to grinding traces on the surface
■ Position variations of the component due to tolerances of the conveyor technology

READING OF ID NUMBERS ON ALUMINIUM BLOCKS

The Task:
Reading and verifying of ID numbers on aluminum blocks for braking system. 
Engraved or needle-scratched characters mixed. Tact time approx. 500 ms per block.

Frame Conditions:
■ 2 different font types and marking processes mixed (needle scratched, engraved)
■ Background texture, different gloss behavior
READING OF PRODUCTION DATA ON PHARMACEUTICAL PACKAGES

The Task:
Reading and verifying batch number and expiration date on pharmaceutical packages. Tact time approx. 200 ms per package.

Special Features:
- High variety of printing processes
- Validated according to 21 CFR Part 11

READING LOT NUMBERS ON CONTACT LENSES PACKAGES

The Task:
Checking the lot number on packages with contact lenses in blisters. Tact time approx. 100 ms per blister.

Special Features:
- Writing on aluminum foil
- Surface shiny and wavy
- High conveyor speed
- Validated according to 21 CFR Part 11

SYSTEM DESCRIPTION

Hardware
- Industrial PC in 19” 4-HE or compact version
- Pentium processor; min. 512 MB working memory; AGP graphics card
- PCI frame grabber card with up to 6 camera terminals
- Up to 24 cameras using expansion cards
- CCD cameras from 768 x 572 to 1620 x 1220 image resolution, also as progressive scan for moving objects or swivel/tilting head cameras built into housing
- Lens with adjustable iris and focus
- Application-specific illumination
- Digital input/output card for communication with PLC units
- Unit interfaces: Profibus, Interbus, serial, Ethernet, I/O, CAN-Bus

Software
- Operating system Windows 2000, XP
- Application software VMT OCR
- Process control
- Test plan and task management
- Recording software
- Automatic data protection (network-proof)
- Result recording with image saving
- System check, e.g., measuring and position recognition data
- Password management with user report
- Version management
- Access recording and process logging
- Approved fully automated calibration and referencing procedures
- Statistical recording, saving and evaluation
- All standardized protocols to current robot controls
- Multilingual user interface
- Teach module for simple model creation and classificators
- Test module for images and classificators for recognition assessment
- Validable according to FDA Standard and 21 CFR Part 11
The core of the system is a neuron network that can be trained to recognize characteristics with the aid of models. This network is trained to recognized model characteristics and symbols, enabling the system to read a liberal number of characteristics.

By adding further appearance variants, the system achieves maximum recognition capability possible. Fluctuations in the surrounding conditions and varying image backgrounds may therefore be easily optimized.

The system is an equally effective tool for the end user and the OEM customer in terms of optimized production procedures, process controlling and documenting, thus reducing need for additional and follow-up work.

The unit is operated with a modern user interface that allows intuitive working. No knowledge of programming at all is required to operate the unit.

Through simple movement of the mouse, the user may call up new models and test tasks, change testing plans, or follow trained recognition. Since operation is being kept so simple, two days of training are usually sufficient to be able to operate the system.

Integrated into an automatic sequence VMT IS fulfills its task reliably. In case of irregularities, it is possible, with the aid of statistics and service tools, to analyze the source of the problem and remove the cause.

- Position, type and completeness check, color verification and processing control
- Type differentiation through combination of several recognized characteristics
- Type recognition with subsequent type-specific inspection
- Suitable also for difficult application conditions, such as changing backgrounds and object properties
- Trainable for an unlimited range of characteristics or symbols
- Automatic image memorizing, therefore short operation startup and time optimizing, as well as error documenting
- Accurate verification of the position of characteristics in relation to the current object position
- Suitable also for quickly moving objects and high tact rate
- Highest recognition certainty possible through use of preset knowledge of character positions or expected characters, e.g., through use of negative examples and blanking out of irrelevant or disturbing areas
- Owing to swivel/tilting-head cameras, details maybe recognized even on longish test objects and in the largest variety of places.
Some examples of realized applications

The illumination concept used for this application has been specially adapted for the given task and are of substantial importance for the reliability of recognition of the whole system.

**ASSEMBLY AND TYPE CHECKING ON GEARSHIFT COMPONENT GROUP**

The Task:
Checking of the completion of various built-in components, inscriptions, symbols and coverings. Tact time approx. 0.3 sec per assembly group.

