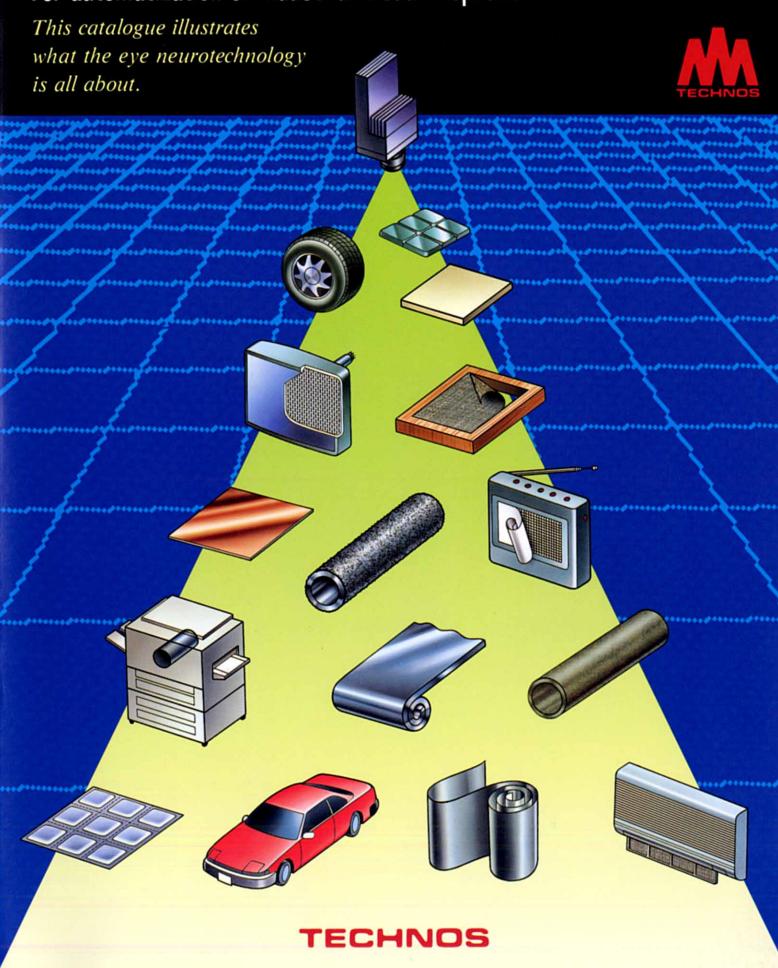
# TECHNOS NEUROSENSOR

For automatization of industrial visual inspection



### A new and revolutionary method for "industrial" visual inspection:

### Technos has passed through a period of evolution and has arrived at the new age of technology.

Most scientists who had dreams early in their lives have seen them materialized in the late 20th century. The universe seemed to be a world which we might be able to touch. However, as the science advances, the human body was found to be the most unknown world.

So-called "biotechnology" has become popular worldwide. And fuzzy also has entered people's daily lives and can be seen in most domestic appliances. Both biotechnology and fuzzy are the results of investigation into the human body.

Recently, people are paying a great deal of attention to the human nerves (or neuro).

We, Technos, have probed into the eye neurotechnology which was often overlooked, and succeeded in the replacement of optic nerves with electronic circuits.

This success is causing a revolution in industrial visual inspections which only a man can perfectly deal with eventually.

Technologies of Technos have absorbed all the features of the human eye, and yet far surpassed the human eye.

The ultimate capability of Technos inspection system is 13 times greater than that of the human eye.

At every second, the system can detect a defect whose size is 1/2560 milion volume of the scanned product section.

This ingenious system can increase not only production efficiency but also management efficiency.

This booklet illustrates what the neurosensor is all about.

Please read it through and realize the enormous power of Technos neurosensor.

(cranial nerves)

(optic nerves)

## Brain neurotechnology and Eye neurotechnology

Technos has pioneered the replacement of optic nerves with electronic circuits.

Science and industrial technologies have been rapidly growing, based on the philosophy and owing to endless improvements and cumulative techniques.

