Machine Vision in Profibus Networks

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***Abstract* - In this paper, a system for the transport of images across Profibus industrial networks acting as support to the monitoring and control system of industrial processes is implemented and evaluated. The capacity of Fieldbus Data Link (FDL) to support the transport of images and the impact on the performance achieved through the utilization of compressed images are analysed. A communications protocol over FDL is implemented and tests are realized with different image sizes, compression ratios and background traffic which allows for the simulation of various scenarios. Profibus networks have been shown to be capable of simultaneously transporting images with control traffic, which opens up a new range of applications.**

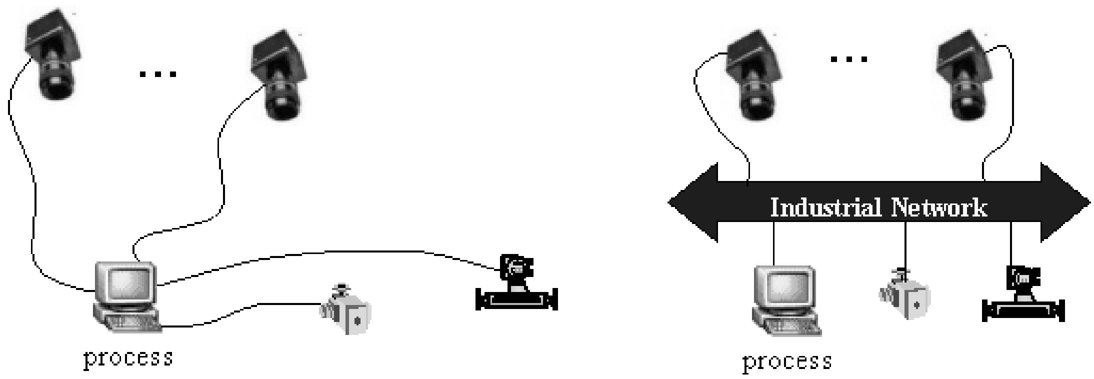
1. INTRODUCTION

In the current globalized economic environment, companies need to concentrate their efforts on improving their efficiency and competitivity. As a consequence, they need to make use of advanced production and management techniques such as Computer Integrated Manufacturing (CIM), Just-in-Time Production (JIT), and Total Quality Management (TQM). In this environment, machine vision combines computers and cameras in order to acquire, analyze and interpret digital images in a manner that simulates human vision. From an industrial point of view, this technology can be applied when realizing control functions of products and processes. Advantages with respect to traditional methods are to be seen in relation to reliability, validity, velocity and objetivity of the analysis realized. A further element which allows for the automation of production is the utilization of field buses or industrial networks, facilitating comunication between production elements in such a way that control is realized in distributed real time. This method is efficient in that it permits control at any given moment in time of the parameters and variables involved in the production process.

In a classical system of industrial machine vision, the following elements are involved:

- Lighting System: this system provides uniform working conditions.
- Camera: Process Sensor which realizes the collection of data about the physical characteristics of the object to be analyzed.
- Frame Grabber: this system communicates with the camera in order for images to be transferred to the computer in an ordered manner so that the computer can realize the processing of the images. Normally, this system carries out the conversion from an analogical to a digital format (A/D), although it is quite common in industry to work with digital cameras which are capable of providing digitalized images with the appropriate characteristics so that the industrial process may be controlled.
- Computer or Processing unit: this system realizes the task of extracting the information that is being looked for in the digitalized images which have been received through the application of the necessary algorithms.
- External actuators: elements which permit interaction with the variables involved in the manufacturing process. This element is not always used and may be just a simple visual alarm signal.

In order that the utilization of these vision systems may be of use to a company, the following requirements have to be fulfilled:



a) Dedicated Systems

b) Distributed System

Fig. 1. Image Transmission Methods. a) usual working method for the integration of machine vision in industry, b) proposed and analyzed method.

• Robust and realiable: the functioning of these sytems has to be constant and false alarms should be avoided.

• Real Time: they have to fulfill the time restrictions which are delimited by the production process into which they are integrated.

• Cost-effectiveness: the total cost of the system should not be beyond the point where it is no longer profitable.

In this situation, time restrictions permitting, the utilization of industrial networks (Fig. 1b) as a system for transporting images to be processed can imply an important cost-saving device, if one also takes into account the large quantity of industrial networks installed in companies.

