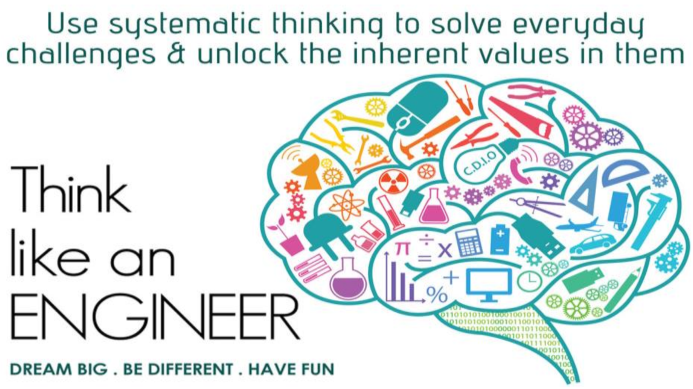
Half Yearly Magazine (June to Dec 2018)

RPTC TECHNICAL MAGAZINE

RANE TECHNO-VATE



RANE POYTECHNIC TECHNICAL CAMPUS

LET'S TAKE THE FIRST STEP TO MAKE THE "SKILLFULL INDIA"…
…………

From the Dean's Desk

Dear All,

It is my pleasure to congratulate the team that has taken the initiative for producing this magazine. It is great to find a considerable improvement in the number of technical articles and drawings that are part of this issue. It certainly proves that our staffs are adequately equipped and possess necessary skill sets to express their expertise in their chosen field.

Zigbee Technology and Disease Analysis thru retina of the eye are definitely thought provoking. Application of smart skins and Supervisory Control & Data Acquisition is again very interesting to read.

Reading this magazine would definitely be an inspiration and motivation for all students and staff to contribute even more to the forthcoming issues. I hope that everyone would continue to give their full efforts to keep the momentum and continue to enhance the standards of the magazine.

RAJALAKSHMI .B. M.S., AICWA
DEAN – ID AND QA

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DESIGNED BY

R.RAVISHANKAR B.E, SMISME

LECTURER

MECHANICAL ENGINEERING

EDITED AND REVIEWED BY

R.SASIDHARAN M.E, Ph.d

PRINCIPAL

R.RAVISHANKAR B.E, SMISME

LECTURER

MECHANICAL ENGINEERING

A.THAIYALNAYAGI M.E,

LECTURER

MECHANICAL ENGINEERING

1.LABVIEW BASED PROCESS MONITORING AND CONTROL USING ZIGBEE TECHNOLOGY

Thaiyal Nayagi.A

Lecturer

Department of Mechanical

Nowadays in most of the industries are controlling the process using DCS. They have to monitor and modify the field parameters with help of SCADA system. The MODBUS, PROFIBUS and industrial Ethernets are communicating the field and the controller. If we want to change the parameter using SCADA, we need a separate server for interfacing SCADA and DCS.LabVIEW encompasses these criteria through its powerful graphical development environment. It has evolved along with PC technology. In this paper, the process parameters are monitored and controlled by using Lab VIEW and ZIGBEE protocol. The ATMEL embedded system converts the field parameter (4 to 20mA) to serial data format. ZIGBEE protocol interfaces the Lab VIEW and converter board. The overall process sequence are controlled by the Lab VIEW.

- ***Keyword: Protocol, ZIGBEE, VISA***

INTRODUCTION

In this project, the real time process parameters are going to be transmitted and received using ZIGBEE and control using LabVIEW in place of a DCS. LabVIEW is a graphical programming language used by professional scientists and engineers as well as students, hobbyists and makers. LabVIEW was designed to enable domain experts to build power systems quickly without getting bogged down in subsystem minutia. LabVIEW is a graphical programming language. Traditionally used by scientists, engineers and other domain experts to build systems quickly. The applications developed in LabVIEW are called VI's LabVIEW is a graphical programming language used by professional scientists and engineers as well as students, hobbyists and *makers. LabVIEW was designed to enable domain experts to build power systems quickly without getting bogged down in subsystem minutia. LabVIEW helps introduce the power of computers in engineering today. Although you are not an electrical engineering major, you will use computers for simulation and testing in your major. LabVIEW can be used to control any instrument that complies with the IEEE 488.2 standard, using GPIB – General Purpose Interface Bus.*

Zigbee *is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need.*

RECENT TREND

Nowadays, entire control of a plant is done using DCS and monitoring is done by SCADA.But a Distributed control system with ZIGBEE is also used in many industries nowadays.recently we are visited the NLC in that we have seen a system which control the entire plant with DCS and ZIGBEE to overcome the disadavantage of DCS we have use the LabVIEW

ABOUT PROJECT

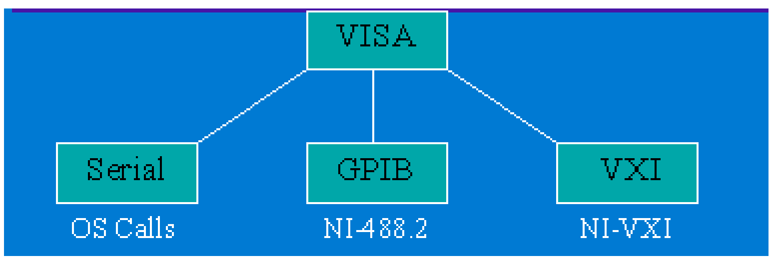
Now,in our project the process parameters are going to be analyzed using LabVIEW in place of a DCS and operated upon .So ,the LabVIEW Software provides a real time simulation tool to analyze the errors which may be an outcome the real process being executed through the DCS. So a ZIGBEE used DCS cannot analysis the new error signal will occur during implementation,but using LabVIEW we can simulate a real time process for the erros and absolute manipulations can be made and then through LabVIEW an interface can be provided to the real process and it will be executed in real time without any delay and problems of any kind.

WHY WE CHOOSE LabVIEW

In DCS have only controlling tool and the supervising is done by SCADA .but in the LabVIEW have a feature of analyzing, controlling and monitoring. So we are choosing a LabVIEW platform for our project. In DCS used ZIGBEE we need a converter to signal to DCS. But in LabVIEW have a inbuilt converter called VISA.

VISA

VISA is expand of virtual instrumentation software architecture .VISA is a I/O instrument programming language .



VISA is capable of controlling VXI, GPIB, or Serial instruments and makes the appropriate driver calls depending on the type of instrument being used. When debugging VISA problems it is important to keep in mind that this hierarchy exists. An apparent VISA problem could in reality be the results of a bug or installation problem with one of the drivers into which VISA is calling.

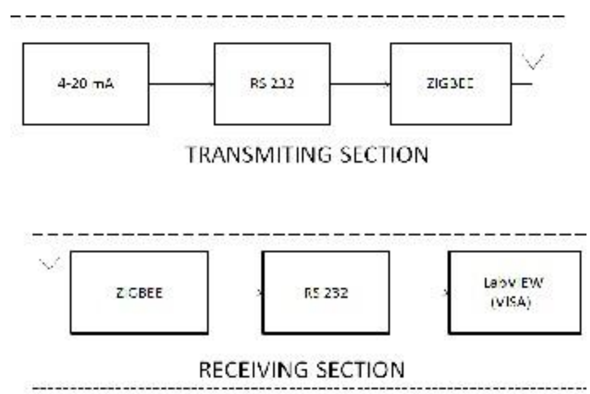
ZIGBEE

It is wireless communicating device which is used to transfer n receive data in a range of 2 km , it is called as transiver(transmitter + receiver) , so it will reduce the system size.

