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Chapter 1 : Machine Vision Market Size, Share | Industry Analysis Report

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Increasing demand for quality inspection and automation in different industrial verticals is estimated to drive the market. Surging demand for application-oriented machine vision systems is also boosting the adoption of the technology over the forecast period. MV systems involve ability of a computer to observe, inspect, and scrutinize the work performance by employing one or more video cameras, digital signal processing, and analog to digital conversion. Captured data is then transferred to computer to analyze and provide desired output. Sensitivity and resolution are two important aspects of any MV system. These systems particularly assist in supervising work environments. It offers features such as robotic guidance, automatic inspection, and process control in industrial applications. Industrial production and manufacturing activities are becoming increasingly complicated day-by-day. They are creating difficulties and increasing unreliability for human eye to keenly detect, observe, and examine production activities. The technology is witnessing high adoption in industrial operations and is rapidly replacing manual measurements and inspection, due to increasing necessity for efficient and reliable inspection and measurements. Machine vision systems deploy smart cameras and image processing to perform measurements and inspections. Rising need for superior inspection and growing automation are translating into greater adoption of machine vision technology. Furthermore, need for increased quality control by consumers and manufacturers coupled with strict government regulations is likely to stoke the growth of the market. On the other hand, lack of efficient system operators due to inadequate training can slow down the adoption rate of machine vision technology. Offering Insights On the basis of offerings, the market has been bifurcated into hardware and software. Hardware accounted for a larger share in the market in It is also poised to register the highest CAGR during the forecast period. Hardware components comprise several objects such as cameras, sensors, processors, frame grabbers, LED lightings, and optics. Among these, cameras held the largest share in , which can be attributed to increasing demand for CMOS imaging sensors. The market for software is application specific and fragmented based on necessity of applications. The software segment is projected to experience steady growth over the same period on account of training and deep learning of the technology. Product Insights PC based systems were the most prominent product segment in the market in The segment is anticipated to maintain its position in the global market throughout the forecast horizon. However, smart camera based systems are estimated to exhibit lucrative CAGR of 8. The growth of the segment is attributable to growing adoption of cameras in 3D imaging. Machine vision systems, also called vision systems, consist of numerous cameras. At times, depending upon requirements, these cameras are mounted over the assembly lines so as to observe and examine products and capture data. This is leading to greater adoption of smart cameras in these systems. Cameras are also capable of reading labels and directing products automatically without any human involvement. Minimized human intervention leads to decreased errors and increased accuracy of inspecting labels and tags. These aspects of smart cameras are influencing the adoption of the technology across various industrial sectors, thereby stimulating the growth of the overall market. The technology is extensively used for scanning and identifying labels, barcodes, and texts, especially in the packaging sector. This automates packaging activities, thereby saving time, avoiding human errors, and increasing efficiency. The technology is frequently used in consumer goods, pharmaceutical, and packaging sectors. Heightened adoption of the technology in these sectors has resulted in reduced counterfeit products to a large extent. Identification using machine imaging is also used in camera surveillance, monitoring traffic, or recognizing number plates for security purposes. The identification segment is expected to post a CAGR of 8. The quality assurance and inspection segment held the largest share in It is likely to register a noteworthy CAGR during the same period, thereby maintaining a hold on the market by generating the largest revenue. The automotive industry is the leading end-use segment of machine

vision systems worldwide. The segment is projected to experience steady growth during the forecast period. Besides, MV systems are also used for dimensional gauging, robotic guidance, and testing automation purposes, which comes under measure, gauge, and guide applications. Regional Insights Asia Pacific accounted for the largest share in the global arena in The region is estimated to rise at the highest CAGR of 9. The growth of the region can be attributed to lucrative opportunities in automotive, packaging, pharmaceutical, and other industrial applications in Asia Pacific. As the region is emerging as the global manufacturing hub, the technology is expected to experience widespread adoption in the region during the forecast period. China and Japan are prominent countries having potential to offer extensive opportunities to emerging as well as matured technologies such as machine vision. In addition to this, expenditure and operational benefits coupled with initiatives being undertaken by governments of emerging countries, such as South Korea, India, Taiwan, and Singapore, are responsible for catapulting investments and encouraging different industry players to establish their production units in APAC. With greater opportunities being offered by both developing and developed nations such as U. Prominent players are undertaking strategic initiatives such as distribution alliances, partnerships, mergers, and acquisitions to consolidate their position in the market.

