The development of AWS AND Introductory to the IWS
(Intelligent Weather System)

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Introduction:

Today, fully automated weather observing systems (AWOS) are gradually replacing manned stations. Some years ago such AWOS were used mainly as clusters of secondary observing stations around manned primary synoptical stations. Since the attainable accuracies of variables measured at AWOS are comparable to the regular synoptical stations, the status of both manned stations and AWOS are comparable and also the need to reduce cost (or to solve lack of personnel) investigations on the automation of visual observations is of high interests .Nowadays the developments in the methods of observation are focused on the technology of optics, Microelectronics, and the artificial intelligent techniques for the data entry and the data out and also the better tools for aviation forecasting .

Evolving capabilities of forecasting tools, the implied challenges and opportunities, the needs to form research and development partnerships, to leverage limited resources, and to create and share new technology to achieve a more intelligently automation, there is a high technique of fuzzy logic, wish is an artificial intelligent method designed to automate the decision-making processes, as a technique for post-processing and intelligent integration of meteorological information, we will provide some idea about the intelligent sensors that have more accuracy ,Reliability ,and more Adaptability with their advantages and their future challenges and also the nowcasting version of IWS (intelligent weather system) .

<u>Sensors:</u>

A sensor is a device that receives an input physical property (stimulus, or measurand) and responds with an electrical signal .The stimulus is the quantity, property, or condition that is sensed and converted into electrical signal which is compatible with electronic circuits. We may say that a sensor is a translator of a generally non electrical value into an electrical value. The sensor's output signal may be in the form of voltage, current, or charge. These may be further described in terms of amplitude, frequency, phase, or digital code. This set of characteristics is called the output signal format. Therefore, a sensor has input properties (of any kind) and ectrical output properties. The term sensor should be distinguished from transducer. The latter is a converter of one type of energy into another, whereas the former converts any type of energy into electrical. Fig. 1. A sensor may incorporate several transducers. e1, e2, and so on are various types of energy. Note that the last part is a direct sensor.

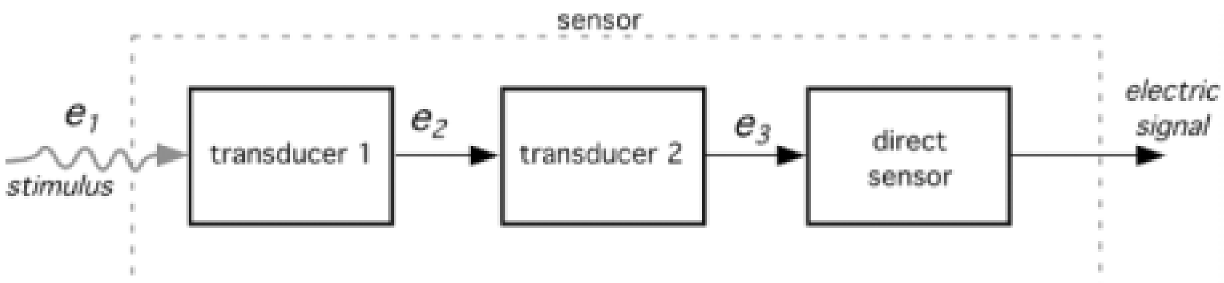


Fig .1

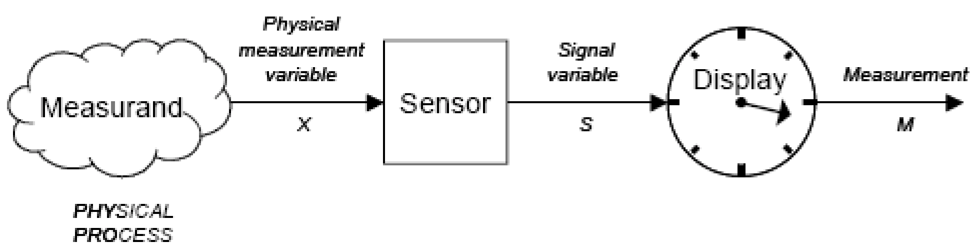
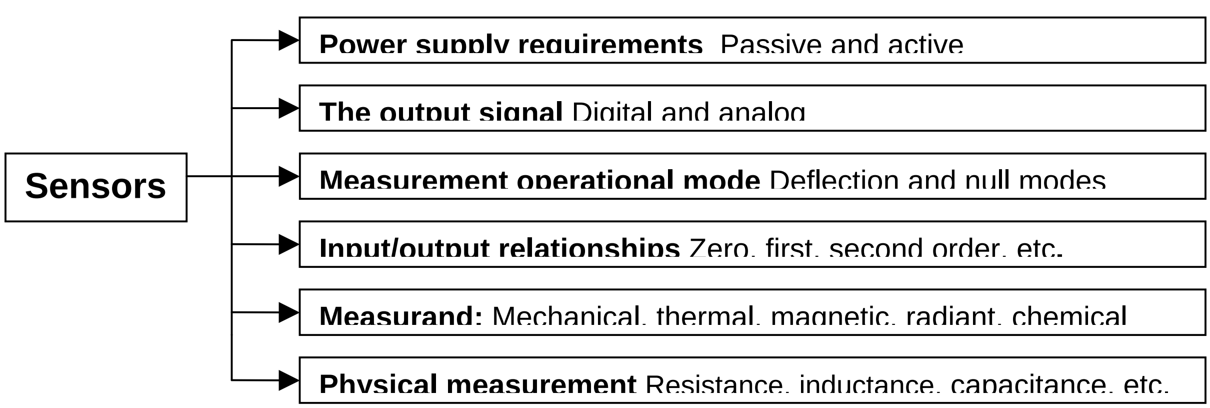