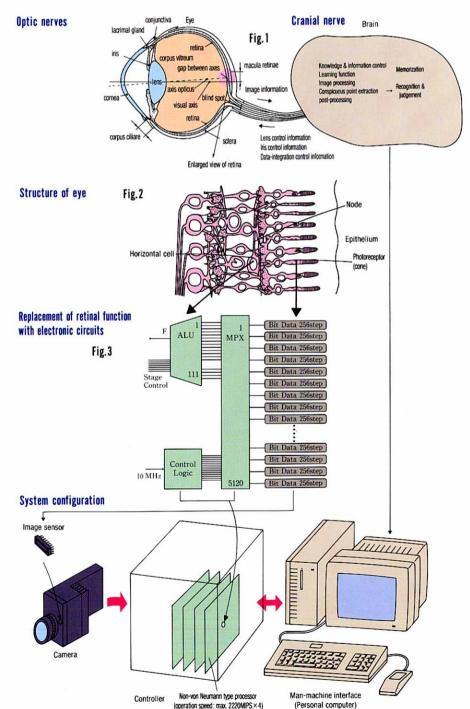
However, in the latter half of 1980's, people began to encounter barriers in the course of developments. Then, people turned away and began to look into the mechanisms of the human body. So-called biotechnology which has become very popular and so-called fuzzy which has been widely seen in home appliances are typical efforts to observe the human body and utilize its mechanisms.

So-called neurotechnology is also attempting to utilize the mechanisms of human nerve cells by using electronic technologies.

Neurotechnology is segregated into 2 areas; brain neurotechnology and eye neurotechnology. Conventionally, the brain neurotechnology has been a mainstream. However, the eventual goal of brain neurotechnology is to obtain a substitute for human's thinking mechanism, as long as the neurotechnology attempts to copy the brain nerve cells.

Therefore, a person has to be the experimented object in brain neurotechnology, which is difficult in reality. And also the structures of the human brain nerve cells have been found extremely complicated. On the other hand, the eye neurotechnology has advanced very quickly because the eye has a simple membranous structure, even though there are still remaining fields to be developed.

We, Thehnos, have probed further into the eye neurotechnology and succeeded in producing an electronic substitute for human optic nerves. It is said that more than 80% of information from outside are through the eyes. Our breakthrough system has as many as 10 million image reading elements which exceeds the number of human's retinal cones (6-7 million). This means our technology has surpassed the performance of human mechanism and moved toward the achievement of much higher precision. When this feature is applied to industrial production lines, it enables a breakthrough inspection system for automatizing in-line inspections at which conventional systems are much more inferior to the human eye.



Please take a look at the cross-sectional drawing of the eye (Fig. 1). An object image comes into the lens from the left and is projected onto the retina. After that, the image moves through the nerve fibers of retinal surface and passes through the blind/spot, and it finally reaches the visual field at the occiput where it is realized by the brainstem. This is a medial explanation of "seeing".

Fig. 2 shows an enlarged view of retina which we have focused on. Light enters from the left, passes through the transparent retina and reaches the pigment epithelium at the right end. Then, the light is reflected by the layer and come into the photoreceptors where the light is converted into electric signals. That is, the photoreceptor is a photo-electric transfer unit of the eye.

The lightness resolution of the photoreceptor is approximately 20 gradations which are a much smaller amount than expected. However, this is true and you know it by yourself at the chapter "Experiment" in this catalog.

Despite that, the detailed lightness precision of the human eye is as high as 1/2000. This means that the human eye achieves high lightness precision by using the low-resolution photoreceptors. How can the eye do this?

It is probably because the horizontal cells (neurons) of the retina have the data-integrating function. The horizontal cell is a neighboring cell of photoreceptor and has tree-like protrusive nodes. The node can integrate the data contained in 60-80 photoreceptors and the data integration can be adjusted in the following way.

The data integration becomes less, if an object to be detected is a small flaw with high contrast, while the data integration becomes greater, if an object is large smear with low contrast. This adjustment is carried out by a substance called "dopamine" which is inherent from birth.