Special Features:
- High position variations and deviations due to tolerances of the conveyor
- Complete test station

**ASSEMBLY CHECK OF CRANK CASES**

The Task:
Completeness test of bearing cap and screw positions. Type verification of bearing caps. Tact time approx. 1 sec per case.

Frame Conditions:
- Changing background through traces of machining and/or coating with oil
- Extreme diversification of variants

**ASSEMBLY CHECK OF AXLE COMPONENT GROUP**

The Task:
Checking of the completeness, position and type of assembly groups and components using 7 allocated cameras.

Frame Conditions:
- Preset position identification for tracking the test areas and checking the position of the mounted components
The Task:
Testing of brake disks for correct type (diameter, thickness, coating).

Special Features:
- Glossy surface with strong traces of machining
- Delivery of complete stations with handling
- Check of inlet and outlet

The Task:
Recognition of the body type (station wagon, limousine, coupé, convertible) as well as reading of the chassis number for verifying information from data carrier. Also checking the hood erector.

Special Features:
- Image acquisition of moving bodies at different conveyor speeds
- Different vehicle lengths and types

The Task:
Identification of the type of sand core before deposition. Tact time approx. 0.5 sec per sand core.

Frame Conditions:
- Flexible identification of the type of sand core (over 20 types)
- Position fluctuations and turns due to tolerances in conveyor technology
- Changing image appearance
**FINAL INSPECTION ON FINISHED SYRINGES IN BLISTERS**

The Task:
Checking the piston color and position in relation to the syringe case and label position. Checking the completeness of the blister.
Tact time approx. 0.3 sec per package.

Special Features:
- Glossy surface of the blisters and syringes
- Marginal differences in the color spectrum of the pistons
- Different bundle sizes
- Validated according to 21 CFR Part 11

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**CHECKING OF SENSOR ELEMENTS**

The Task:
Checking for correct assembly of the pins on sensor elements (automobile electronic).
Tact time approx. 0.5 sec per sensor.

Special Features:
- Variable appearance of the forms due to solder residues, wearing, different pins

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**ASSEMBLY CHECK ON TRUCK UNDERCARRIAGES**

The Task:
Checking correct assembly of components on undercarriages of trucks. Checking the assembly and the position of component groups in relation to the truck type.
Tact time approx. 10 sec per chassis.

Special Features:
- Completed truck undercarriage in 3 different lengths
- Different surface properties of components and chassis
- Entire undercarriage is covered by 3 movable cameras
Checking for inserted parts in line tracking

The Task:
Checking for presence of different inserted parts (wires, rings, loops, soft strips, etc.) in foam forms. Tact time approx. 1 sec per tool.

Special Features:
- Glossy, constantly changing surface of tools
- Marginal contrast between inserted parts and tool surface
- Done during online operation (line tracking)

Checking components inserted into foam forms for seats

Checking for presence of components in door modules. Checking of the speaker assembly in relation to the type. Tact time approx. 0.5 sec per module.

Special Features:
- Glossy module surface
- Highly differing surroundings

Checking of door modules

Detailed view of door modules and cameras

Type recognition and reading of the casting date on crank cases

The Task:
Recognition of the type of crank case and reading the casting date on the side. Tact time approx. 0.5 sec per head.

Special Features:
- 9 different crank cases
- Dates of casting in highly different quality.

Type recognition and reading of the casting date on crank cases

Example of visualization

The Task:
Checking the type and presence of a large variety of parts (wires, loops, clips etc.) in cockpits. Tact time approx. 1 sec per cockpit position.

Special Features:
- Different cockpit colors
- Marginal differences in the color contrast between the inserted parts and the cockpit
- Enormously large variety of types
- Positioning by means of robots in front of the cameras
ASSEMBLY CHECK OF TRUCK CABINS

The Task:
Checking the presence of various components in bodyshell work during finishing truck driver cabins. Tact time approx. 10 sec per cabin.