The objetive of this paper is to analyze and determine the time restrictions which machine vision systems that utilize industrial networks may be able to fulfill. Profibus (Fig. 1b) is analyzed as a means of transporting images between digital cameras and the processing units, avoiding the use of frame grabbers (Fig. 1a) and observing the impact that this kind of transport has on the traffic that controls the industrial network. Moreover, the increase in productivity obtained in the number of images per second which the system is capable of transmitting is analyzed, as a result of the utilization of image compression techniques which permit the reduction in bandwidth used in the transportation of the images.

2. INDUSTRIAL NETWORK. PROFIBUS

Industrial networks are found at process levels and cell hierarchy in CIM (Computer Integrated Manufacturing) [5]. One is dealing with telematic systems which have substituted the classical star-shaped cable system (typically links of 4-20mA) between sensors/actuators and control sytems, via a communications bus. This fact has allowed for cost reduction, easiness of installation and configuration, the use of diagnostics for the detection of breakdowns, etc. These networks allow for the decentralization of the connection of the elements which participate in the control system and thereby achieve distributed processing systems which satisfy the critical time requirements needed in some of the applications which use them.

Within these networks, Profibus [10] has been chosen for the realization of the research presented in this paper, as it is a widely utilized standardized solution (EN 50170, IEC 61158) and available for industrial networks of a general character which operate at the level of process and cell. The architecture of the protocol does not contemplate levels 3, 4, 5 and 6 of the OSI model with the objective of increasing efficiency and reducing processing time. Profibus permits a wide range of industrial applications to make use of its functions, including high transmission velocity (up to 12 Mbps) and the management of complex processes or processes with critical time requirements.

There are three variations of Profibus, whose objective is to satisfy the different requirements of applications, Profibus-FMS, Profibus-DP and Profibus-PA. Profibus FMS is implemented at the application level and permits the transfer of information in an open way between application processes. Its principal inconvenience is that the system

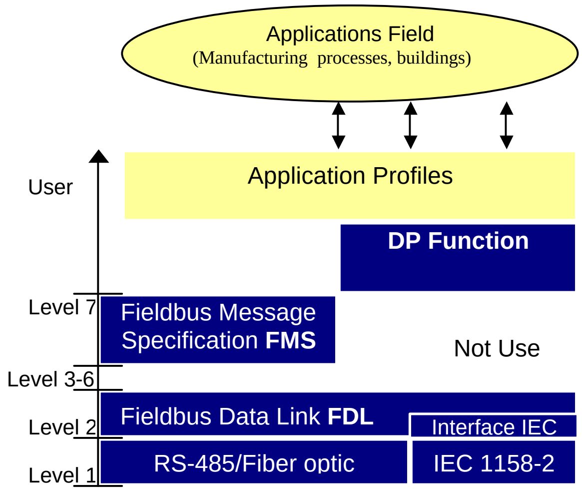


Fig. 2. Profibus Architecture

reaction times are diminished because of the processing needed. The maximum transmission velocity is 1.5 Mbps. Profibus DP (Distributed Peripheral) is designed to enable communication between controllers and peripherals distributed throughout the network at a very high speed. It maps services directly at level 2 (called FDL, Fieldbus Data Link), avoiding application level and reaching a maximum speed of 12 Mbps. Profibus PA is used with applications that require intrinsic security, the protocol which is available allows for the possibility of utilizing at the physical level the protocol IEC 1158-2, although this limits speed to 31,25 Kbps.

The application developed to evaluate the functioning of Profibus has been implemented directly at the level of FDL, utilizing some of the services offered by Profibus, which means that it can coexist with the rest of the existing traffic on the network. The stations can be integrated into DP networks as both utilize FDL services for communication, and all the master stations would enter into the exchange of the token, whether FDL or DP. SDA (Send Data with Acknowledge) services are utilized to test all aspects of negotiation between stations such as image characteristics, resolution and number of bits per pixel, the signalling of the end of the image, and to indicate the end of transmission and SDN (Send Data with No acknowledge) services for image transmission.

The protocol implemented is oriented to connection and, given that the transported images are processed in real time and action is taken on the process as a result of the aforementioned processing, no attempts to recover the images are made in the case of failure. In section four, the precise detail of this protocol is given.

3. IMAGE COMPRESSION

Image compression can increase considerably the performance of the system as it helps to reduce the bandwidth consumed by the transport of the images. This reduction can be useful when the bandwidth available is scarce, due to the consumption of bandwidth by control traffic and that reserved for aperiodic traffic, for the size and frequency of images which have to be transmitted.

The compression systems for digital images (with or without movement) are based on spatial and temporal redundancy in the images ([9] JPEG, MJPEG, MPEG1, MPEG2, MPEG4, H.261 y H.263). These techniques present different properties with respect to the quality of the compressed image, the spectral efficiency, the complexity of coding and decoding, etc.