Fig.2

Sensors can be classified, among others, according to one of the following criteria



According to the last scheme the Passive or self-generating sensor is that directly generate an electrical signal in response to an external stimuli without the need for an external power supply for examples the thermocouple and the piezoelectric sensors but the active or modulating sensors require external power supply or an excitation signal for their operation for example thermistors and chemo-resistors. There are another characteristics that is very important to the calibration process wish called Static characteristic like accuracy ,resolution ,precision ,errors , drift ,sensitivity ,linearity ,hysterics, etc.

Data acquisition systems

A sensor does not function by itself; it is always a part of a larger system that may incorporate many other detectors, signal conditioners, signal processors, memory devices, data recorders, It positioned at the input of a device to perceive the outside effects and to signal the system about variations in the outside stimuli. The sensors are always a part of some kind of a data acquisition system, they collect the data from an object. This object may be temperature, relative humidity, wind speed, wind direction ,rain ,radiation ,etc. wish are the stimuli of the meteorological system. The next figure is a simple diagram for the data acquisition system wish used for measuring the meteorological data.

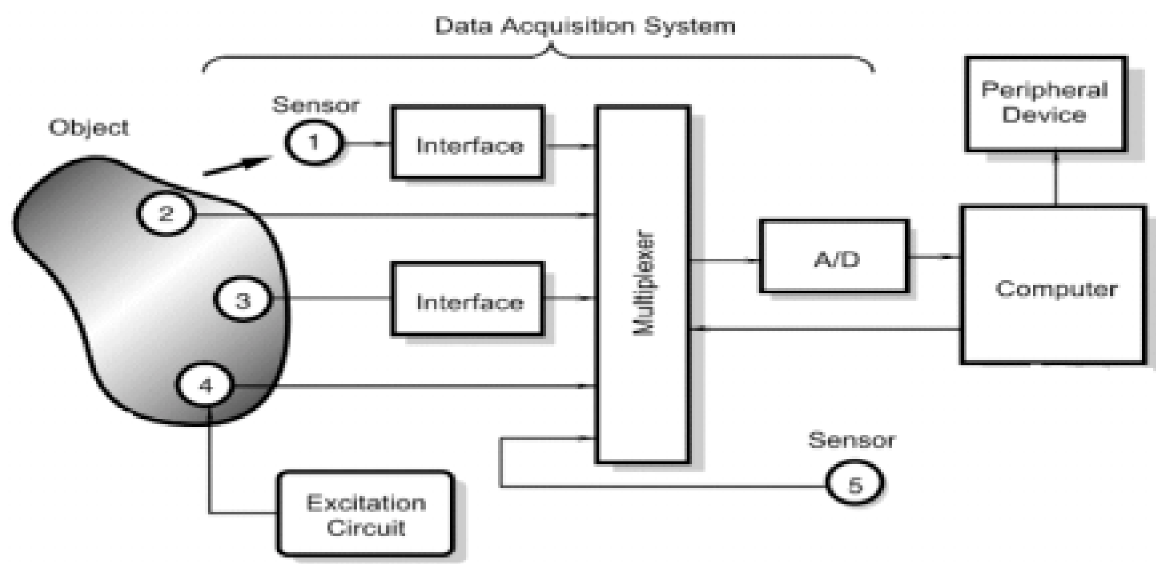


Fig. 3 Positions of sensors in a data acquisition system. Sensor 1 is noncontact, sensors 2 and 3 are passive, sensor 4 is active, and sensor 5 is internal to a data acquisition system.