ADDVANTAGE OF ZIGBEE OVER RF

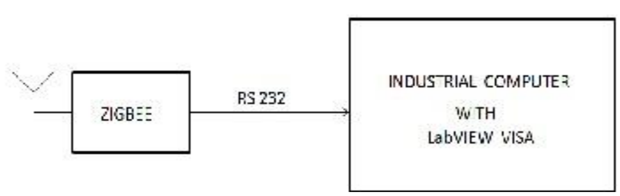
When compared to RF , ZIGBEE has high transmission length up-to 2 km, In RF we have different module for transmitter and receiver , but a single ZIGBEE module can act as both transmitter and receiver , And the size of the RF *receiver is very large when compared to ZIGBEE , so it will reduce the system size*

BLOCK DIAGARAM



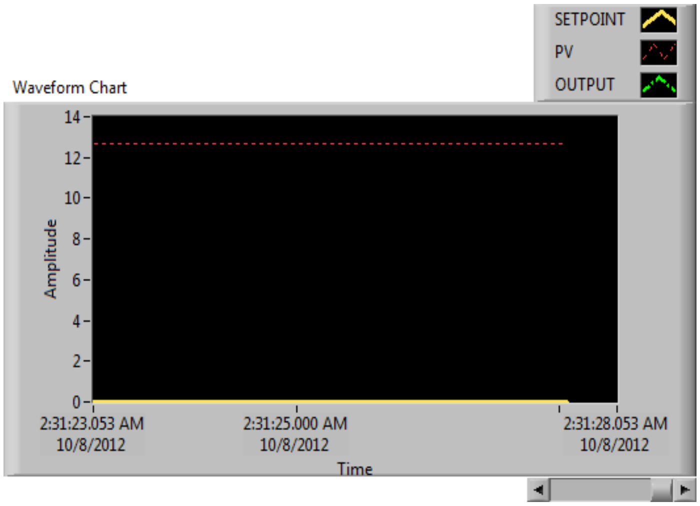
In that we have two section one is transmitting section another one is receiving section . In the transmitting section a 4-20ma signal is acquired from process to a zigbee transmitter. In the receiving section we have a zigbee receiver after that received signal transmit to LabVIEW through RS 232 cable

PHYSICAL DIAGRAM



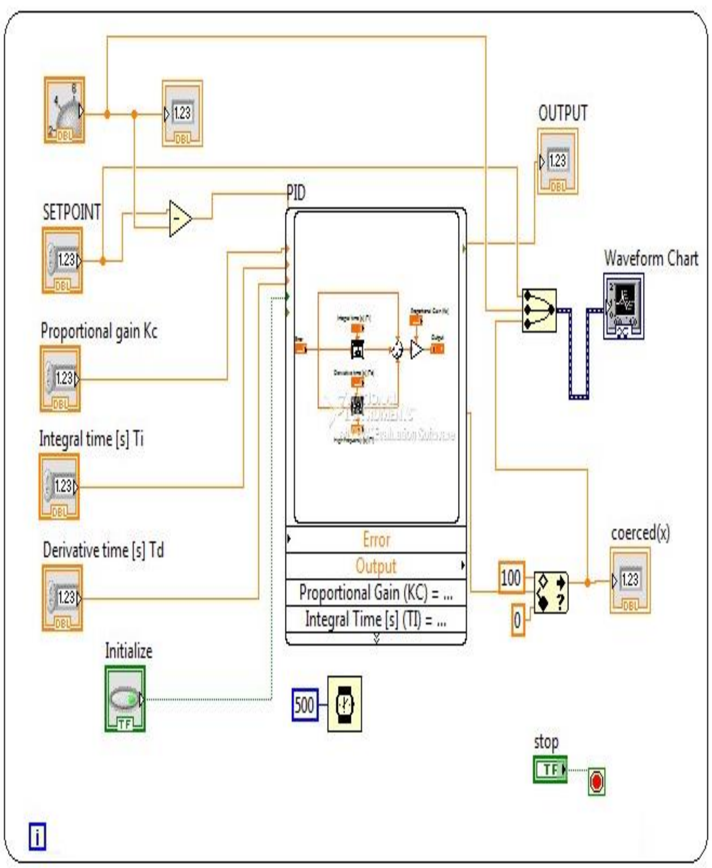
In this physical diagram we have shown the architecture of real time process of our system

RESULT

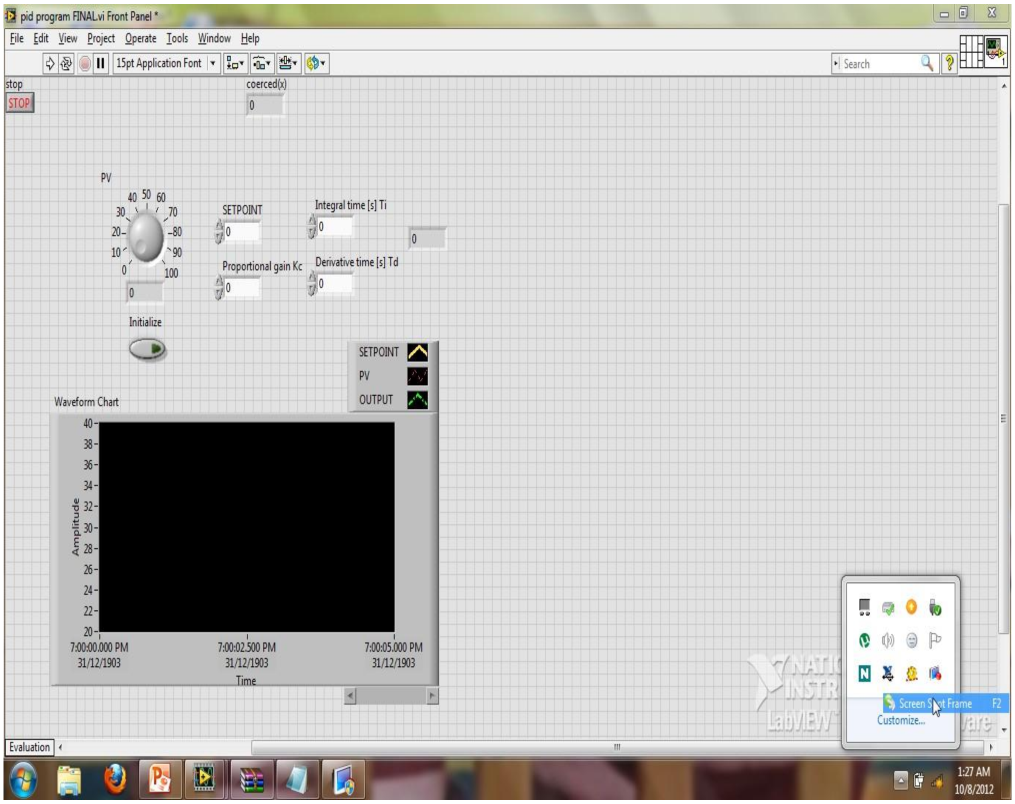


This is the graph result for our program.

BLOCK DIAGRAM



FRONT PANEL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2.DISEASE ANALYSIS THROUGH THE RETINA OF THE EYE USING MATLAB

Thaiyal Nayagi.A

Lecturer

Department of Mechanical

This paper aims at producing a detailed analytical statistics of diseases like diabetic retinopathy, vein occlusion and glaucoma of the eye through the use of haar wavelet transform in MATLAB wavelet toolbox through which the possibility of the defect can be determined. The retinal images of the eye are first acquired either through the ophthalmoscope or fundoos camera which is a high end imaging device. The healthy image statistics are derived through the toolbox which is kept as reference for the comparison of the infected images through haar wavelet.

Keywords- *Image compression, wavelet transform, Image analysis, Biomedical instrumentation and bioinformatics*

I.INTRODUCTION

Disease analysis plays a major role in medicine. Analysis of the disease can be done through various techniques of which some may be cost efficient and would give good results. Various technological advancements are available for analyzing the images of the eye for any diseases. Producing clear output data for the analysed images of diseases is very vital for proper medication. Eye being the very delicate organ of the human body, needs very cautious techniques for analysis. This painless procedure is very much of use.

II.PRESENT TECHNOLOGY

The present technology is that the retina images are taken with the help of fundoos camera which is a medical imaging device that works on refraction of light waves. This medical imaging device gives a clear analysis of the images taken and also allows the doctor to get a very clear view of the retina and analyse the image. It is a high end imaging device which is very popular for retinal image acquisition and analysis.