The fundamental parameters to be taken into account when one has to compress digital images in the context of applications are:

- Real Time: depending on acquisition requirements, transmission and processing in real time, the choice may be conditioned by CODEC complexity (coder/decoder).
- Compression with or without loss: compression with loss of information implies a greater rate of compression and some degradation in signal quality. If this degradation is acceptable for the application which receives the image, its utilization is advisable as it achieves greater throughtput in image transmission.
- Inter-frame/intra-frame: In inter-frame mode, each image is compressed into one take as if dealing with a static image whereas, with intra-frame schemes, predictive techniques are employed, by which greater levels of compression are achieved, although the image needs to have spatial continuity. This is not the case in this paper and therefore these kinds of compression will not be analyzed.
- Resolution: this refers to the number of pixels per image, which will depend on the application: in supervision and monitoring processes, one can employ general resolutions of the order of QCIF (176x144) to CIF (352x288). In quality control, resolutions needed may be 4CIF (720x576) or greater.

The techniques utilized for moving image compression have not been considered to be valid for image transmission in real time within industrial applications of machine vision. This is fundamentally due to the fact that the acquisition of images in these applications is usually governed by a control signal (photocell, encoder, etc), which takes charge of synchronizing the acquisition of the image with the exact moment in time when the object to be analyzed is to be found in the field of vision of the cameras, which impedes the utilization of intra-frame predictive techniques.

Another inconvenience of the techniques utilized for moving image compression which, in fact, also affects compression techniques of static images are the modes of codification control VBR (Variable Bit Rate) or CBR (Constant Bit Rate), which impact on the quality of the image and the number of bytes needed to represent the coded image [3]. These parameters need to be known and to be controlled in an application of this kind, given that the image quality can affect the information extracted by the vision process, while the number of bytes utilized in the coding affects the time employed in the transmission of the images. Both modes present image quality and a constant flow of information when the variability in the scene is very small. When there are changes in this variability, the CBR mode maintains a constant flow of information reducing the quality of the image. The VBR mode maintains the quality of the image constant but increasing the flow of information.

The image compression technique utilized in this paper has been JPEG software, given the image quality, the lower level of CODEC complexity and the compression rates that can be achieved. JPEG (Joint Photographic Experts Group) is a 1991 ISO standard (ISO DIS 10918-1) utilized in image compression with continuous tones (photographic images) which permit four modes of functioning [4]. In order to carry out compression, an Intel JPG library has been utilized [11]. This library allows for the specification of the level of quality desired, acting in a similar way to VBR mode. As a result of which, in the analysis, measurements (as shown in section 5) have been taken utilizing scenes with an average variability, where the size of the compressed images are not superior to a specified value, a fundamental aspect in order to be able to realize an analysis of the transmission times of the compressed images.

4. SCENARIO AND APPLICATIONS

4.1. System Description

Machine vision systems do not always require all the bandwidth available between the camera and the frame grabbers. Generally, in industrial applications of machine vision, the acquisition of the image is governed by a synchronization signal proceeding from the process, which habitually has a constant period or known maximum and

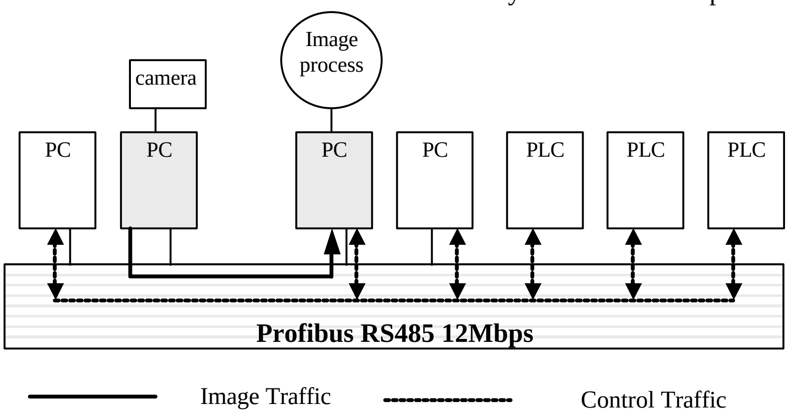


Fig. 3. Work Scenario.

Table 1. Network configuration parameters.