In that diagram electrical signals from the sensors are fed into a multiplexer (MUX), which is a switch or a gate. Its function is to connect sensors one at a time to an analog-to-digital (A/D) converter if a sensor produces an analog signal, or directly to a computer if a sensor produces signals in a digital format. the computer controls a multiplexer and an A/D converter for the appropriate timing. Also, The system contains some peripheral devices and a number of components, which are not shown in the block diagram. These may be filters, sample-and-hold circuits, amplifiers, and so forth.

Intelligent Sensor Systems:

A sensor that is capable of modifying its internal behavior to optimize the collection of data from the external world or that combines a sensing element and a signal processor on a single integrated circuit. The principal sub-systems within an ISS are:

- **Primary sensing element.**
- **Amplification.**
- **Data conversion**
- **Excitation control.**
- **Analogue filtering.**

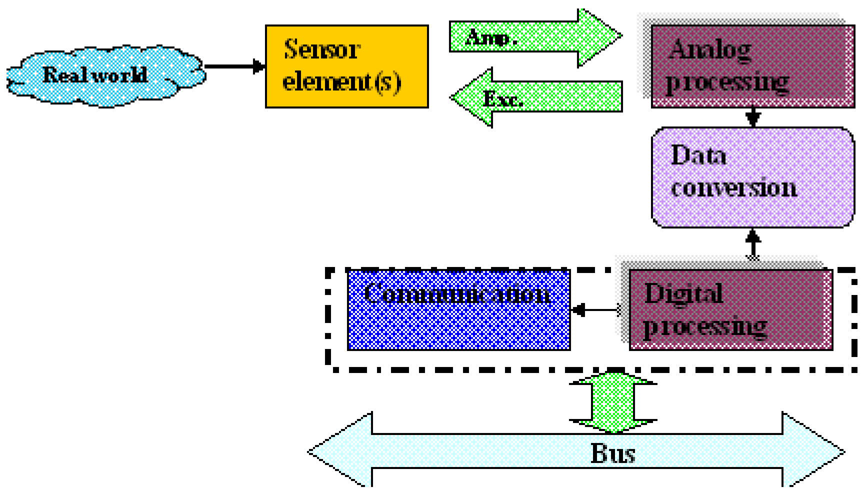


Fig.4

The intelligent sensor has a self-diagnostics, self-calibration, and adaptation to utilize the reasonable value of the output and also utilize the Compensation of the Offset, Gain, Linearity, and Cross –sensitivity it used in some meteorological systems for example pressure sensors, solar tracker and may be in some wind systems**.**

Instrument development

It is known that the AWS systems in many case a combination of a data-acquisition, a set of appropriate sensors suitable for this system and also data-dissemination system. the developments are going on to design new devices to measure air temperature, humidity, wind, precipitation, radiation, etc. for both surface and upper air measurements. So the Development of that system yields to:

- Development in the properties of the sensing elements, or the method used for measurements mechanical, electrical or electronics for the sensors.
- Development in the data acquisition by increasing the memory of archiving and decreasing the time of logging the data to the system.
- Development holds for the instruments due to the new types of observations to measure meteorological parameters by using the alternative technologies. For example the

significant developments in the techniques of PW observations using the optical sensors to measure the visibility, radiation, and precipitation identification by so-called Present Weather Sensors. There are a new integration between the observing systems or networks and NWP to give a necessary constraint for further developments in terms of observations.

According to the design of the AWS systems most of them are not really designed to perform intelligent calculations using data from a set of sensors to present alternative variables but there are some complex algorithms used to achieve the needed observations.

Modern weather forecasting is based mainly on the results of operational NWP calculations. NWP models with high resolution in space and time are becoming very accurate, reliable and therefore popular for the meteorologists. For this purpose new types of topographic information is required and observations should be performed more frequently as well. Using these high-resolution models, running almost continuously the actual state of the atmosphere is described on a three dimensional manner. By using this source of information a now-casting system is available to provide any user any actual meteorological information. From this point of view the need for the direct deliverance to a user of actual measured data from a weather station will reduce in future because any user may retrieve the more appropriate data from such now-casting system. Today all types of observational data are assimilated into models and the impact of these data depends on appropriate weighting functions. In the near future with now-casting systems, were observations and NWP are highly integrated, a significant shift in the functional requirements for the variables is to be expected.

For specific purposes since the integrated system will provide such information by using other data sources. From this point of view the traditional "continuous improvement of instrument" will not be a leading force in instrument development, but the search for the most appropriate observational parameters for input in a now-casting system. As stated already, the push behind instrument development is the cost effectiveness and automation of visual observations. The latter motive can also be interpreted as a goal to reduce costs. In many countries automation of manned stations is going on and it can be expected that primary synoptical stations will become 100% unmanned within the next years. Control for maintenance and quality will be performed remotely from a central facility.