That is, when a person sees slight smear with low contrast or color unevenness with slightest change, the dopamine fully acts to bring about the largest integration of 80 data units for each of the 20 gradations, so that the eye can have the lightness precision of as many as 1600 (20 x 80). This explains very well how a man can easily detect color unevenness or slight smear with very low contrast. We, Technos, have been studying the eye neurotechnology,

We, Technos, have been studying the eye neurotechnology, and succeeded in the development of a system which allows to inspect product surfaces with high precision.

Furthermore, the lightness gradation of the systems's image sensor (a counterpart of the human photoreceptor) is 13 times greater than that of the photoreceptor, that is, 256 gradations which correspond to bit data at the right end of Fig. 3. The maximum integration of our system is 111, greater than that of the horizontal cell (neuron)—80.

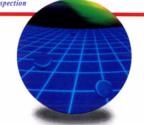
Therefore, our system can have the maximum lightness precision of 28416 (256 x 111).

This is approximately 15 times greater than the eye's lightness precision. And the system enables the surface inspections instead of spot inspections, by using its superb precision which is about 10 times greater than that of a color difference meter.

Furthermore, we have developed a non-von Neumann type processor with operation speed of 2220MIPS (mega-instructions per second) which allows real-time data processing and leads to automatic continuous inspection systems in manufacturing lines. Our system is originally based on the functional principles of human eyes, but it is now utilized for detecting surface defect using technology, which is far superior to the human eye in performance.

### Skyscraper effect of eye neurotechnology (i.e. Data-integrating function)

The electronic eyes of Technos can see an object simultaneously from both near and far points.



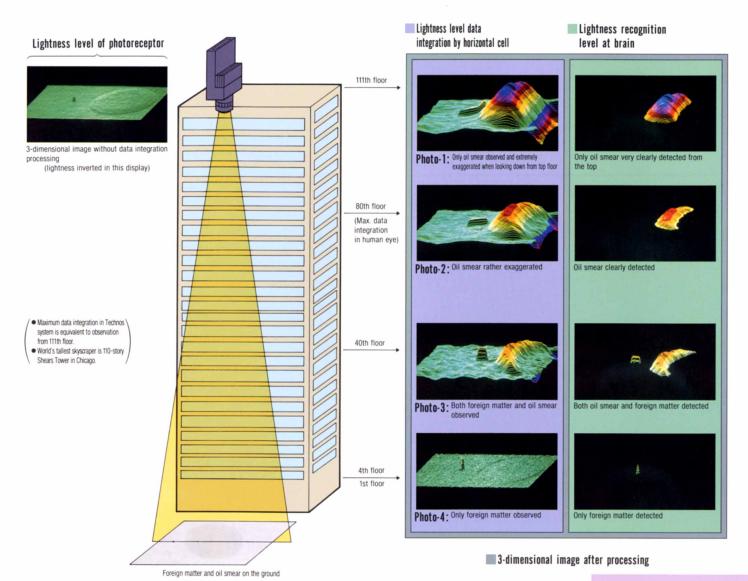
When looking down from a skyscraper, a person can obtain a whole view of a large object on the ground, but cannot get detailed view at small spots. Conversely, when looking down from the lowest floor, a person can obtain a detailed view of the object, but cannot get a whole view. The dopamine in the eye mentioned earlier acts on the neurons to help to select an observing manner among a whole view and a detailed view. Our system has exactly the same selecting mechanism.

The selection range of the human eye is from the lst floor to 80th floor in this explanatory skyscraper sketch.

Conventional image processing systems (inspection systems) did not have the same integrating function as that of the eye, which means those conventional methods are equivalent to the observation and detection of defects from the lst floor.

Therefore, the conventional systems are far inferior to the eye in lightness precision and there are a lot of products to inspect which can be dealt with only by the eyes.

Our optic neurosensor enables observations and inspections from various points ranging the 1st—111th floor, and such extensive ability can deal with almost all types of defects.



#### Limitation of the eye function;

As mentioned above, the eye can see the object on the ground from the point ranging the 1st—80th floor.