Transmission Rate	*Tslot*	*Min. Tsdr*	*Max. Tsdr*	*Tset*	*Tqui*	*Trdy*	*Tid1*	*Tid2*	*Ttr*	
12 Mbps	**1000 t_b**	**12 t_b**	**800 t_b**	**16 t_b**	**9 t_b**	**11 t_b**	**76 t_b**	**800 t_b**	**80896 t_b**	**6.7ms**

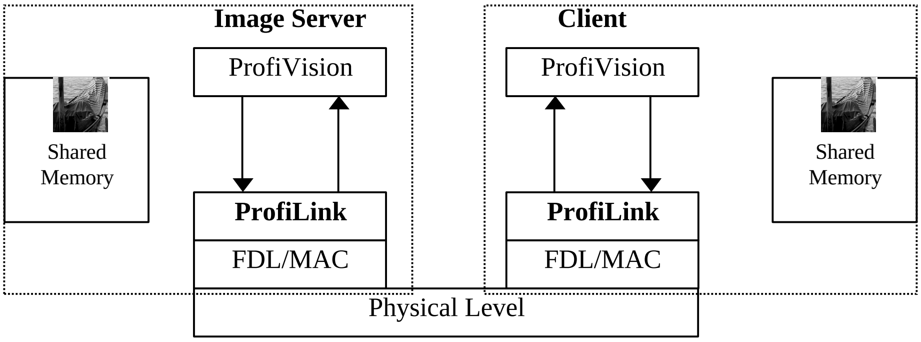


Fig. 4. System Architecture

minimum frequencies. The maximum frequency of acquisition can vary from various hundreds of images per second, to relatively few units or tens of these. This frequency will depend on the characteristics of the manufacturing process to which machine vision systems have to be adapted. For example, in the inspection process of a particular product, as might be the quality control of fruits, of bottled products, of finished fabrics, it is necessary to achieve the greatest inspection velocities possible (data rate >> 10 Mbps) so as to be able to make the system profitable, which might mean rejecting this application. Nevertheless, in cases in which the inspection process is realized in parallel with the production process, the velocity of the production process will determine the necessary speed of the inspection process, being viable this kind of architecture when the transfer rates are just a few Mbps. In general, the utilization of systems of this kind is possible in any production sector where the quantity and quality of the information generated can be adapted to the available bandwidth of the industrial network.

In this context, the utilization of dedicated systems (direct connection between the camera and the frame grabber. Fig. 1a) would suppose an elevated level of waste of the processing units for quality control, besides implying higher cost levels.

The scenario chosen to analyze the viability of the transport of images for their treatment by machine vision on Profibus networks is made up of four Pentium III 800Mhz PCs and three PLCs. A PC is utilized as a server of images and another PC has been used for visualization and processing. The rest of the PCs and PLCs are employed in the generation of traffic control that may typically be found in an industrial network, as can be seen in Figure 3. The parameters utilized in the configuration of the network, measured in bit time, are shown in table 1.

Given that the designed system, once configured and operating, will suffer little or no change in its parameters, the server of images has been implemented on a master station as it has to function autonomously and to launch, within the token holding time, images to the receiver stations without requiring any requests. Moreover, a master station is capable of operating in Multicast mode (from one to a group), which can be important for some control applications which require simultaneous monitoring or processing in various clients.

4.2. Communications Protocol

The image transmission system is implemented based on two processes which are executed at the same time on two different machines (Fig. 4) connected to a Profibus network. One denominated ProfiLink, which is the interface with the Link Level of the network, in this case the Profibus FDL. The other process, ProfiVision, can act indistintively as a server or as a client. As a server, the process will acquire, compress and supply in a synchronized manner the image to the ProfiLink process so that the image's transmission to the client is realized. On the other hand, the ProfiVision process configured as a client will receive the image and the information related to its descompression, if this is necessary, so that the information may be extracted and processed.

In order to synchronize the functioning of these concurrent processes in the same machine, CEvent objects from the Application Program Interface (API) of Windows have been utilized [6]. As far as the information to be exchanged between these processes, a FileMapping structure (Windows API) is utilized in shared memory (Fig. 4) in each one of the machines, which allows them to have a common

Table 2. Data field of the SDA packets.

1	2	2	1	← nº bytes utilized
code				
0	X	Y	4bits / 4 bits compression/color	negotiation
1	nº bytes	-	-	End of image
2	-		-	End of the communication

Table 3. Service Primitives.

Primitive	Origin	Description
negotiation (neg)	ProfiVision	Communication of the parameters of the image to the Profibus communication process.
parameters (par)	ProfiLink	Communication of the parameters of the image to the client ProfiVision process.
send_image (snd)	ProfiVision	Request for image transmission
receive_image (rec)	ProfiLink	Communication to the client ProfiVision process of the arrival of a new image.
liberation (lib)	ProfiVision	Request for the liberation of the connection
liberation(lib)	ProfiLink	Communication of the liberation of the connection

memory area where they dump the information in a synchronized form with the processes which are being executed on the same machine.