Fuzzy Logic :

The term "fuzzy logic" emerged in the development of the theory of fuzzy sets by Lotfi Zadeh in the mid-1960s a fuzzy expert system is an expert system that uses fuzzy logic instead of Boolean logic. In other words, a fuzzy expert system is a collection of membership functions and rules that are used to reason about data. It provides an approximate but effective means of describing the behavior of systems that are too complex, ill-defined, or not easily analyzed mathematically. Fuzzy variables are processed using a system called a fuzzy logic controller. It involves fuzzification, fuzzy inference, and defuzzification. The fuzzification process converts a crisp input value to a fuzzy value. The fuzzy inference is responsible for drawing conclusions from the knowledge base. The defuzzification process converts the fuzzy control actions into a crisp control action. Fuzzy logic uses graded statements rather than ones that are strictly true or false. Thus, fuzzy logic provides an approximate but effective way of describing the behavior of systems that are not easy to describe precisely. Fuzzy logic controllers, for example, are extensions of the common expert systems that use production rules like “if-then.” With fuzzy controllers, however, linguistic variables like “tall” and “very tall” might be incorporated in a traditional expert system. The result is that fuzzy logic can be used in controllers that are capable of making intelligent control decisions in sometimes volatile and rapidly changing problem environments. Fuzzy logic techniques have been successfully applied in a number of applications: computer vision, decision making, and system design including ANN training. The most extensive use of fuzzy logic is in the area of control, where examples include controllers for cement kilns, braking systems, elevators, washing machines, hot water heaters, air-conditioners, video cameras, rice cookers, and photocopiers. The fuzzy inference also successfully applied for the sensor integration system.

Intelligent Weather System (IWS)

Scientists and software engineers had developed the tools of forecasting using the technique of fuzzy logic to provide a high reliable, high resolving more accurate and a good end meteorological product by incorporating all the available sources of intelligence related to a meteorological variable. As an example we will handle the RAP design

The design exploits the use of fuzzy logic (FL) in a more fundamental way than the traditional methods employed in what is commonly referred to as artificial intelligence The figure below shows the general system design for a nowcasting IWS, in other words a system that provides a set of high-resolution meteorological fields for a single parameter in a time frame of t=0 out to a few hours, at some specified time step (typically 1 to 30 minutes depending on the variability of the parameter). There are two primary processing tracks I) Modeling wish includes the three basic steps: a) data assimilation, b) model run, and c) application of special algorithms to the model output. II) Real-time data that emanate from the available data sources. In this design the FL Integration algorithm is the focus for all of the final input information.

The sensor system suite is any set of sensors that produce data relevant to the meteorological parameter that is the focus of the nowcast. Typically this might include radiosondes, wind profilers, automated surface stations, satellites and conventional or Doppler radars …..etc

The model output algorithms are an important component of the overall system in that they convert the standard state variable output of the model into useful, operationally-significant variables like icing, turbulence, visibility, road conditions, etc. These algorithms can have any type of basic construct: rule-based, neural-net, etc., but they must have an FL interface if not basically designed using FL, so that an interest field can be constructed for submission to the FL Integration Algorithm. There may be multiple types of real-time data used in each algorithm. For example, in the en-route icing IWS, satellite, radar and surface observations are used, each of which contributes a single FL interest field to the integration algorithm.

All of the various inputs enter the FL Integration Algorithm as FL interest fields. An interest field is a field of values that range from 0 to 1 that depicts the level of "interest" of the input parameter to the meteorological variable that is to be nowcast. An interest value of one indicates the highest level of association and an interest level of 0 indicates no association. Human expertise enters in two key areas. The first is in the definition of FL functions that produce the interest fields associated with each of the independent inputs. Normally these functions are created by experts in a particular field. The second area is in the derivation of weight functions for the various interest fields that enter the FL Integration Algorithm. These weights are first estimated by experts, then are fine tuned to produce the best final product. The final step in the process is the product generator. The interest field is converted to a new product format that has a look and feel that is tailored to the specific operational needs of the end user.

Fig.5 design for nowcasting IWS

To apply this technique two things are essential: a) relevant data that correspond to desired space/time resolution of the end product, and b) understanding the physical relationships between the intelligent inputs and the parameter that is being nowcast. Given these two ingredients, almost any quality control, detection, nowcasting or forecasting problem is an eligible candidate for the IWS design.

Further applications of the IWS design are now underway in the areas of single-site thunderstorm initiation, growth and decay; regional thunderstorm products that address initiation, growth and decay; en-route icing for aviation decision makers; en-route turbulence for aviation decision makers; and road weather detection systems that aid highway managers. So far, levels of accuracy and reliability have exceeded those possible with more conventional system designs.

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