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Chapter 2 : Machine Vision| Cognex

PROCEEDINGS VOLUME Machine Vision Applications in Industrial Inspection XII. Machine vision system for surface inspection on brushed industrial parts.

These limitations result in the misassessment of cotton quality and may have a serious impact on the evaluation of the economic value of the cotton crop. This paper reports on the recent advances in the use of a 3D x-ray microtomographic system that employs image processing and pattern recognition techniques to accurately detect and classify trash present in cotton. The proposed method offers an attractive alternative to existing trash evaluation technologies, because of its ability to produce 3D representations of the samples, to robustly segment the trash from its background, and to accurately classify the contaminant types. This procedure could have a serious impact on the process control technologies cotton lint cleaning , and indeed on the economic value of cotton. Initially crystals were manually passed through various increasingly finer sieves so that one could manually calculate what percentage of crystals and crystal masses lay in various size groups. Later microscopes were used on small samples to take pictures of crystals so that they could be sized manually at higher degree of accuracy. In order to increase the accuracy, image processing are being used to analyze the pictures taken under microscope. The main concern is to analyze crystals with width greater than 50 micrometers. The ideal crystal is roughly square and has a width of approximately micrometers. There is then a need to separate crystals into two main classes: This classification process involves: During this process, there is more often a lost of information and in some case an intrusion of noise. These can have as result some misclassifications. These misclassifications can be caused by touching crystals or overlapping crystals that are treated as single crystal. These can also be due to the fact that edges of crystals are not well extracted. In this paper we present a method to alleviate those misclassifications using mathematical morphology and a combination of binarization and edge detection. This method gives better classification. Some results are presented. This paper presents a new approach for a real-time self calibrating stereo based system. The concept is based on calculating the difference-map of registered stereo images that contains qualitative depth information. The principle is valid for a variety of applications; a prototype for a 3D code reader is presented in detail. Experimental results from a laboratory prototype demonstrate the full functionality of the system concept. Francois Martin ; John Laurent Show Abstract In order to meet the needs of many diverse industrial 3D inspection tasks, INO has developed a new concept for the design of a smart and modular 3D laser profiler. This stand-alone sensor which we call Smart Laser Profiler SLP is composed of a laser line projector, collection optics, a high frame rate camera and a digital signal processor DSP. The on-board DSP is the key to this technology. The SLP sensor has been designed to be both compact and rugged and it is enclosed in a water resistant NEMA 4 class housing that is easy to install on a production line. The Smart Laser Profiler has several preprogrammed functions on the DSP that implement basic shape analysis algorithms like volume measurement and shape conformance. For more complex shape analysis, the sensor can transfer the raw 3D profiles to a PC through a high-speed communication link. The present article will describe both the unique hardware, electronics and optical architecture of the sensor and the software tools that were developed. In this paper we therefore present a light-sectioning based measurement head, which is suitable for the edge inspection of different workpieces. Beyond the design we also present a new calibration technique for its camera. The calibration is mainly based on several perspective projections, which are successively executed. In each step, the linear system of homogeneous equations is solved by using singular value decomposition. Each mapping is therefore obtained in the least squares sense. Because of the novel design of the calibration device, a high number of reference points can be used for the description of these mappings. The inspection of a workpiece detail implicates a large amount of data, some of which is useless. After the description of the segmentation process we propose a measurement progression, which enables us to obtain a fast and easy perspective correction of the three-dimensional light sectioning data. Finally, a fitting method is presented.