The Profibus data link level provides the necessary SDA and SDN services for the transmission of images analized in this paper. The SDA packets, with the aim of maximizing the image transmission capacity of Profibus, are only utilized to realize operations whose reliability has to be guaranteed (Table 2), while with image information SDN transmission packets are utilized.

Establishing connection.

Given that the protocol is oriented to connection, the first action is to establish this connection (see Figure 5). The ProfiVision process server initiates the connection, the initiation will also serve to communicate the rest of the processes involved with the characteristics of the images which are to be transmitted. This initiation will always occur when the fundamental characteristics of the images to be transmitted and processed are changed, such as the sizes of X and Y, the number of bits per pixel utilized, and if the image is or is not compressed. To carry out this connection, the primitive *negotiation* (***neg***, Table 3, Fig. 5) is utilized, starting the request for the commencement of the connection. The ProfiLink process, on receiving this request, realizes the transmission of a SDA packet type 0 (Table 2) transmitting information about the image to the ProfiLink process receiver. This process using primitive *parameters* (***par***) comunicates all the parameters of the images to the ProfiVision process which acts as a client and needs to know this information to be able to correctly process the images received.

At the same time, as a consequence of the reception of the SDA(0), the FDL of the ProfiLink process receiver sends a recognition signal to the ProfiLink process transmitter, which allows for the confirmation of the establishment of the connection to the ProfiVision process server, which from this moment is ready to begin the transmission of images at the programmed rate from the server station.

Transmission of images

Once negotiated the parameters of transmission, each time that the server station has at its disposal an image, it will place it in the shared memory of the ProfiVision-ProfiLink processes, and will signal this fact to ProfiLink using the primitive *send_image* (***snd***, Fig. 6). ProfiLink, on receiving this request, will send the image by the bus using the transmission of as many SDN as is necessary, sending a SDA type 1 to indicate both the end of transmission of the image as well as the number of bytes which the image is composed of. When using image compression, this data can be somewhat variable for each one of the acquired images. This SDA will cause the ProfiLink receiver to communicate to the ProfiVision process client the reception of a new image using the primitive *received_image* (***rec***). At the same time, recognition that the SDA packet has been sent will cause the ProfiLink process sender to confirm the transmission of the image, which will prepare the ProfiVision process server for the acquisition of the next image.

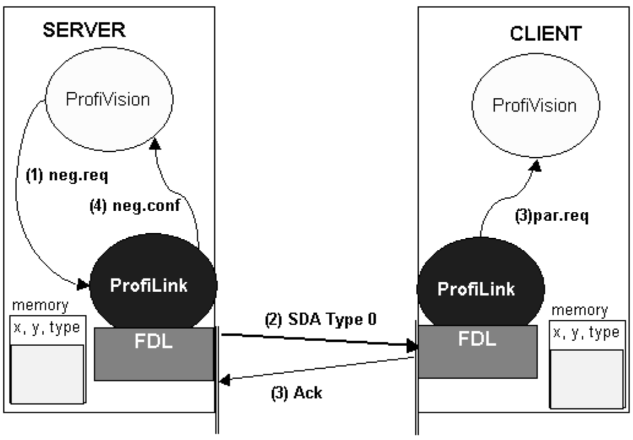


Fig. 5. Establishing connection phase

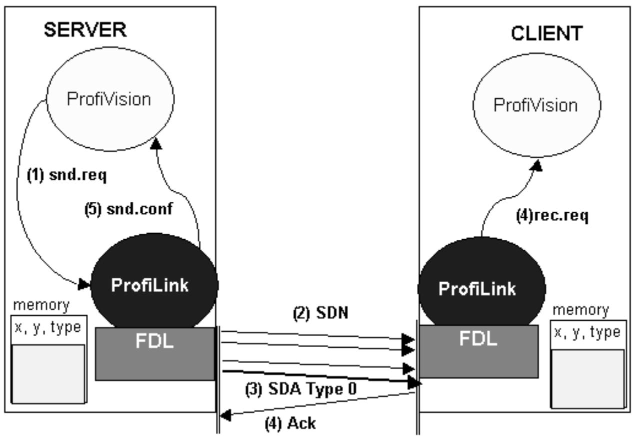


Fig. 6. Image transmission phase

Table 4. Modified SDN Packet

nº packet LSB	nº packet MSB	byte 0	byte 1	byte 2	...	...	byte 237

Table 5. Characteristics of the images transmitted

Compression ratio (quality Intel IJL)	Average size of the images (Mbits)		
	640x480	320x240	160x120
1:1 (-)	7,031	1,758	0,439
10:1 (75)	0,703	0,176	0,044
16:1 (50)	0,439	0,110	0,027
25:1 (25)	0,281	0,070	0,018