Conventional image processing systems are

equivalent to observation from 1st floor

However, at the instant when observing from a certain point (or floor), the eye can see the ground object from that position alone. This inflexibility is caused by the structures of eye cells. Therefore, when the inspector is concentrating on the detection of color unevenness with low contrast, he takes the least notice of small foreign matters, since his manner of inspection is just like the observation from a very high floor. On the other hand, when the inspector is concentrating on the detection of foreign matters with high contrast, he takes the least notice of color unevenness or slight smear, since his manner of inspection is just like the observation from a very low floor.

This inflexibilty comes from the structure of the optic cells and is beyond man's control.

#### Solution of Technos to the limitation

We succeeded in removing this limitation of the eye by assigning divided responsibilities to 3 different floors.

(3 different floors are enough, but 4 floors are possible at the maximum.) The 3 processors equivalent to the 3 assigned floors (e.g. the 4th, 40th and 80th) can be operated simultaneously in our system.

The 4th floor representative of the lower building portion takes a responsibility of finding detailed foreign matters and flaws. (Photo-4) The 40th floor representative of the middle building portion takes a responsibility of defects with moderate contrasts. (Photo-3) The 80th floor representative of the upper building portion takes a responsibility of oil smear or color unevenness. (Photo-2)

These 3 inspections can be carried out in parallel in our system, so that failures in noticing can be avoided which often happens with the eye.

Furthermore, the analysis function of our system enables simulation for determining the best point from which to observe a certain defect. Therefore, the best points can be always determined in our system, according to kinds of defects.

Photo-1 show how the processing goes with the observation from the top floor.

### Simple Experiments on Optic Nerve Cells

Let's use our own eyes to realize the data-integrating functions of the eye.

Unlike biotechnology or brain neurotechnology, eye neurotechnology can be easily tested using your own vision.

#### Comparison between human eye and neurosensor (Minimum dimension for defect detection and maximum dimension for integration) Fig.1 Enlarged view of retina Human eye 8mm Maximum dimension for integration for integration Minimum dimensio for defect detect for defect detection Cross-sectional drawing of eve

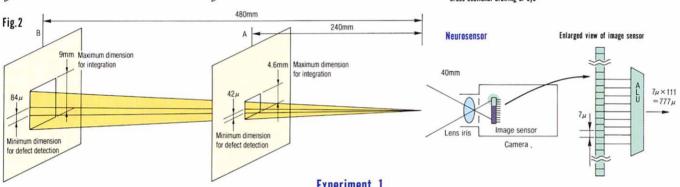
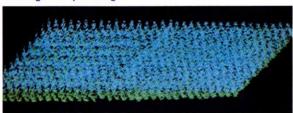
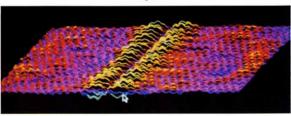


Photo-1: 3-D image after processing



3-D image of fiber cloth with wrinkle after folded (lightness inverted in this display)



After 40-step triangular processing (defect exaggerated)



After judgement processing by using threshold (detection of defect)

#### Experiment 1

Purpose:To understand the fact that a person cannot judge slight difference in lightness, if the eye nerve cells are lacking in "data integrating function"

Method: As mentioned earlier, each photoreceptor has the resolution of only 20 lightness levels. As the human eye can understand the detailed lightness level owing to the data integrating function of horizontal cells, for the experiment purpose, the integrating function of your neuron (horizontal cell) is eliminated in order to know the effect.

First, take a look at a vertical streak at the right side of this page in which the lightness changes very gradually, then set your eyes distant from the streak up to approximately 240mm.

(The diameter of the human eve is said to be 24mm

Therefore, this situation is comparable to the state of the imaging size of the retinal cell which has become 10 times greater at the streak surface.)