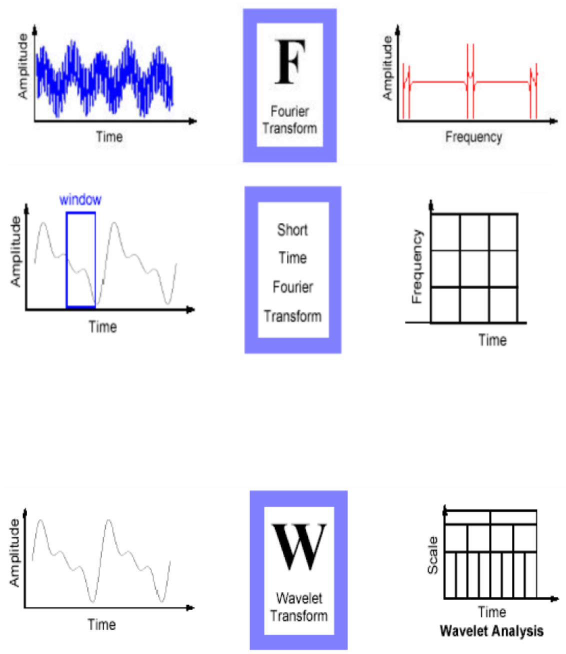
III.STEPS INVOLVED

*The image is first acquired from the fundoos camera or the ophthalmoscope (in this case from fundoos camera).The image is converted to 160*160 sizes. The wavelet toolbox is chosen in MATLAB and wavelet 2-D is opened and then image is loaded. The haar wavelet is chosen with level 2 analysis which allows compression of image. The statistics is then generated for different genres of images which include original image, approximated image, and detailed image. The image from fundoos camera can be acquired just like we get images from a personal computer. This method allows us to analyse all other images based on reference image statistics.*

IV.MECHANISM INVOLVED

Discrete wavelet transform is a tool used for image compression and edge detection. Wavelets can keep track of time and frequency information. They can be used to "zoom in" on the short bursts, or to "zoom out" to detect long, slow oscillations. Fourier analysis consists of breaking up a signal into sine waves of various frequencies. Similarly, wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or mother) wavelet. The advantage of wavelet transform is that it has self-adjusting window size for the analysis of the complete wave, when image is converted into signal. This advantage is not present in Fourier transform or short time Fourier transform.

*The images is converted into 2*2 matrix with low-low,low-high,high-low and high high pixels based on level of compression we choose in Wavelet toolbox.*



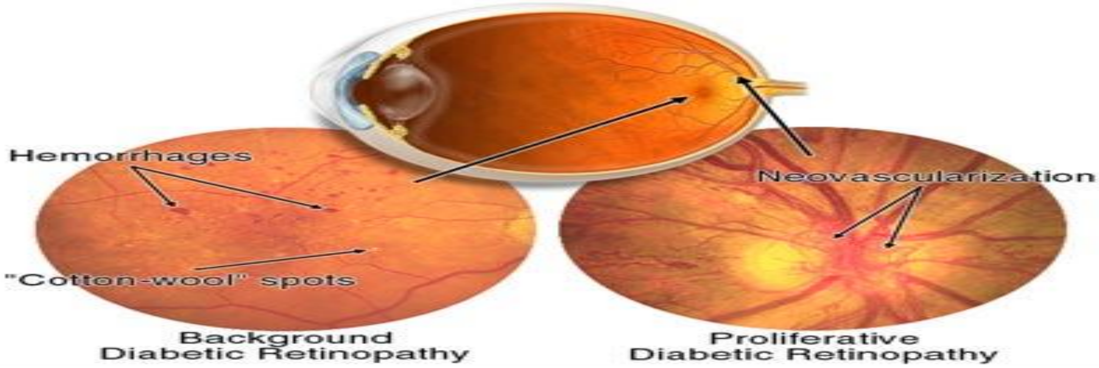
V.DISEASE ANALYSIS

The disease to be analysed here are Diabetic retinopathy, glaucoma and vein occlusion. Other defected images can also be analysed by this technique. The explanation for the disease analysed in this paper are as follows:

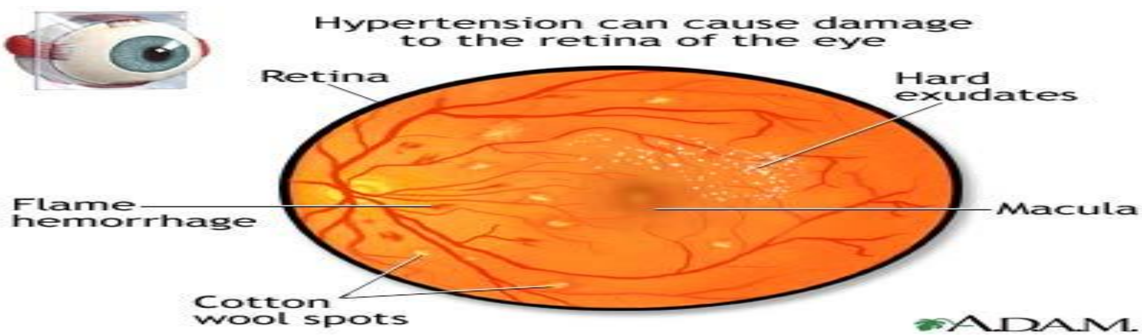
1.)Diabetic Retinopathy:Diabetic retinopathy is damage to the eye's retina that occurs with long-term diabetes. There are two types, or stages of retinopathy:

1. Nonproliferative (less growth)

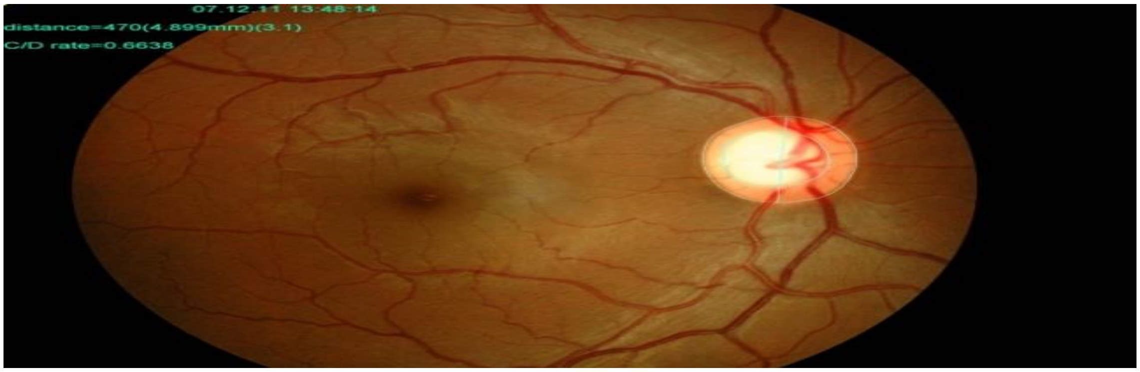
2. Proliferative (more growth)



2.) Vein Occlusion: Branch retinal vein occlusion (BRVO) is a common retinal vascular disease of the elderly. It is caused by the occlusion of one of the branches of central retinal vein.



3.) Glaucoma: Glaucoma is an eye disease in which the optic nerve is damaged in a characteristic pattern. This can permanently damage vision in the affected eye(s) and lead to blindness if left untreated. It is normally associated with increased fluid pressure in the eye. Glaucoma has been called the “silent thief of sight”