Based on singular value decomposition, the data is fitted to the corresponding form of the fillet or chamfer. As the fit is done in the least squares sense, one can obtain statistical information out of the decomposition process. Based on analyzing the photogrammetric calibration and self-calibration methods, a new planar way is proposed in this paper for calibrating the camera for the 2D objects. Induced some non-linear distortion factors, a fast algorithm is adopted to solve the complicated non-linear equations in calibration model. With this algorithm, a concatenation technique is used to reconstruct a 3D object from two 2D planar photos. In the second part of this paper, a calibration method using only one plane, which can be moved on some simple equipment, is deduced for 3D object dimensional measurement. Mathematic model and its transformation process are discussed in detail. This method can be used especially for profile inspection of machine parts in industrial working-field. An application to inspect the profile of train wheel is given in this paper. Experimental results are given to show the parameters of camera system and the measuring accuracy. Nicolas Bonnot ; Ralph Seulin ; Frederic Merienne Show Abstract This work aims at detecting defects on metallic industrial parts with streaked surface. The orientation of those parallel streaks is totally random. The searched defects are scratch and lack of machining. A specific machine vision system has been designed to deal with the particular inspected surface features. One image is acquired with an annular lighting in bright field and six images are acquired with a rotating lighting in dark field. A particular image processing is applied on the six images in order to get one image that represents all the revealed imperfections. A thresholding processing is then applied on this image in order to segment the imperfections. A trained classification, created with well known typical objects of each class, is performed. The classification has to recognize the different defects and the small imperfections that are not defects. The decision phase is used to know if the defects are acceptable, and therefore if the inspected part is acceptable. Some acceptability rules are defined for every defect class. This paper reports on the image processing system and optical servoing for one such a robot. A panoramic image of the vessels inner surface is produced by performing a coordinated robot motion and image acquisition. The level of projective distortion is minimized by acquiring a high density of images. Normalized phase correlation calculated via the 2D Fourier transform is used to calculate the shift between the single images. The narrow strips from the dense image map are then stitched together to build the panorama. The mapping between the panoramic image and the positioning of the robot is established during the stitching of the images. This enables optical feedback. The robots operator can locate a defect on the surface by selecting the area of the image. Calculation of the forward and inverse kinematics enable the robot to automatically move to the location on the surface requiring repair. Experimental results using a standard 6R industrial robot have shown the full functionality of the system concept. Conventional infrared based systems MIR, FIR provide very accurate results, but their quality also comes at high cost, and moreover these systems cannot always be properly applied in every case, e. The aim of this work is to measure the temperature distribution of objects at relatively low temperatures of approx. Special emphasis is put on the influence of the emission factor, which plays an important role in the field of non-contact temperature measurements, especially when thermo-chemically processed surfaces are considered. In addition, the noise characteristics of the imaging system have to be taken into account to ensure reproducible results. David Fofi ; Tadeusz Sliwa ; Yvon Voisin Show Abstract This paper proposes a comparative survey on techniques of vision based on invisible structured lighting. We have classified them in three distinct families: For each of them, definition, minimal configuration and main applications found in the literature are given. Then, we compare them regarding to several criteria: We think that this study could be useful to researchers that are looking for a compromise between stereovision and structured light vision, combining the processing tools extent of the former with the point matching reliability and simplicity of processing of the latter. Rafic Bachnak ; Jeng Funtanilla; Jose Hernandez Show Abstract Recent advances in technology have made light emitting diodes LEDs viable in a number of applications, including vehicle stoplights, traffic lights, machine-vision-inspection, illumination, and street signs. This paper presents the results of comparing images taken by a videoscope using two different light sources. One of the sources is the internal metal halide lamp and the other is a LED placed at

the tip of the insertion tube. Images acquired using these two light sources were quantitatively compared using their histogram, intensity profile along a line segment, and edge detection. Also, images were qualitatively compared using image registration and transformation. The gray-level histogram, edge detection, image profile and image registration do not offer conclusive results. The LED light source, however, produces good images for visual inspection by an operator. The paper will present the results and discuss the usefulness and shortcomings of various comparison methods. Standard gray scale charts are used to verify the intensity response and the signal to noise ratio at different f-stops. It is shown that the high dynamic range of the CMOS-sensor makes the camera suitable for differential image laser profiling. Furthermore, the cross-section of steel rods and wires are observed to verify the industrial applicability of the different standards. Both, material at room temperature and red-hot glowing steel bars were measured. The advantages and disadvantages for each technology are shown on the basis of these tests. Finally, a laser profiler was manufactured with the CMOS-camera and successfully implemented in a steel-mill. Michael Kelley Show Abstract Reliable and productive manufacturing operations have depended on people to quickly detect and solve problems whenever they appear. Over the last 20 years, more and more manufacturing operations have embraced machine vision systems to increase productivity, reliability and cost-effectiveness, including reducing the number of human operators required. Although machine vision technology has long been capable of solving simple problems, it has still not been broadly implemented. The reason is that until now, no machine vision system has been designed to meet the unique demands of complicated pattern recognition. The ZiCAM family was specifically developed to be the first practical hardware to meet these needs. The next-generation smart cameras will need to evolve as a fundamentally different kind of sensor, with new technology that behaves like a human but performs like a computer. Neural network based systems, coupled with self-taught, n-space, non-linear modeling, promises to be the enabler of the next generation of machine vision equipment.