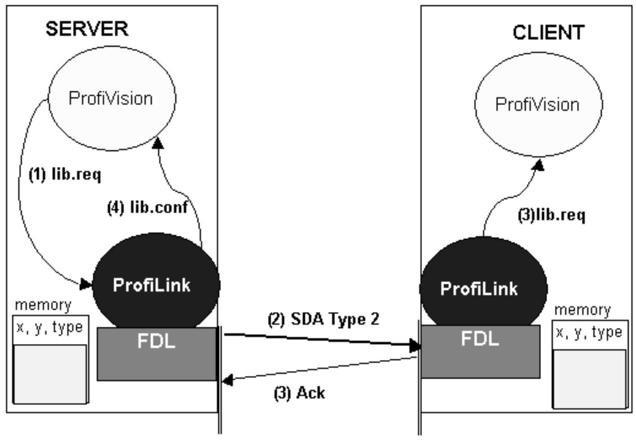


Fig. 7. Connection Liberation Phase

Data Packet Format

The modified format of the SDN packet utilizes 238 of the 240 bytes available to transmit information about the image, and the first two bytes for the numeration of the packets (Table 4). Taking into account the fact that the Profibus packets dedicate 16 of the 256 bytes available to control information [10], useful information is reduced for each packet to 94.11% utilized per every pure Profibus packet, to 93.33% utilized in the designed application, which represents a fairly insignificant decrease.

This numeration is important because the application is one of image processing and the disordering of packets at destination occasioned by the loss of a packet could mean an important distortion in the image. This can affect the extraction of information and cause erroneous conclusions, which could generate important sequences of incorrect control actions. The utilization of this numeration guarantees that each packet is located in the appropriate place in the reception buffer. If a packet is lost, information about the last image would be maintained, which would cause an error percentage in the processing of the image which is practically speaking insignificant; especially if one takes into consideration the low rate of lost packets that a Profibus network provides and the low probability that the lost packet is precisely the one with the most important and relevant information about the image. Nevertheless, when image compression is used, the loss of a packet can mean the loss of a very significant part of the image. The greater the ratio of compression utilized the greater the loss will be. In these cases, it is preferable to discard the image received as it is unlikely that using the information from the previous image that a decompressed congruent image can be obtained.

Connection Liberation

To finalize the transmission of the images, the ProfiVision process utilizes the primitive liberation, which causes ProfiLink to generate a service SDA with code 2 (Table 2, Fig. 7), which guarantees the liberation of the resources consumed by all the processes.

5. EXPERIMENTS AND MEASUREMENTS

In order to study the viability of the proposed system, measurements have been taken utilizing the scenario shown in Figure 3. For the realization of the tests, colour images (640x480x24) with compression ratios of 1:1, 10:1, 16:1 and 25:1 have been utilized. Compression has been carried out utilizing the Intel IJL 1.5 library, which permits the carrying out of compression on memory buffers for their packing and transmission. These compression ratios have been chosen, as 10:1 is a ratio that can be achieved by the compression algorithms without loss, which may be very important in

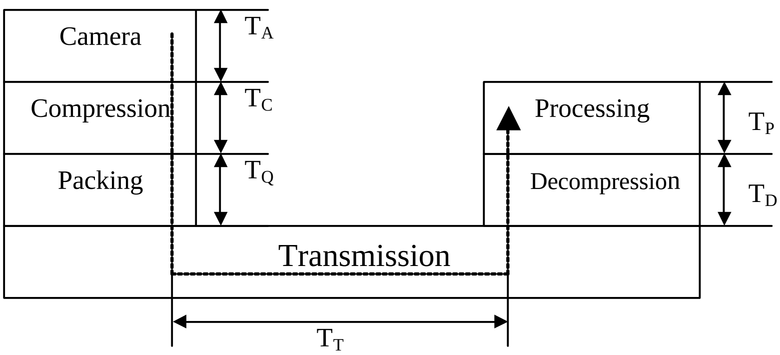


Fig. 8. Diagram of times involved

certain quality control applications. 25:1 is a compression ratio with an acceptable level of loss for many other machine vision applications [1], obtaining in this manner a representative range of compression ratios that may be utilized in machine vision applications.