Special Features:
- Different and variable surfaces and materials
- Checking with the aid of cameras and swivel/tilting-head cameras for acquisition of all characteristics.
- Enormously high type variability

SYSTEM DESCRIPTION

Hardware
- Industrial PC in 19” 4-HE or compact version
- Pentium processor; min. 512 MB working memory; AGP graphics card
- PCI frame grabber card with up to 6 camera terminals
- Up to 24 cameras using expansion cards
- CCD cameras from 768 x 572 to 1620 x 1220 image resolution, also as progressive scan for moving objects or swivel/tilting head cameras built into housing
- Lens with adjustable iris and focus
- Application-specific illumination
- Digital input/output card for communication with PLC units
- Unit interfaces: Profibus, Interbus, serial, Ethernet, I/O, CAN-Bus

Software
- Operating system Windows 2000, XP
- Application software VMT IS
- Process control
- Test plan and task management
- Recording software
- Automatic data protection (network-proof)
- Result recording with image saving
- System check, e.g., measuring and position recognition data
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- All standardized protocols to current robot controls
- Multilingual user interface
- Teach module for simple model creation and classifiers
- Test module for images and classifiers for recognition assessment
- Validable according to FDA Standard and 21 CFR Part 11

ASSEMBLY AND TYPE CHECK ON REAR AXLE COMPONENT GROUPS

The Task:
Checking the presence and rotating position of the springs of different component groups during assembly of the rear axle of automobiles. Tact time approx. 3 sec per assembly group.

Special Features:
- Different and variable surfaces and materials
The core of the system are specially developed methods of testing adhesive beads and surfaces with rubber applications. Also, the system is able to check for weak-contrast bead applications.

Owing to the integrated position recognition and position tracking, the system ensures accurate position control of adhesive beads. This is possible even with the cameras overlapping and different camera resolutions.

The unit is operated with a modern user interface that allows intuitive working. No knowledge of programming at all is required to operate the unit.

Since operation is being kept so simple, two days of training are usually sufficient to be able to operate the system.

Setting up of the test areas is interactive with few movements of the mouse.

Integrated into an automatic sequence VMT ACS fulfills its task reliably. In case of irregularities, it is possible, with the aid of statistics and service tools, to analyze the source of the problem and remove the cause.

- Detection of interruptions, enlargements, contractions and positional faults
- Suitable for all irregularities and local defects on surfaces where adhesive beads are applied
- Contact-free and damage-free testing immediately after application allows 100% control of all workpieces
- Recognition of position for correction of tested areas when the workpiece is unsteady
- Caliberable metric identification of all measuring parameters, independent of camera resolution or focus direction
- Automatic image saving, thus requiring little time for operation startup, time optimization and error documenting
- High testing speed
- Saving of all individual results and test data for subsequent statistical evaluation
- Application possible with stationary and hand camera robots, as well as combination of both
- Multiple image presentation from multiple cameras
- Display of the defective spot
Some examples of realized applications

The illumination concept used for this application has been specially adapted for the given task and are of substantial importance for the reliability of recognition of the whole system.

ADHESIVE ON WINDSHIELD

General view of the front windshield

View of upper left section with testing areas shown

Frame Conditions:
- Color: windshield, transparent
- Bead on a black sieve print
- Color of the adhesive bead: black
- Positioning with a robot in front of a camera
- Solution with a single high-resolution camera
- Very special illumination concept

SEAL AND SUPPORT BEAD ON OUTER DOOR PANEL

Machining and testing station – door left

Section view of door with supporting and folding bead

Frame Conditions:
- Blank unpainted metal; strong reflections
- Color of the bead: green/grey
- Correction of position tolerances
- Multiple positioning by robot
Frame Conditions:
- Blank aluminum body
- Color of the bead: red
- Different stick-on pictures
- Accurate gluing

Frame Conditions:
- Blank metal; strong reflection
- Color of the bead: black.
- Correction of position tolerances

Camera illumination in the test station
ADHESIVE ON MOBILE PHONE CASES

Frame Conditions:
- Transparent adhesive
- Different colors of the case
- Correction of position tolerances

SYSTEM DESCRIPTION

Hardware
- Industrial PC in 19” 4-HE or compact version
- Pentium processor; min. 512 MB working memory; AGP graphics card
- PCI frame grabber card with up to 6 camera terminals
- Up to 24 cameras using expansion cards
- CCD cameras from 768 x 572 to 1620 x 1220 image resolution, also as progressive scan for moving objects or swivel/tilting head cameras built into housing
- Lens with adjustable iris and focus
- Application-specific illumination
- Digital input/output card for communication with PLC units
- Unit interfaces: Profibus, Interbus, serial, Ethernet, I/O, CAN-Bus