Chapter 3 : Machine vision - Wikipedia

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Wee Show Abstract An algorithm for 3D surface reconstruction of large objects using a structured light pattern ranging system is presented. Highly accurate industrial inspection applications have been constrained by the limited range resolution and accuracy of current ranging devices and techniques. To overcome the limited range resolution, the ranging sensor uses a small field-of-view and multiple views. The proposed algorithm fuses surface data patches from the views to construct a large object surface. The algorithm also increases the accuracy of the reconstructed object with efficient numerical analysis and pre-processing. Experimental results show that the algorithm and the current sensor setup can reconstruct an object for inspection applications with the accuracy of approximately 1 mil 2. Intelligent cameras grab and process the image data. A switch with integrated firewall makes services available to the supervisory control system. Results are available as XML-logfiles. Dual Grassmanian coordinates are used to fit two parallel lines to the edge points by singular value decomposition. This gives the distance between the lines and the confidence interval of each measurement simultaneously, whereas latter is used to reject poor data. Changes of the distance are analysed computing local central moments. Presently, 12 images per second are acquired. The application is able to detect spontaneous rotation of the wire around the axis of rolling directly at the rolling stands and treats also poor images due to steam of cooling water. It indicates resulting defects, which may go undetected otherwise. Liwei Zhang ; Abbas A. Dehghani; Zhenwei Su ; Tim King; Barry Greenwood Show Abstract This paper describes the research approach to identify the contaminants which have similar color to the background wool and their removal from wool in real time. First, different light source is sought for getting the high contrast image between wool and contaminants. Second, different CCD detector including infrared camera, monochrome area scan camera was tried for identification of white contaminants. Relative infrared theory and spectral theory are also presented. Third, different image processing algorithms including threshold in HSV color space, local adaptive threshold, region-growing algorithm and their comparisons are presented. The combination of local adaptive threshold and global threshold algorithms can well identify most of white contaminants. At last, a research approach on contaminant removal from wool by the image processing algorithm in real time is presented. Both software and hardware approach are reported. Zhenwei Su ; Abbas A. In this paper, a computer vision system is presented for the objective identification and classification of pigmented fibres, which consists of a web maker, an image acquisition system and a computer for image processing. The techniques of fibre preparation, image acquisition and the development of suitable algorithm together with software for removal of the background fibres and counting of pigmented fibres, are described in detail. Lynn Abbott; Clifford Shaffer Show Abstract The use of laser technology to scan hardwood log surfaces for defects holds great promise for improving processing efficiency and the value and volume of lumber produced. The location, type, and severity of defects on hardwood logs are the key indicators of log quality and value. These visual cues provide information about internal log characteristics and products for which the log is suitable. We scanned logs with a high-resolution industrial four-head laser surface scanner. The resulting data sets contain hundreds of thousands of three-dimensional coordinate points. The size of the data and noise presented special problems during processing. Robust regression models were used to fit geometric shapes to the data. The estimated orthogonal distances between the fitted model and the log surface are converted to a two-dimensional image to facilitate defect detection. Using robust regression methods and standard image processing tools we have demonstrated that severe surface defects on hardwood logs can be detected using height and contour analyses of three-dimensional laser scan data. Susumu Hattori ; Keiichi Akimoto; Tetsu Ono; Satoru Miura Show Abstract The NATM, a widely used tunnel excavation