Background traffic has been created establishing links between the clients and placing periodic as well as aperiodic petitions. An average occupation rate of between 30% and 50% was reached.

These characteristics are representative for the analysis of the limits of the transport of images of medium-low resolution on Profibus, covering a range of images which go from 0.44 to 7 Mbits (Table 5).

As has been previously stated, the aim of this paper is to analyze the number of images per second that the system is capable of dealing with, and the total time between the acquisition of the image and its processing. The first time involved in this analysis is the time that it takes to acquire the image, $\mathbf{T_A}$, which is the time that has passed from the acquisition of the image by the camera and the notification of the availability of this image to the lower processes which have to process or transmit the image. Another significant time is the time employed in compression, $\mathbf{T_C}$, and decompression, $\mathbf{T_D}$, of the image in the transmitter and receiver, given that they may have an important impact on the efficiency of the system. The transmission process, once the information is available to be transmitted, has to prepare packets in an appropriate format for the network to be utilized. This is denominated as the packing time $\mathbf{T_Q}$. Once the packets have been prepared, the Profilink process will send all the packets which form the image, consuming a time $\mathbf{T_T}$ in order to realize the transmission. In this analysis, reception and unpacking time of the image has not been considered, given that this process is realized in the receiver as the emitted packets arrive from the transmitting station and is therefore an insignificant amount of time. Finally, the time employed in the processing of the image and the execution of actions resulting from this analysis is denominated $\mathbf{T_P}$. In a conventional machine vision system, the total processing time of an image would be equal to $T^1 = T_A + T_P$. In the system proposed, the total processing time is $T^2 = T_A + T_C + T_Q + T_T + T_D + T_P$.

Consequently, the latency to be analyzed and which has been introduced by this transmission system of the image is:

$L = T_C + T_Q + T_T + T_D$

The times, measured in seconds, can be found in tables 6, 7 and 8.

Therefore, latency added by the method of transmission utilized, for each one of the cases analized, is shown in table 9.

Without utilizing compression, only with images with lower resolution can there be any guarantee of delivery times in less than a second, which reduces the range of applications for this technique. Nevertheless, a compression ratio of 10:1 with images with an average resolution, which can be achieved through lossless techniques, can obtain an important increase in the number of images transmitted; being able to guarantee in this case delivery times lower than 300 msec.

In cases where the application is able to tolerate images with a compression ratio 25:1, one can achieve delivery times of less than 150 msec.

In Figure 9, one can see the number of images per second which can be transmitted taking into account the latency introduced by the transmission of the image across an industrial network, including packing times and compression and decompression times which allow for a significant increase in the number of images by reducing the quantity of information to be transmitted.

Table 6. T_T

LOAD 30%	1:1	10:1	16:1	25:1
160x120	0,094	0,017	0,012	0,010
320x240	0,373	0,046	0,032	0,021
640x480	1,633	0,160	0,103	0,057
LOAD 50%	**1:1**	**10:1**	**16:1**	**25:1**
160x120	0,098	0,017	0,012	0,008
320x240	0,389	0,048	0,029	0,018
640x480	1,716	0,161	0,078	0,048

Table 7. T_Q

LOAD 30%	1:1	10:1	16:1	25:1
160x120	< 0,001	< 0,001	< 0,001	< 0,001
320x240	0,002	< 0,001	< 0,001	< 0,001
640x480	0,010	< 0,001	< 0,001	< 0,001
LOAD 50%	**1:1**	**10:1**	**16:1**	**25:1**
160x120	< 0,001	< 0,001	< 0,001	< 0,001
320x240	0,002	< 0,001	< 0,001	< 0,001
640x480	0,011	< 0,001	< 0,001	< 0,001

Table 8. T_C y T_D

compression	10:1	16:1	25:1
160x120	0,003	0,003	0,002
320x240	0,030	0,011	0,011
640x480	0,053	0,044	0,041
decompression	**10:1**	**16:1**	**25:1**
160x120	0,003	0,003	0,002
320x240	0,012	0,011	0,018
640x480	0,054	0,046	0,043

Table 9. L

LOAD=30%	1:1	10:1	16:1	25:1
160x120	0,094	0,024	0,018	0,016
320x240	0,375	0,090	0,056	0,050
640x480	1,644	0,269	0,195	0,142
LOAD=50%	**1:1**	**10:1**	**16:1**	**25:1**
160x120	0,099	0,024	0,018	0,014
320x240	0,391	0,092	0,053	0,048
640x480	1,727	0,270	0,170	0,133