VII.SCREENSHOTS

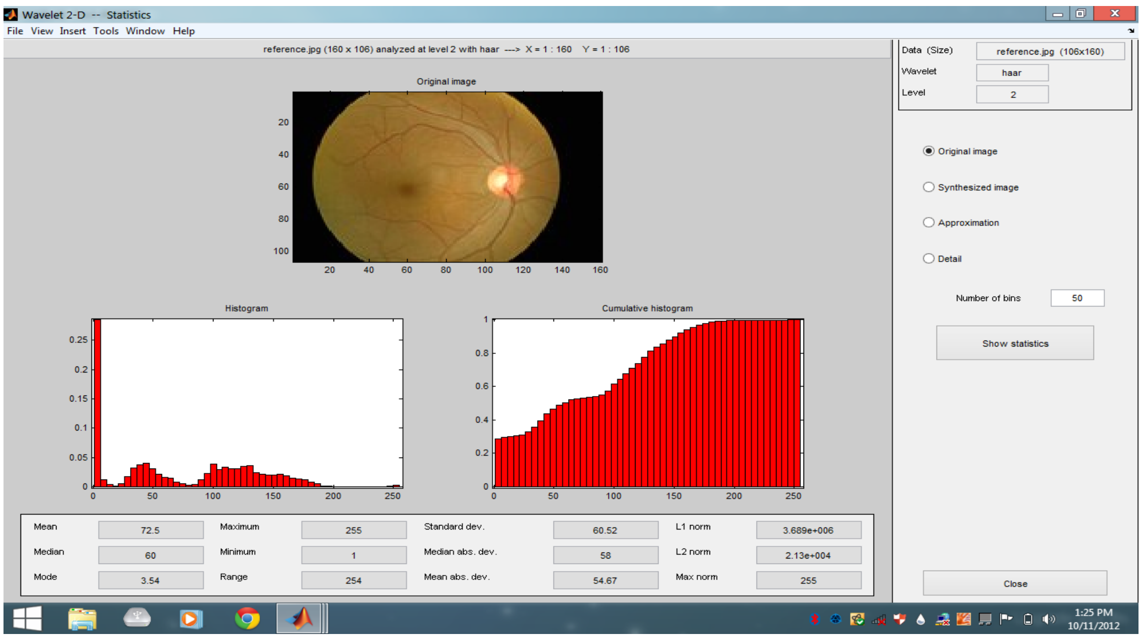
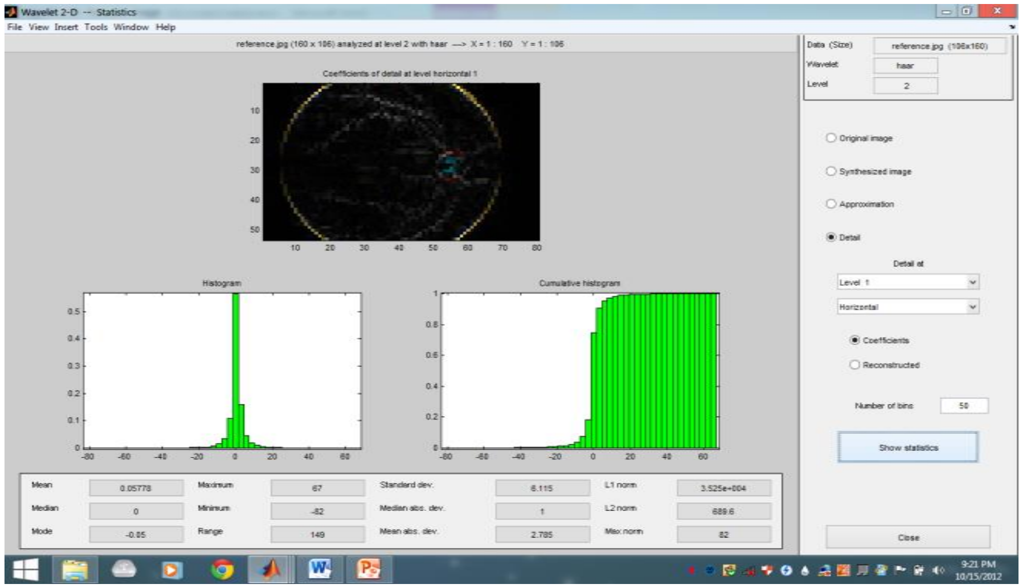


Fig:Reference Image



VIII.HISTOGRAM ANALYSIS

Histogram is a statistical graph that allows the intensity distribution of the pixels of an image. The x-axis and y-axis of first histogram denotes the intensity levels and number of image pixels respectively. The cumulative histogram represents the cumulative intensity distribution of the pixels of an image, i.e. the number of pixels having at least a given luminous intensity.

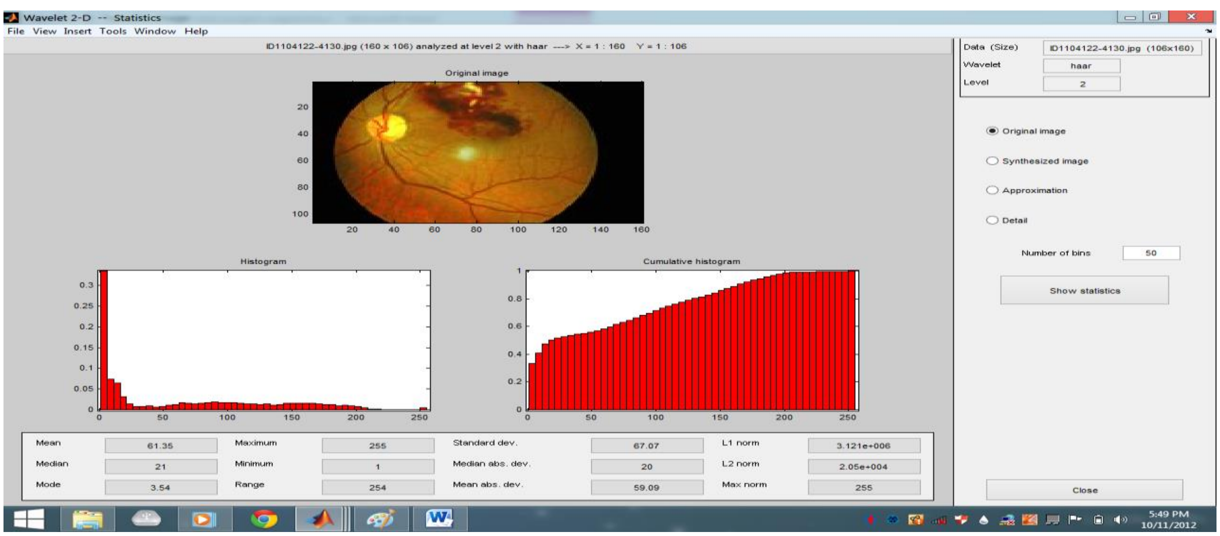


Fig.Vein occlusion

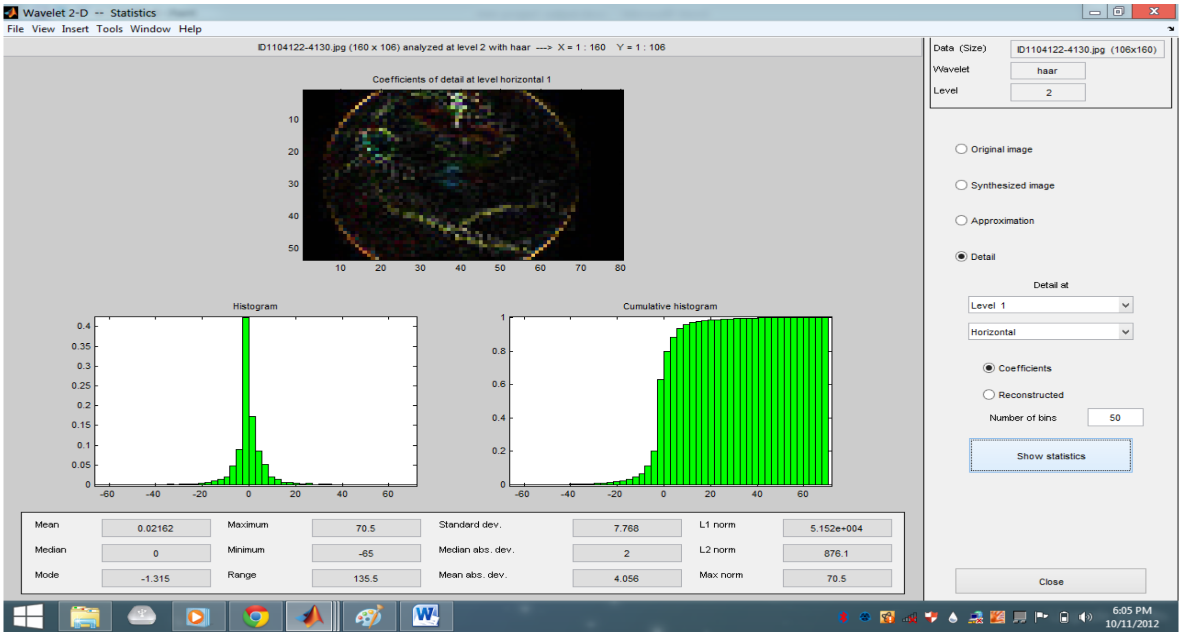
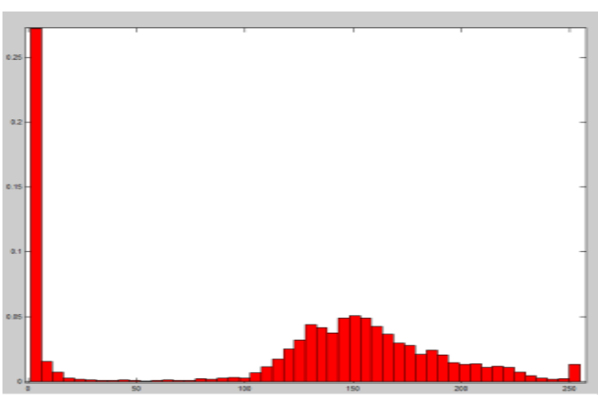
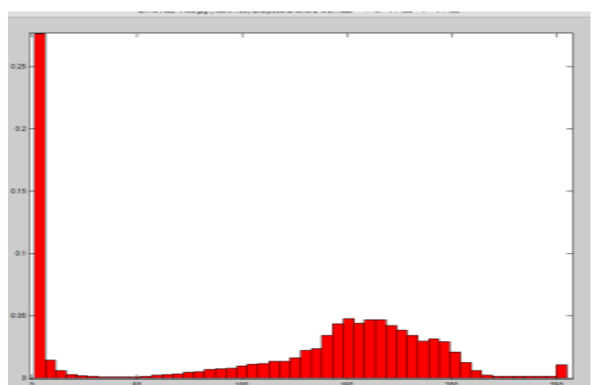


Fig :Vein occlusion

The generated histograms of the color images clearly denote the image intensities from lightest to darkest colors. The analysis done here is through the statistical data generated based on the reference image and then comparing with infected images tabulating the data completely.