Next, bring the edge of the left page or white paper up to the streak's left side in parallel. Here, you still can differentiate the extremely gradual lightness change on the streak which is held between the top and bottom black bars

Then, move the edge of left page or white paper to the right in such a way that the width "L" finally becomes 0.05mm (50 $\mu$  m ). This 50 $\mu$  m width is equivalent to 5 $\mu$  m (one tenths of  $50\mu$  m) at your eye retinal surface, and the  $5\mu$  m is equal to the width of one photoreceptor. In this phase, you can still identify the top and bottom black & white contrasts, but cannot differentiate the extremely slight lightness change any more

Even when you move the paper edge back in order to make the L slightly greater than  $50\mu$ m, you still have the similar difficulty in differentiating.

These phenomena occur simply because the white paper or left page covers sections of the streak from which your eye neurons (horizontal cells) try to integrate the horizontal data, but the efforts are in vain. If you make the L greater than 4mm, the L exceeds the total length of 80 photoreceptors and your eye neurons recover their original integrating function, and subsequently you can see the lightness change. Summary and application:

Now you understand the data integrating function of the human eye. Our inspection system employs the similar integrating function, so that it can detect flaws, color unevenness and slight smear with lowest contrast which only man has been able to detect

Fig. 1 is the relation between the human eye and object.

Fig. 2 is our system and you can see our system is more advanced than the eye.

#### Experiment 2

Purpose: To understand that the eye takes no notice of micro-changes, but obtains a clear view of macro-changes when looking down from a high floor.

Method: The top of photo-1 is a picture showing glass fiber cloth which was folded before. There is a wrinkle in the center of the cloth. However, it is a extremely slight change of gloss and you cannot identify the location within the picture, because your eyes are seeing fiber filaments. When you set the picture distant from you and look at it again, you can

Summary: This experiment explains adequately the fact that you cannot identify a defect on an object when you look at the object from a near point (equivalent to a low floor) because surroundings of the defect are noticeable to the eye as well, but you can identify the defect when you look at the object from a far point (equivalent to a high floor).

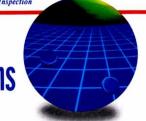
Having a similar mechanism, our system enables automatic inspections of watermarked banknotes, LCD panels, unwoven cloth, shadow masks etc which can conventionally be carried out only by the eye.





(Triangle processing: Data integration Plus self-correlation function)

### **Further Combination and utilisation of Human Mechanisms**



Technos has brought inspection systems much closer to the human eye in terms of performance.

As described earlier, eye neurotechnology utilizes the micro-detection mechanism for high-contrast defects as well as macro-detection mechanism for low-contrast defects.

By using the 2 mechanisms, eye neurotechnology allows inspection systems to carry out their tasks in the same manner as a human inspector.

However, inspection systems have difficulties in detecting slight defects, if lightness data entering the system sensor vary depending on ambient lightings or electronic part's drifting. But this problem is solved again by employing the human optic mechanism. That is, a triangle processing.

People live in circumstances which always change in lightness from morning, noon to night. And the lightness is changed by daily weather as well. Despite that, people have no problems in daily lives. This is because people obtain relative image lightness, when they see the surround-

ings. The intake of the relative image lightness is done naturally from birth. The mechanism similar to human inherent mechanism can be produced by using the theory of self-correlation.

The non-von Neumann type processor previously mentioned actually works out a combination of the neurosensor's micro-& macro-detection results and the self-correlation processing result. This triangle processing can cope with the inspection of products (cars, tiles etc) which often vary in lightness or colors. And also the triangle processing can handle inspections of 3-D products without memorizing the product shapes.

Furthermore, the system is not easily affected by aging or dirting of lightings in production lines or dirtying of camera lens or temperature change.