method, requires precise periodical monitoring of deformations especially at fault zones, which tends to hamper traffics with conventional measurement means. In this paper vision metrology was applied to tunnel profile measurement with a view to developing a new method. Two hundred of Retro-targets are placed on a one-meter spacing lattice at a tunnel site of 7m in diameter and 15m in longitude, and 66 images were taken to cover the target field. The object space coordinates of targets obtained by bundle adjustment were compared with ones obtained by high-precision total station observation. The root mean square RMS of differences of coordinates was 0. Cutting desired profiles opens new fields of application for these machines. The precision of the profile, which is cut, depends on the kinematics of the machine and its calibration. The dimensions of the profiles up to 10 m wide and 5 m high make it difficult to calibrate and even measure. This paper presents an image processing system, which was developed to solve this problem. An ultra-bright infrared LED was mounted on the primary calibration point of the machine. The 2-R manipulator i. The 2-R kinematics of the machine result in the calibration point moving along the surface of a torus. The imaging system acquires a sequence of images, each of them captures the machine in one point along the profile. This delivers a 2-D central projection of the 3-D motion. The inverse projection is determined using projective geometry. The true position of the calibration points is determined by applying the inverse projection, which is then compared to the desired position. Measurements of a mining machine and a comparison with the desired profile are presented. This 3D reconstruction is obtained through the elaboration of a photometric model, which takes into account camera and light source positions according to the plan of the rough surface. The proposed model expresses the gray level on the image according to the local relief variations. Three images of the same relief obtained under different angles of lighting are used to reconstruct the altitude map of the rough surface. The effectiveness of this method was checked by comparing the extracted relief to its corresponding relief obtained from a mechanical device method using autofocus laser sensor. This photometric model display good results in simulation experience and will be applied on real photographic images of road covering surface in order to study its wear level and its adherence. The aim of the paper is the computation of suitable features for describing the characteristics of sequentially acquired profiles. The features should discriminate well between flaws, the intact surface, and pseudo errors caused by inhomogeneous surface properties such as, e. The orthogonal distance from the planar curve to its spline approximation serves as a suitable descriptor. In addition, the multi-scale curvature is useful since the defects are characterized as local perturbations of a relatively smooth curve. Since the embedded flaws on the surface of the steel block are existent in neighboring profiles, a measure for evaluating the local perturbations with respect to subsequent profiles is presented. Therefore, a kernel is used for weighting the neighborhood of a defect. The shape of the kernel might be Gaussian, however, a special kernel was developed for emphasizing a preference direction of the flaws. Ford ; Jeffrey A. Mercier Show Abstract The inspection of sidewall thickness provides important information about the production processes for glass container manufacture. By monitoring the thickness profile around the perimeter of bottles in real-time, the manufacturing process can be altered to produce higher quality products. This also provides the ability to identify and remove defective products. In order to improve the speed and accuracy of inspections, a new non-contact method for acquiring thickness profiles of glass bottles that employs optical and machine vision techniques has been developed and tested. Based upon this principle, a new non-contact glass thickness measurement technique has been developed and it has demonstrated good accuracy. Eskarne Laizola ; Antonio Ramon Jimenez ; Fernando Morgado; Mar Calvache; Fernando Seco Show Abstract This paper presents a computer vision system for measuring the weight of gobs during a glass forming process, and a control strategy to correct automatically any weight deviation from a given set-point. During the formation of molten glass gobs, several noise sources can cause a deviation in the weight from a predefined reference value. Among them, there is a random white-noise disturbance caused by the lack of synchronisation of mechanical devices, the periodic disturbances due to changes in the spinning direction of the tube inside the feeder, and some long-term drifts caused by variations in temperature and viscosity of the raw glass material. The gob weight measurement system developed is based on a monochrome CCD