IX.STATISTICAL DATA

DISEASE	IMAGE	ME-AN	MEDIAN	MODE	RANGE	STD DEV.	MEDIAN ABS. DEV	MEAN ABS. DEV
Reference Image	ORIGINAL	72.5	60	3.54	254	60.52	58	54.87
	DETAIL	0.05778	0	-0.05	149	6.115	1	2.785
Vein occlusion	ORIGINAL	41.87	13	3.54	254	47.26	12	39.92
	DETAIL	-0.02315	0	-0.075	82.5	4.444	1	2.297
Diabetes								
a)Mod NPDR	ORIGINAL	56.87	16	3.54	254	67.45	15	56.66
	DETAILS	-0.401922	0	0.075	127.5	6.049	1.5	3.279
b)NPDR	ORIGINAL	58.25	19	3.54	254	68.86	18	58.12
	DETAIL	-0.0007	0	1.44	148	8.022	2	4.744
c)PDR	ORIGINAL	66.93	16	3.54	254	80.28	15	68.21
	DETAIL	-0.2023	0		170	9.315	2.5	5.153
d)Severe NPDR	ORIGINAL	74.05	39	3.54	254	72.35	38	64.89
	DETAIL	-0.1357	0	-0.105	183.5	7.29	1.5	3.48
Glaucoma	ORIGINAL	68.47	31	3.54	254	67.43	29	57.3
	DETAIL	-0.0315	0	1.35	157	7.883	1.5	4.064

X.DATA ANALYSIS

DISEASE	IMAGE	MEAN(DIFF)	STD DEV.(DIFF)	MEDIAN ABS.DEV(DIFF)	MEAN ABS. DEV(DIFF)
Reference Image	ORIGINAL	72.5	60.52	58	54.87
	DETAIL	0.05778	6.115	1	2.785
Vein occlusion	ORIGINAL	30.63	13.26	46	14.95
	DETAIL	0.08093	1.671	0	0.488
Diabetes					
a)Mod NPDR	ORIGINAL	15.63	-6.03	43	-1.79
	DETAILS	-0.3441	0.066	-0.5	-0.494
b)NPDR	ORIGINAL	14.35	-8.34	40	-3.25
	DETAIL	0.05848	-1.907	-1	-1.959
c)PDR	ORIGINAL	5.57	-19.76	43	-13.34
	DETAIL	0.26008	-3.2	-1.5	0.285
d)Severe NPDR	ORIGINAL	-1.58	-11.83	20	-10.02
	DETAIL	0.191478	-1.175	-0.5	-0.695
Glaucoma	ORIGINAL	4.03	-6.91	29	-2.43
	DETAIL	0.37272	-1.768	-0.5	-1.279

XI.ANALYSIS AND CONCLUSION

The analysis is the difference in the mean, standard deviation, mean absolute deviation and median absolute deviation values based on which the probability of defect can be determined which require further doctor medication. The difference is the deviation from reference image (healthy image) Thus it can concluded that the HAAR wavelet transform is powerful for image compression which also leads to detailed image analysis as shown.

XII.REFERENCES:

- *MATLAB tutorial*
- *An introduction to digital image processing using MATLAB*
- *Wavelet toolbox Tutorial*

3.APPLICATION OF SMART SKINS IN AEROSPACE INDUSTRY

R.Perumal-III Year

S.Thirumurugan –III Year

Diploma in Mechanical Engineering

Smart systems consist of sensors and actuators that are either embedded in or attached to the system containing central control and command unit to form an integral part of it. Smart or intelligent materials are materials that have the intrinsic and extrinsic capabilities, first to respond to stimuli and environmental changes and second to activate their functions according to these changes.

SMART MATERIAL IN AEROSPACE IN INDUSTRY

There two types of materials used

1. *Piezoelectric material*
2. *Magnetostrictive Material*
3. *Shape memory alloys*
4. *Electro-Rheological fluid*

1. Piezoelectric material

The pressure, acceleration, temperature, strain (or) force converting them to an electric charge. Piezoelectric materials have the special property of producing an electrical voltage in response to an applied force. Usually crystals or ceramics, piezoelectric materials have a variety of uses including sonar, sound detection and high-voltage generation in addition to everyday uses, such as cigarette lighter ignition sources and barbecue-grill igniters.

APPLICATIONS;

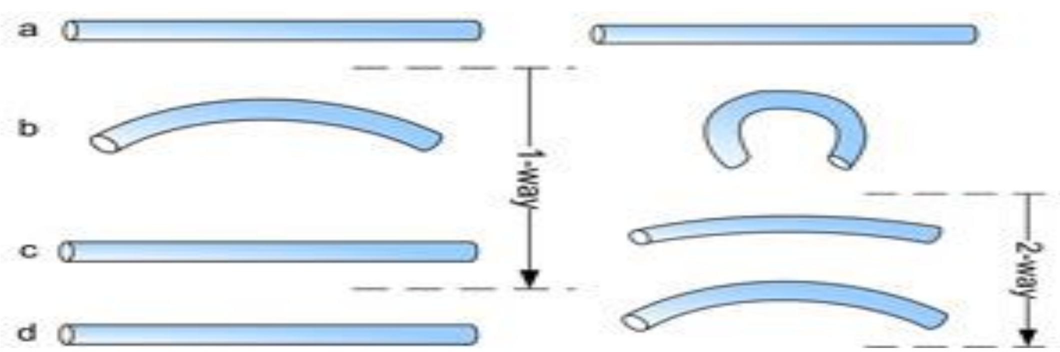
- *Auto mobile industry*
- *Nuclear instrument*
- *Aerospace instrument*

2. Magnetostrictive Material

Ferromagnetic material that causes them to change their space (or) dimension of magnetization. Magnetostrictive materials include nickel and alloys such as Fe-Al (Alfer), Fe-Ni (Permalloy), Co-Ni, Fe-Co, and Co-Fe-V (Permendur); several ferrites ($CoFe_2O_4$ and $NiFe_2O_4$); and some rare earths and their alloys and compounds. Nickel has good magnetostrictive, mechanical, and anticorrosion properties. Permendur has large values of saturation magnetostriction Δ_s and magnetization. The ferrites have high specific electric resistivity and corrosion resistance; they are also the least expensive magnetostrictive materials.

3. ***Shape memory alloys***

A shape memory alloy its original shape and that when deformed returns to its pre-deformed shape when heated. This material is a lightweight. ***Nickel titanium****, also known as* ***Nitinol*** *(part of shape memory alloy), is a metal alloy of nickel and titanium, where the two elements are present in roughly equal atomic percentages e.g. Nitinol 55, Nitinol 60. A shape-memory alloy is an alloy that can be deformed when cold but returns to its pre-deformed ("remembered") shape when heated. It may also be called memory metal, memory alloy, smart metal, smart alloy, or muscle wire. Parts made of shape-memory alloys can be lightweight, solid-state alternatives to conventional actuators such as hydraulic, pneumatic, and motor-based systems. They can also be used to make hermetic joints in metal tubing.*



APPICATIONS:

- *Aircraft and spacecraft*
- *Robotics*
- *Orthopedic surgery*
- *Telecommunication*
- *Dentistry*
- *Optometry*

4.Electro-Rheological fluid

Magnetic field the fliud greatly increase its apparent viscosity the point of becoming a viscoelastic solid. A class of liquid which stiffens into a semi-solid when subjected to a electric field. Electrorheological fluids are most commonly colloidal suspensions, and their stiffening under an electric field is reversible. Under the electric field, electrorheological fluids form fibrous structures which are parallel to the applied field and can increase in viscosity by a factor of up to 10^5. *The stiffening of an electrorheological fluid is sometimes called the winslow effect after its first investigator, Willis Winslow in 1949.*

CLASSIFICATION OF SMART MATERIALS

They possess the capacity to modify their geometric or material properties under the application of electric, thermal or magnetic fields, thereby acquiring an inherent capacity to transduce energy. Smart materials are common name for a wide group of different substances. The general feature of all of them is the fact that one or more properties might be significantly altered under controlled condition. The present age is considered to be the smart materials era. Earlier, smart material was defined as the material, which responds to its environments in a timely manner. However, the definition of smart materials has been expanded to the materials that receive, transmit, or process a stimulus and

respond by producing a useful effect that may include a signal that the materials are acting upon it. This study focuses on the introduction of smart materials and their classifications. Different applications of smart materials in various fields are also being discussed starting from engineering to the present environment.