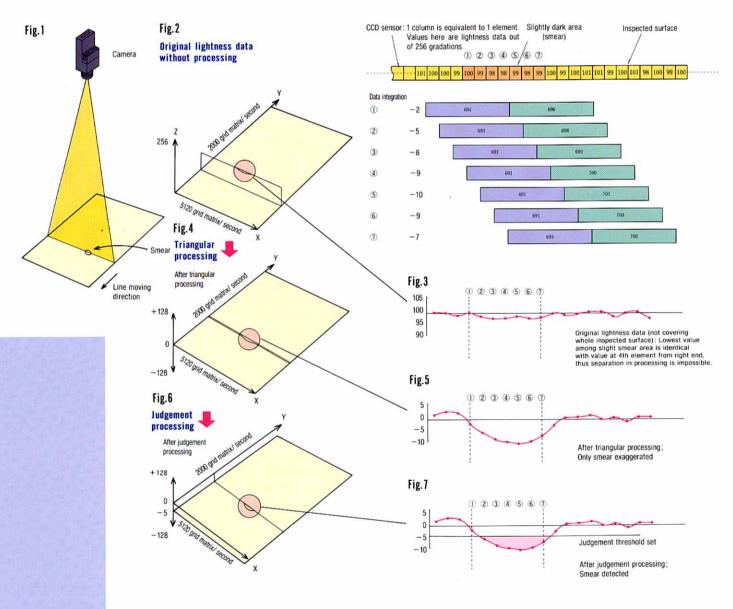


Fig. 1 shows how the camera detects brightness changes.

The camera is situated over the line and products to be inspected move on the line. Fig. 2 shows how the reading data is evaluated in a coordinate. (Lightness in axis-Z)

Fig. 3 is an enlarged result diagram of 7 data points along the defect (or slightly dark area). For your easy understanding, the values shown here are around 100 instead of various values among 256 gradations.

Therefore, you can regard the value differences as lightness differences. The lowest value of the slightly dark area is 98. In conventional image processing, the threshold level is 98. However, when evaluating this result diagram with that threshold, 98 (the lowest value in the defect) and another 98 (in the 4th column from the right end) becomes identical in processing, which mixes up the defect area with the normal area.

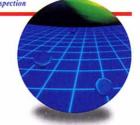
To avoid this mixture, 7 left-handed data at each point are integrated. And 7 right-handed data are also integrated. Then, the both integration results are correlation-processed. In this example, the number of integrated data is 7, but actually the number would be from 1 to 111 as mentioned earlier. In case of 111, for instance, 111 neighboring data are also integrated, and are correlation-processed at the operation speed of 10 million per second which is equivalent to 2220 MIPS.

This kind of correlation processing is continuously carried out without interruption in real time for the data which is obtained via the camera portion of our inspection system. The result of correlation processing is shown in Fig. 4, and the enlarged diagram of the result is shown in Fig. 5. You see that the slightly dark area has been clearly exaggerated. Now the inspection judgement becomes much easier by using the threshold shown, as in Fig. 6 and Fig. 7. (Fig.7 is an enlarged view of Fig. 6)

(Ultrasmall image reading element Plus Lightness precision achieved by 3-D neurosensor and self-correlation function)

# Secret of Our Extremely High Precision Technos System

3-D method which can cope with faster production lines.



The Technos neurosensor is a 3-D type which has lightness data of image elements on axis-Z. Ordinary photosensors are of 3 types, according to the amount of processed information. That is, 0-D sensor for point, 1-D sensor for line, 2-D sensor for plane and 3-D sensor for solid.

Our system employs a 3-D type which deals with the largest amount of information among these 3 types.

Furthermore, the number of image reading elements in our system is enormous—10 million per second.

Therefore, a great deal of information can be obtained correctly, which leads to the achievement of automatic continuous inspection.

In addition to that, the big advantage of our system is that the single image element can be further divided. By this advantage, a defect equal to 1/80000 of the whole inspected area size can be detected. (1/80000 is a theoretical value.) Therefore, our system has no problem in coping with faster production lines.

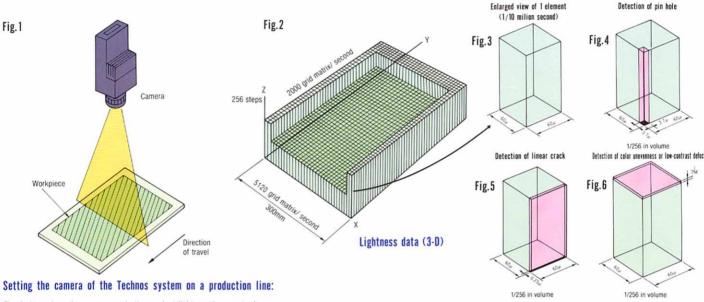


Fig. 1 shows how the camera reads the product lightness in an actual use. Image data are set in the grid matrix coordinate, as shown in Fig.2. (Lightness on axis-Z)

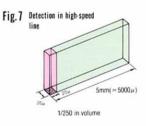
The image element width is 1/5000 of the scanning width in direction-X. At each second, the camera of Technos system scans a rectangle comprising 5000 elements in axis-X and 2000 elements in axis-Y (line's moving direction).