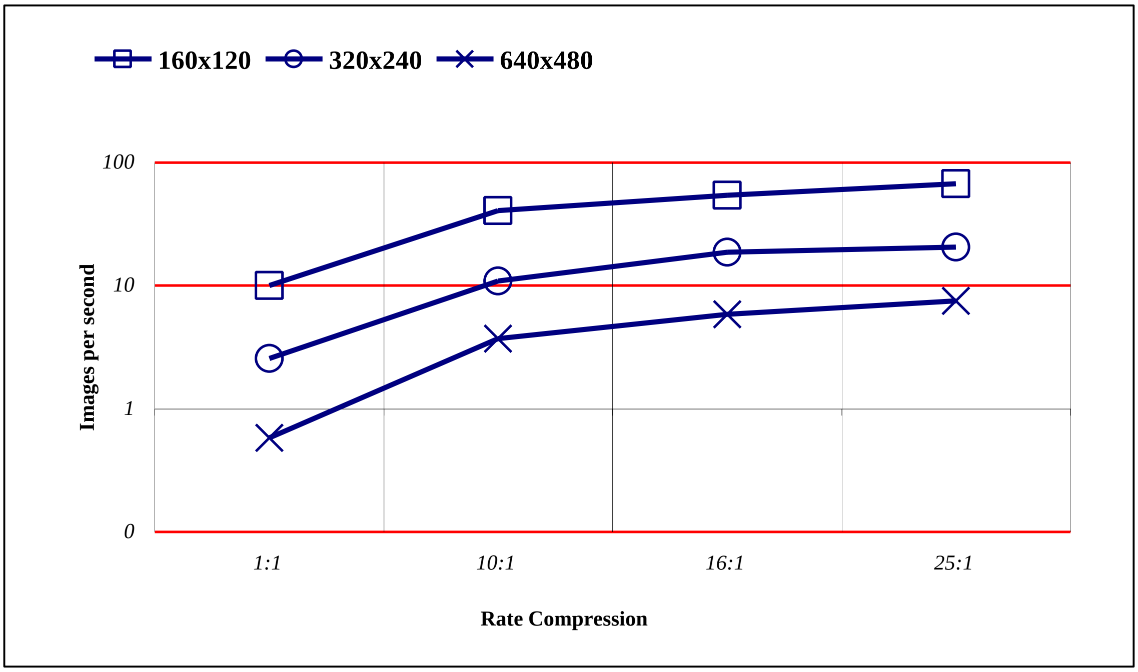


Fig. 9. Number of images per second which may be transmitted with control traffic load of 50%

6. CONCLUSIONS AND FUTURE RESEARCH.

As a result of the experiments realized on the Profibus network, one can conclude that these types of systems are viable without utilizing compression techniques, within the environment that was analyzed; that is to say, in cases where the rate of an image per second is admissible with the application being used and always when the image is approximately smaller than 5 Mbits (for example, 540x410x24, or 1024x640x8). In cases where the rate of incoming images is greater than 5 images per second, only low resolution images are possible, approximately less than 1 Mbit (for example, 270x165x24, or 460x280x8).

The capacity for image transmission of the Profibus network, when compression is not utilized, is therefore relatively low, principally due to the characteristics of the method of access to the medium which has to guarantee restrictions in delivery time of the information, which limits the number of industrial applications where its use may be viable.

If some degradation of the image produced by a 25:1 process of compression is acceptable, the increase in the number of images obtained is significant. In these cases, the proposed method is valid for the transmission of more than 5 images in all the combinations analyzed and besides permits the utilization of the system in very high speed processes which admit low resolutions. Under these premises, one can practically achieve 67 images (160x120) per second and 21 images (320x240) per second.

This system has been simulated using cameras connected to computers and these at the same time to a Profibus network, given that there are no devices available on the market which are connected directly to these networks. Currently, we are working on the development of a sensor capable of capturing images and of realizing all the linking and transmission functions directly on to a Profibus network. In parallel, it is necessary to incorporate a hardware compression stage capable of processing the entry flow at the speed which the network is capable of transmitting, in such a way that one can control the maximum levels of quality and flow of information generated by the compression process.

Other aspects which are being worked on are the realization of a formal model of the system. This will allow for an in-depth analysis of various aspects not included in the practical, physical implementation. This model will permit us to draw precise conclusions about the real impact on background traffic of the transmission of images and about what solutions or measures may be taken so as not to diminish performance in the exchange of images while simultaneously not impacting negatively on the performance of traffic control.

Currently, work is also being carried out on the implementation of the system proposed in this paper utilizing an Industrial Ethernet.

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