Smart materials, called also intelligent or responsive materials,[1] [2] *are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, temperature, moisture, pH, electric or magnetic fields, light, or chemical compounds. Smart materials are the basis of many applications, including sensors and actuators, or artificial muscles, particularly as electroactive polymers (EAPs) Terms used to describe smart materials include shape memory material (SMM) and shape memory technology (SMT).*

Types

There are a number of types of smart material, of which are already common. Some examples are as following:

- *Piezoelectric materials are materials that produce a voltage when stress is applied. Since this effect also applies in a reverse manner, a voltage across the sample will produce stress within sample. Suitably designed structures made from these materials can, therefore, be made that bend, expand or contract when a voltage is applied.*
- *Shape-memory alloys and shape-memory polymers are materials in which large deformation can be induced and recovered through temperature changes or stress changes (pseudoelasticity). The shape memory effect results due to respectively martensitic phase change and induced elasticity at higher temperatures.*
- *Photovoltaic materials or optoelectronics convert light to electrical current.*

- *Electroactive polymers (EAPs) change their volume by voltage or electric fields.*
- *Magnetostrictive materials exhibit a change in shape under the influence of magnetic field and also exhibit a change in their magnetization under the influence of mechanical stress.*
- *Magnetic shape memory alloys are materials that change their shape in response to a significant change in the magnetic field.*
- *Smart inorganic polymers showing tunable and responsive properties.*
- *pH-sensitive polymers are materials that change in volume when the pH of the surrounding medium changes.*
- *Temperature-responsive polymers are materials which undergo changes upon temperature.*
- *Halochromic materials are commonly used materials that change their color as a result of changing acidity. One suggested application is for paints that can change color to indicate corrosion in the metal underneath them.*
- *Chromogenic systems change color in response to electrical, optical or thermal changes. These include electrochromic materials, which change their colour or opacity on the application of a voltage (e.g., liquid crystal displays), thermochromic materials change in colour depending on their temperature, and photochromic materials, which change colour in response to light—for example, light-sensitive sunglasses that darken when exposed to bright sunlight.*
- *Ferrofluids are magnetic fluids (affected by magnets and magnetic fields).*
- *Photomechanical materials change shape under exposure to light.*
- *Polycaprolactone (polymorph) can be molded by immersion in hot water.*
- *Self-healing materials have the intrinsic ability to repair damage due to normal usage, thus expanding the material's lifetime.*
- *Dielectric elastomers (DEs) are smart material systems which produce*

large strains (up to 500%) under the influence of an external electric field.

- Magnetocaloric materials are compounds that undergo a reversible change in temperature upon exposure to a changing magnetic field.
- Thermoelectric materials are used to build devices that convert temperature differences into electricity and vice versa.
- Chemoresponsive materials change size or volume under the influence of external chemical or biological compound.

SMART SLINS

Smart skin is a large-area, flexible array of sensors with data processing capabilities, which can be used to cover the entire surface of a machine or even a part of a human body. Depending on the skin electronics, it endows its carrier with an ability to sense its surroundings via the skin's proximity, touch, pressure, temperature, chemical /biological, or other sensors. Aerospace products such as rockets, satellites and aircrafts are typically monologue shell-like structures featuring a thin skin whose structural integrity is generally mission-critical.

COMPONENTS OF SMART STRUCTURES:

The basic five components of a smart structure are

1. **Data Acquisition** (tactile sensing): the aim of this component is to collect the required raw data needed for an appropriate sensing and monitoring of the structure.

2.Data Transmission (sensory nerves): the purpose of this part is to forward the raw data to the local and/or central command and control units.

3.Command and Control Unit (brain): the role of this unit is to manage and control the whole system by analysing the data, reaching the appropriate

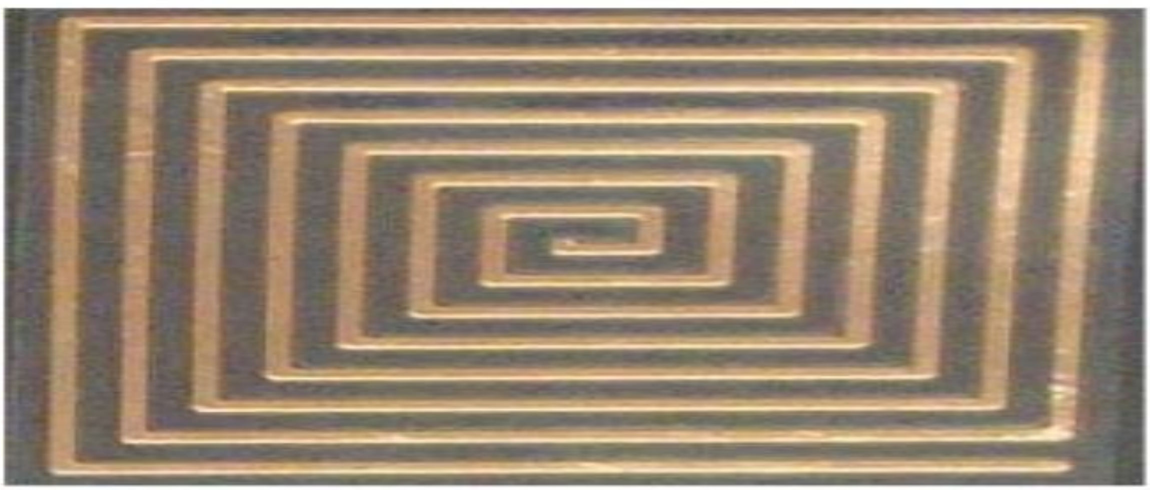
conclusion, and determining the actions required.

4.Data Instructions *(motor nerves): the function of this part is to transmit the decisions and the associated instructions back to the members of the structure.*

5.Action Devices *(muscles): the purpose of this part is to take action by triggering the controlling devices/ units.*

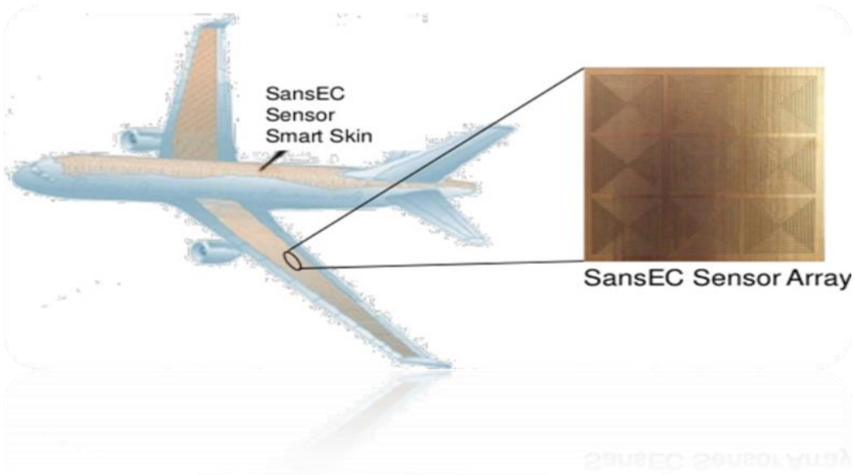
SansEC:

SansEC sensor technology is a new technical framework for designing, powering, and interrogating sensors to detect various types of damages in composite materials. The source cause of the in-service damage(lightning strike, impact damage, material fatigue, etc., to an aircraft composite is secondary. The sensor will detect damage independent of the cause.



Smart Skin concept in Aeroplane

The concept is to apply an array of sansEC Sensors to an aircraft surface forming a smart skin Layer on the composite. Lighting protection, enhanced shielding effective, damage detection and diagnosis function



Smart skin for Lightning Strike Protection

Conclusion

This presentation has reviewed applications of 'smart skins' technology to aerospace industry. The application includes lightning strike protection, damage detection, smart wings, aircraft health monitoring, morphing aircraft structures etc.. The applications of smart structures showed the capability to address difficult dynamic structural problems with novel techniques with positive results.