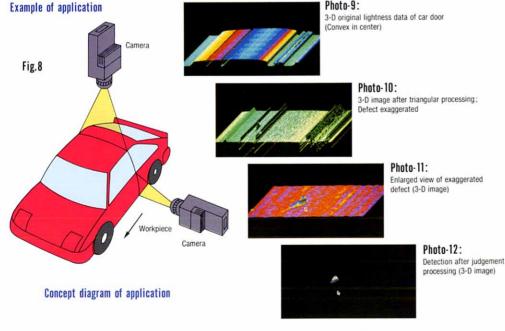
This means the whole inspected area is divided into 10 million units of information per second. Fig. 3 is a single element—i.e. 1/10 millionth. Our system further divides this single element into 256 subelements. For instance, an extremely small defect such as a pin hole can be detected as shown in Fig. 4.

The subelement width is 1/16 of the element width in axis-X—i.e. 1/16 x 1/16 = 1/256. That is, a 1/80000 square of the total inspected area width in axis-X can be inspected for lightness changes. In case of a linear crack, the rectangular subelement which has 1/256 of element width in direction-X (the direction of product width) or in direction-Y

(line moving direction) can be inspected, as shown in Fig. 5. Fig. 6 shows the case when more detailed lightness change is detected for low-contrast defects.

Our system enables more detailed detections owing to its eye neurotechnology. As the production line increases in speed, the products below the camera move futher during one scanning period of the camera. In case of 600m/min of line speed, for instance, the element width in axis-Y becomes 5mm as shown in Fig. 7. However, if the element width in axis-X is 0.02mm (20 $\mu$ m), the 20 $\mu$ m square subelement has 1/250 of the total element volume, and the detection is possible for lightness changes. However, these theoretical values cannot be accepted, if the change exceeds 1/250 due to ambient illumination change, lens getting dirty and temperature change. However, our system utilizes the self-correlation processing to eliminate such influences. Therefore, the Technos system has a distinct advantage for production lines which are sped up year after year.





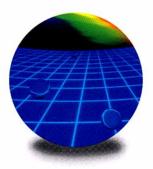
The neurosensor of Technos system can be applied to various fields. It becomes very active, especially for the inspections of 3-D products such as cars, aircraft, trains, cans, pipe and electric wire. Fig. 8 shows a sketch of the painting inspection unit for car bodies. (In actual use, the camera is fixed to a robot and aimed at desired points.)

Photo-9 shows an actual application to the

inspection of car door coating. The door has 3-D shape which generates lightness changes over the entire surface. The door pannel surface produces a convex lightness change. Therefore, conventional inspection systems cannot deal with car doors simply because original lightness changes already exist over the surface. Please take a look at Photo-10 which shows the result of triangle processing. Original gradual changes have been eliminated, and only the defect area (great change area) has been exaggerated. Therefore, the area of great lightness change remains after triangle processing, even when the applied paint changes gradually in color.

Photo-11 is an enlarged view of the defect (area of great lightness change). Photo-12 is the result of judgement by setting the threshold of inspection. By feeding the non-von Neumann processor with predetermined threshold values, inspections can be carried out in real time on our system.

TECHNOS Neuro System for Automatized Industrial Visual Inspection





# TECHNOS JAPAN CORPORATION 4-2-3 SIBA, MINATO-KU, TOKYO,

4-2-3 SIBA, MINATO-KU, TOKYO, 108-0014 JAPAN TEL.81-3-3453-9111 FAX.81-3-5484-6785