high-resolution camera and photo-detector for synchronizing the frame acquisition. The molten glass provides the illumination, so a high contrast image is obtained with a bright object and dark background. Several image-processing algorithms are presented for reliable area estimation. A learning weight control strategy is proposed based on a PI-repetitive control scheme. The weight deviation from a set point is used as a control signal to adjust the glass flow into the feeder. This regulation scheme allows effective weight control, canceling mid and long-term effects. Eusebio Carasusan ; Fernando Canal Show Abstract In this paper a new automatic strain analyzer system for sheet metal stamped parts is presented. This device is based on an optic 3D scanner working with structure white light, that performs measurements with high speed and accuracy. This new device can be a very useful tool in manufacturing industry. Hui Wang ; Xudong Bao; Limin Luo; Guoqiang Lv Show Abstract Serial number plays an important role in the manufacturing and managing processes to identify the industry products, and automatic recognition of the serial number has become an essential step in modern industries. The limits of manufacture condition in factories and the requirement of real-time operation, however, make the design of a practical automatic serial number recognition system a difficult task. We developed a novel automatic serial number recognition system for railway wheel products, which has been successfully used in real production lines. This system uses visual inspection approaches to automatically recognize the serial numbers in real-time. The flexibility and low cost of the system make it very suitable for the applications described in this paper. Jian Lu ; Kyoko Hamajima; Koji Ishihara Show Abstract As a prospective intelligent sensing method for Autonomous Guided Vehicle AGV , machine vision is expected to have balanced ability of covering a large space and also recognizing details of important objects. For this purpose, the proposed hybrid machine method here combines the stereo vision method and the traditional 2D method. This paper is mainly about the coarse recognition. In order to extract objects in the coarse recognition stage, the disparity image calculated according to stereo vision principle is segmented by two consequent steps of region expansion and convex split. In our example AGV application, some navigation-signs are introduced to indicate the travel route. When the attribute shows that the object is a navigation-sign, the 3D measurement is used to gaze the navigation-sign, in order for the fine recognition to analyze the specific meaning by means of traditional 2D method. Its purpose is the detection of topographies of highly reflective, metallic surfaces of quickly moving metallic tokens. It represents a decisive improvement of the serial-SSGM. The objective is to decide from comparison of the measured characteristic surface topography with topographical data stored in a database whether the token belongs to a reference class or not. Using the spectral properties of the illumination, which matches to the special spectral characteristics of the camera, three independent images can be extracted. The comparison between these images leads to a discrimination between a real object with 3D topography and a photographic image.

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Chapter 4 : Vision Systems - National Instruments

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Dark Field Lighting Staging Staging usually is mechanical. It also usually includes a Part-in-Place sensor that tells the machine vision system when a part is in front of the camera. Staging is required for three reasons: To ensure that the surface of the part that you want to inspect is facing the camera. To hold the part still for the brief moment required for the camera to take a picture of the part. If the part moves too much while the picture is taken, the image may blurr. In some cases the parts move so slowly that they do not need to be held still for a good picture. To speed up the processing by putting the part in a location known to the Vision Appliance. All machine vision systems must first search to find the part in the image, and this takes time. Optics and Lenses The lens gathers the light reflected or transmitted from the part being inspected, and forms an image in the camera sensor. The proper lens allows you to see the field-of-view you want and to place the camera at a convenient working distance from the part. To pick the proper lens you will first need to know the field-of-view FOV and the working distance. The FOV is the size of the area you want to capture. Here is a typical example: If the part to be inspected is 4" wide and 2" high, you would need a FOV that is slightly larger than 4", assuming your staging can position the part within this FOV. In the previous example, the 4" x 2" part size would fit in a 4: The working distance is approximately the distance from the front of the camera to the part being inspected. A more exact definition takes into account the structure of the lens. From the FOV and working distance and the camera specifications, the focal length of the lens can be estimated. Common focal lengths for lenses in machine vision are 12 mm, 16 mm, 25 mm, 35 mm and 55 mm. When the calculations are done, the estimated focal length will probably not exactly match any of these common values. We typically pick a focal length that is close and then adjust the working distance to get the desired FOV. There are other important specifications for lenses, such as resolution image detail - depends on the camera and the lens , the amount and type of optical distortion the lens introduces and how closely the lens can focus. A standard VGA camera has x physical pixels width x height , and each physical pixel is about 7. From these numbers, resolution can be estimated for your "real world" units. We usually specify resolution as a fraction of a physical pixel, as this is independent of your particular imaging set-up. The sensors used by machine vision cameras are highly specialized, and hence more expensive than say, a web cam. First, it is desirable to have square physical pixels. This makes measurement calculations easier and more precise. Second, the cameras can be triggered by the machine vision system to take a picture based on the Part-in-Place signal.

Chapter 5 : What is Machine Vision - Introduction to Machine Vision | Cognex

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Chapter 8 : Machine Vision and Inspection | Teledyne DALSA

- Machine vision is the substitution of the human visual sense and judgment capabilities with a video camera and computer to perform an inspection task.

Chapter 9 : Machine Vision Systems

Inspection Automation based on Machine Vision applications offers great potential to achieve all four goals. Our cameras utilize 10 GigE technology which opens new opportunities to enhance existing applications, enable new machine vision applications, and cut costs with an unbeaten total cost of ownership.