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4.OVERVIEW OF SUPERVISORY CONTROL AND DATA ACQUISITION

Thaiyal Nayagi.A
Lecturer
Department of Mechanical

INTRODUCTION

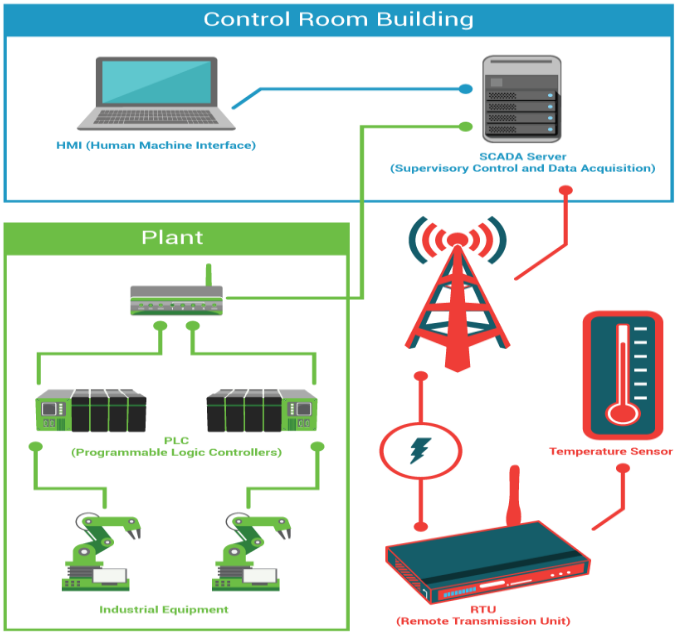
Supervisory Control and Data Acquisition *is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management, but uses other peripheral devices such as programmable logic controller (PLC) and discrete PID controllers to interface with the process plant or machinery. The use of SCADA has been also considered for management and operations of project-driven-process in construction.*

A SCADA (supervisory control and data acquisition) is an automation control system that is used in industries such as energy, oil and gas, water, power, and many more. The system has a centralized system that monitors and controls entire sites, ranging from an industrial plant to a complex of plants across the country. A SCADA system works by operating with signals that communicate via channels to provide the user with remote controls of any equipment in a given system. It also implements a distributed database, or tag database, that contains tags or points throughout the plant. These points represent a single input or output value that is monitored or controlled by the SCADA system in the centralized control room. The points are stored in the distributed database as value-timestamp pairs. It's very common to set up the SCADA systems to also acquire metadata, such as programmable logic controller (PLC) register paths and alarm statistics.

While these systems simplify a given infrastructure, their components are quite complex. There are five essential composing parts of a SCADA system:

- *Human Machine Interface (HMI)*
- *supervisory system*
- *Remote Terminal Units (RTUs)*
- *Programmable Logic Controllers (PLCs)*
- *communication infrastructures*

The HMI processes data from each tag and sends it to a human operator, where he or she then can monitor or control the system. The supervisory system gathers the data sent from each tag and sends commands or operations to the process. The RTUs connect sensors and convert their signals to digital data and send it to the supervisory system, where it can be stored in a distributed database. PLCs are used as field devices because they are much more versatile and economical than process-specific RTUs. Finally, the communication infrastructure delivers connectivity to the supervisory system and then to the RTUs and PLCs for the user to command. The communication infrastructure is necessary to relay data from remote RTU/PLCs, which run along electric grids, water supplies, and pipelines. Communication is the absolute most essential link for a SCADA system to operate properly; however, how well the system manages communication from HMI to RTUs and PLCs fundamentally determines how successful a SCADA system can be. Below is a figure of what a basic SCADA system might look like for a given infrastructure.



SCADA system components:

1.Supervisory computers

This is the core of the SCADA system, gathering data on the process and sending control commands to the field connected devices. It refers to the computer and software responsible for communicating with the field connection controllers, which are RTUs and PLCs, and includes the HMI software running on operator workstations. In smaller SCADA systems, the supervisory computer may be composed of a single PC, in which case the HMI is a part of this computer. In larger SCADA systems, the master station may include several HMIs hosted on client computers, multiple servers for data acquisition, distributed software applications, and disaster recovery sites. To increase the integrity of the system the multiple servers will often be configured in a dual-redundant or hot-standby formation providing continuous control and monitoring in the event of a server malfunction or breakdown.

2.Remote terminal units

Remote terminal units, also known as (RTUs), connect to sensors and actuators in the process, and are networked to the supervisory computer system. RTUs are "intelligent I/O" and often have embedded control capabilities such as ladder logic in order to accomplish boolean logic operations.

3.Programmable logic controllers

PLCs are connected to sensors and actuators in the process, and are networked to the supervisory system in the same way as RTUs. PLCs have more sophisticated embedded control capabilities than RTUs, and are programmed in one or more IEC 61131-3 programming languages. PLCs are often used in place of RTUs as field devices because they are more economical, versatile, flexible and configurable.

4.Communication infrastructure

This connects the supervisory computer system to the RTUs and PLCs, and may use industry standard or manufacturer proprietary protocols. Both RTU's and PLC's operate autonomously on the near-real time control of the process, using the last command given from the supervisory system. Failure of the communications network does not necessarily stop the plant process controls, and on resumption of communications, the operator can continue with monitoring and control. Some critical systems will have dual redundant data highways, often cabled via diverse routes.

5.Human-machine interface

The human-machine interface (HMI) is the operator window of the supervisory system. It presents plant information to the operating personnel graphically in the form of mimic diagrams, which are a schematic representation of the plant being controlled, and alarm and event logging pages. The HMI is linked to the SCADA supervisory computer to provide live data to drive the mimic diagrams, alarm displays and trending graphs. Mimic diagrams consist of line graphics and schematic symbols to represent process elements, or may consist of digital photographs of the process equipment overlain with animated symbols.

Supervisory operation of the plant is by means of the HMI, with operators issuing commands using mouse pointers, keyboards and touch screens. For example, a symbol of a pump can show the operator that the pump is running, and a flow meter symbol can show how much fluid it is pumping through the pipe. The operator can switch the pump off from the mimic by a mouse click or screen touch. The HMI will show the flow rate of the fluid in the pipe decrease in real time.

The HMI package for a SCADA system typically includes a drawing program that the operators or system maintenance personnel use to change the way these points are represented in the interface. These representations can be as simple as an on-screen traffic light, which represents the state of an actual traffic light in the field, or as complex as a multi-projector display representing the position of all of the elevators in a skyscraper or all of the trains on a railway.

*A **"historian",** is a software service within the HMI which accumulates time-stamped data, events, and alarms in a database which can be queried or used to populate graphic trends in the HMI. The historian is a client that requests data*

from a data acquisition server.

6.Alarm handling

An important part of most SCADA implementations is alarm handling. The system monitors whether certain alarm conditions are satisfied, to determine when an alarm event has occurred. Once an alarm event has been detected, one or more actions are taken (such as the activation of one or more alarm indicators, and perhaps the generation of email or text messages so that management or remote SCADA operators are informed). In many cases, a SCADA operator may have to acknowledge the alarm event; this may deactivate some alarm indicators, whereas other indicators remain active until the alarm conditions are cleared.

Alarm conditions can be explicit—for example, an alarm point is a digital status point that has either the value NORMAL or ALARM that is calculated by a formula based on the values in other analogue and digital points—or implicit: the SCADA system might automatically monitor whether the value in an analogue point lies outside high and low- limit values associated with that point.

Examples of alarm indicators include a siren, a pop-up box on a screen, or a coloured or flashing area on a screen (that might act in a similar way to the "fuel tank empty" light in a car); in each case, the role of the alarm indicator is to draw the operator's attention to the part of the system 'in alarm' so that appropriate action can be taken.

7.Communication infrastructure and methods

SCADA systems have traditionally used combinations of radio and direct wired connections, although SONET/SDH is also frequently used for large systems such as railways and power stations. The remote management or monitoring

function of a SCADA system is often referred to as telemetry. Some users want SCADA data to travel over their pre-established corporate networks or to share the network with other applications. The legacy of the early low-bandwidth protocols remains, though.

SCADA protocols are designed to be very compact. Many are designed to send information only when the master station polls the RTU. Typical legacy SCADA protocols include Modbus RTU, RP-570, Profibus and Conitel. These communication protocols, with the exception of Modbus (Modbus has been made open by Schneider Electric), are all SCADA-vendor specific but are widely adopted and used. Standard protocols are IEC 60870-5-101 or 104, IEC 61850 and DNP3. These communication protocols are standardized and recognized by all major SCADA vendors. Many of these protocols now contain extensions to operate over TCP/IP. Although the use of conventional networking specifications, such as TCP/IP, blurs the line between traditional and industrial networking, they each fulfill fundamentally differing requirements.[7] Network simulation can be used in conjunction with SCADA simulators to perform various 'what-if' analyses.