Software
- Operating system Windows 2000, XP
- Application software VMT ACS
- Process control
- Test plan and task management
- Recording software
- Automatic data protection (network-wide)
- Result recording with image saving
- System check, e.g., measuring and position recognition data
- Password management with user report
- Version management
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- Approved fully automated calibration and referencing procedures
- Statistical recording, saving and evaluation
- All standardized protocols to current robot controls
- Multilingual user interface
- Teach module for simple model creation and classifiers
- Test module for images and classifiers for recognition assessment

ADHESIVE BEADS ON AUTOMOBILE ELECTRONIC COMPONENT

Frame Conditions:
- The adhesive is applied into deep slots
- Different color of the casing
- Correction of position tolerances
- Testing bead and points
VMT GEO is a flexible measurement and inspection system for geometric testing. It uses data obtained from geometry sensors to evaluate the quality-determining properties of a workpiece.

The acquisition of the surface geometry is mostly independent of the colour and background of the workpiece surface. The system supports local tests on expanded workpieces and includes, apart from an easy-to-operate testing task administration, a link to the process control as well.

**TYPICAL APPLICATIONS**

- Reading and quality testing of embossed numbers
- Local geometry inspection of surfaces
- Measurement of geometric features
- Quality control and process control
- Height and width monitoring
- Geometry and profile monitoring

**SENSORS AND SYSTEM STRUCTURE**

Selected light intersection sensors are used for the geometric acquisition of the test object. If required, apart from the surface geometry, the surface brightness and optionally also the colour are acquired. Since the sensors acquire the part geometry along a line, they must move relative to the test object.

When checking very fine structures, which require a high-resolution sensor with a correspondingly small sensor measurement range, a 3D position recognition can be connected upstream of the system (see page 4). By doing so, the sensor can be positioned precisely even with respect to large objects, independently of the position tolerances of the workpiece to be tested.

For acquisition of the part surfaces, the following options are provided:

- **Sensor mounted fixed, test object moves**
  Advantages: Reasonably priced, often no additional movement elements required, since the parts e.g. pass on a conveyor belt.

- **Sensor moved through linear or rotational axis, test object fixed**
  Advantages: Controlled relative movement, matched to the task.

- **Sensor at the robot, test object fixed**
  Advantages: Free positioning of the sensor on the workpiece, hence small measurement distances and high resolutions possible even on expanded workpieces. Acquisition of inside surfaces, simple adaptation to workpiece changes and changes in the scope of testing.
YOUR BENEFITS

- Robust determination of the workpiece quality, independent of the surface brightness
- Simple and directly interpretable parameterisation with plausible quality limits
- As a result, lower setting up, operation, and maintenance costs
- System that is flexibly and quickly adaptable to new tasks
- System-compatible with VMT image processing systems

PERFORMANCE FEATURES

- Acquisition of the workpiece geometry mostly independent of ambient brightness and surface properties
- Evaluation of the surface images geometrically or with the full functionality of the VMT image processing system
- Exact metric acquisition of the object geometry by using calibrated sensors
- Analysis of local surface defects independently of the position and bending of the surface
- Exact metric limit values can be set when inspecting surface defects

WHEN USED WITH ROBOTS

- Highly flexible and universally usable
- Acquisition of surface strips of any length on the workpiece, according to the robot movement
- Optionally pre-connected type recognition facilitates the selection of different measurement tracks, depending on the recognised workpiece
- Logging of all system activities internally and at the interfaces to the machine controller and to the robot
- Easily configurable protocol for the communication with all the common industrial robots
- Optional fine positioning of the robot by means of a pre-connected VMT 3D position recognition on the same system computer (see page 3)

TECHNICAL CONSTRAINTS

Machine interfaces
Profinet, Interbus, serial, Ethernet, I/O, other interfaces on request

Implementation with robots
KUKA, ABB, Fanuc, Reis, Cornau, Mitsubishi and other manufacturers possible through standardised interface

Light intersection sensor
Laser triangulation, resolution and measurement range according to requirement, scan rate up to 5 kHz, if required, pneumatically operated sensor protection housing.
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<td>Adam Opel AG</td>
<td>EFTEC Engineering AB</td>
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