With increasing security demands (such as North American Electric Reliability Corporation (NERC) and critical infrastructure protection (CIP) in the US), there is increasing use of satellite-based communication. This has the key advantages that the infrastructure can be self-contained (not using circuits from the public telephone system), can have built-in encryption, and can be engineered to the availability and reliability required by the SCADA system operator. Earlier experiences using consumer-grade VSAT were poor. Modern carrier-class systems provide the quality of service required for SCADA.[8]

RTUs and other automatic controller devices were developed before the advent of industry wide standards for interoperability. The result is that developers and

their management created a multitude of control protocols. Among the larger vendors, there was also the incentive to create their own protocol to "lock in" their customer base. A list of automation protocols is compiled here.

OLE for process control (OPC) can connect different hardware and software, allowing communication even between devices originally not intended to be part of an industrial network

SCADA architecture development:

First generation: "monolithic / Stand Alone"

Early SCADA system computing was done by large minicomputers. Common network services did not exist at the time SCADA was developed. Thus SCADA systems were independent systems with no connectivity to other systems. The communication protocols used were strictly proprietary at that time. The first-generation SCADA system redundancy was achieved using a back-up mainframe system connected to all the Remote Terminal Unit sites and was used in the event of failure of the primary mainframe system.[13] Some first generation SCADA systems were developed as "turn key" operations that ran on minicomputers such as the PDP-11 series made by the Digital Equipment Corporation

Second generation: "distributed"

SCADA information and command processing was distributed across multiple stations which were connected through a LAN. Information was shared in near real time. Each station was responsible for a particular task, which reduced the cost as compared to First Generation SCADA. The network protocols used were still not standardized. Since these protocols were proprietary, very few people beyond the developers knew enough to determine how secure a SCADA

installation was. Security of the SCADA installation was usually overlooked.

Third generation: "networked"

Similar to a distributed architecture, any complex SCADA can be reduced to the simplest components and connected through communication protocols. In the case of a networked design, the system may be spread across more than one LAN network called a process control network (PCN) and separated geographically. Several distributed architecture SCADAs running in parallel, with a single supervisor and historian, could be considered a network architecture. This allows for a more cost-effective solution in very large scale systems.

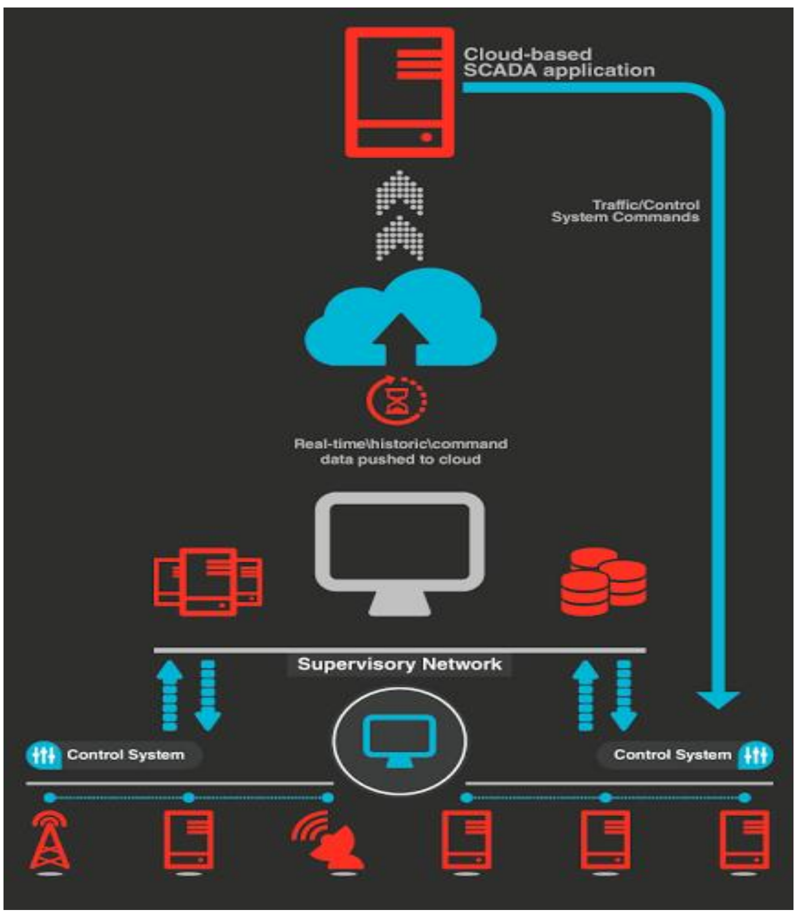
Fourth generation: "Web-based"

The growth of the internet has led SCADA systems to implement web technologies allowing users to view data, exchange information and control processes from anywhere in the world.[14][15] The early 2000s saw the proliferation of Web SCADA systems.[16][17][18] Web SCADA systems use internet browsers such as Google Chrome and Mozilla Firefox as the graphical user interface (GUI) for the operators HMI.[19][16] This simplifies the client side installation and enables users to access the system from various platforms with web browsers such as servers, personal computers, laptops, tablets and mobile phones.[16][20]

Optimizing Performance

While many power, electric, and water companies still use manual labor to perform measurements and adjustments, these tasks can be easily automated with SCADA systems. With utilization from automation in a framework, labor costs can be cut as well as minimize errors with measurements or adjustments. It may seem that SCADA systems just process and store data in a distributed

database, but there's much more complexity to the system itself. The system provides numerous benefits over manual labor such as redundancy adjustments, stable backups of time stamped data, and a secure alarm system. Instead of using humans to check for errors throughout the plant, grid, or pipeline, SCADA uses scripts that detect problems in the system, and quickly adjusts the system from creating an outage. If an outage were to occur that slipped past, a SCADA system's distributed database would help workers instantly identify the location of failure. Also, the automation system significantly increases the time of power restoration that comes with an outage; from the control room, at the press of a button, a worker can enable switches and help reroute power to unaffected sections.



SCADA systems now have the available power of cloud computing; these systems can report close to real-time accuracy and use cloud environments to implement more complex algorithms. These algorithms otherwise would not be implementable on traditional PLCs or RTUs. Without even being at the plant, workers can access computing resources such as networks, storage, servers, and equipment controls. Cloud computing can be supported by two ways: The SCADA system is running on-site, connected to the communication infrastructure directly, and delivering information to the cloud or the SCADAsystem is running completely in the cloud network and remotely connected to the communication infrastructure. As practical as accessing controls to an on-site location might be, cloud computing through SCADA applications is still very vulnerable to cyber attacks. If the system were hit with an attack, hackers could have access to organizational data and resources that could expose the company and inadvertently push customers to another service provider. Below is a figure of what a common SCADA platform looks like utilizing cloud computing methods.

SCADA Security

While they were once isolated entities that were at the hands of engineers, operators, and system technicians, SCADA systems didn't always prioritize secure connections to public networks, leaving many SCADA platforms open to attack. Today there are numerous standards that are required for a secure SCADA platform to run and be operated by its users. If any of these procedures and standards are not practiced correctly, the SCADA platform can be left open for attacks or viruses. However, even with all of these procedures and practices, there is a huge lack of authentication in the design and operation of some existing SCADA networks. While these systems control electricity grids, gas and oil pipelines, and water distribution, the security of these systems needs to be developed extremely well because it can cause massive problems to many areas

ofsociety.

While SCADA platforms provide a vast number of benefits and reductions of cost and downtime of the system, there are still many security threats that need to be worked out. The drive of SCADA platforms is to provide users with quick access to PLCs/RTUs and provide simplistic integration of equipment controls to user interfaces. These systems can be a great tool, but need to be heavily monitored through HMIs. For example, the system can switch a motor or power on or off and can operate the equipment locally.

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"The improvement of understanding is for two ends:
first, our own increase of knowledge;
secondly to enable us to deliver that knowledge to others."

- John Locke

For Your Valuable Feedback/Suggestion: r.ravishankar@ranepolytechnic.edu.in

RANE POYTECHNIC TECHNICAL CAMPUS

No.82, Sethurapatti , Fathima Nagar (PO),

Tiruchirachirapalli.