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Certain Applications of LabVIEW in the Field of Electronics and Communication

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Abstract

The LabVIEW platform with graphical programming environment, will help to integrate the human machine interface controller with the software like MATLAB, Python etc. This platform plays the vital role in many pioneering areas like speech signal processing, bio medical signals like Electrocardiogram (ECG) and Electroencephalogram (EEG) processing, fault analysis in analog electronic circuits, Cognitive Radio(CR), Software Defined Radio (SDR), flexible and wearable electronics. Nowadays most engineering colleges redesign their laboratory curricula for the students to enhance the potential inclusion of remote based laboratory to facilitate and encourage the students to access the laboratory anywhere and any-time. This would help every young learner to bolster their innovation, if the laboratory environment is within the reach of their hand. LabVIEW is widely recognized for its flexibility and adaptability. Due to the versatile nature of LabVIEW in the Input- Output systems, it has find its broad applications in integrated systems. It can provide a smart assistance to deaf and dumb people for interpreting the sign language by gesture recognition using flex sensors, monitor the health condition of elderly people by predicting the abnormalities in the heart beat through remote access, and identify the stage of breast cancer from the Computed tomography (CT) and Magnetic resonance imaging (MRI) scans using image processing techniques. In this chapter, the previous work of authors who have extensively incorporated LabVIEW in the field of electronics and communication are discussed in detail.

Keywords: speech signal, embedded systems, robotics

1. Introduction

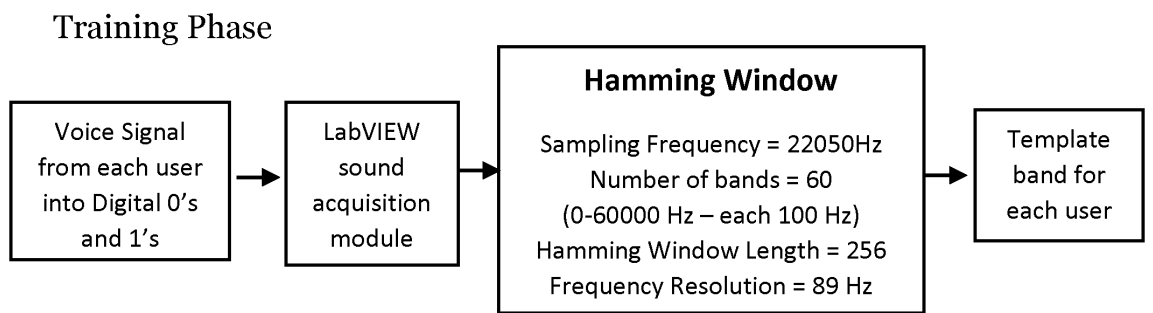
The recognition and processing of speech signal plays a key role in any real time implementation. The plethora of approaches has been followed to analyze the continuous speech spectrum namely Perceptual Linear Prediction (PLP) statistical approach, Relative Spectral (RASTA) method, Mel-frequency cepstral analysis (MFCC), hidden Markov models (HMM), artificial neural networks (ANN), etc. The speech signal processing can be further enhanced by filtering out the noisy environments using single channel or multi-channel methods.

Radek et al., [1, 2] have incorporated the multi-channel methods using least mean square algorithm (LMS) and independent component analysis (ICA) to provide the mathematical calculations to avoid additive noise in speech signal. For smart home implementation, the LabVIEW SW tool is used for visualization, speech recognition, virtual cable connection to the sound card, and the actual mathematical calculations within additive noise canceling. The speech recognition engine will provide communication between LabVIEW and the recognizer. Its function is to convert input command into stream of text outputs. The output will be compared with the recognized command and the appropriate command will be given to ON/OFF the devices like Fan, Television, Washing Machine, Vacuum Cleaner, Dish Washer, etc. in the home. The Virtual Audio Cable (VA – Cable) is a software used for communicating between the devices using the audio streams.

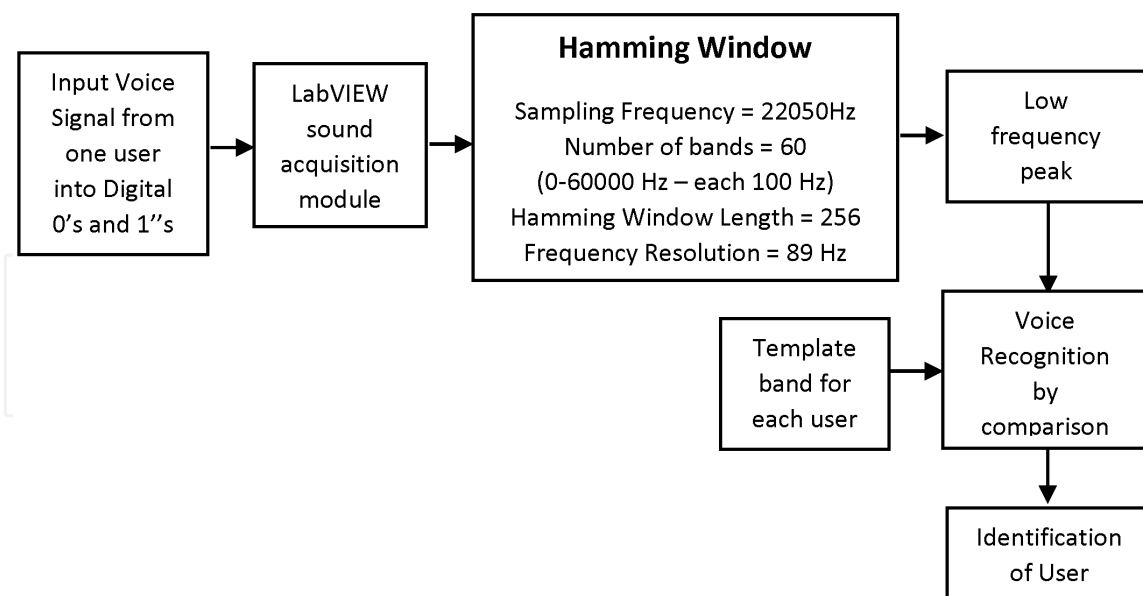
LabVIEW is capable of executing/implementing many parallel loops on FPGA and real-time controllers by using a set of complex math functions. To make it more powerful, it has been integrated with LabVIEW SoftMotion Module and Kollmorgen AKD drives and motors to control the smart machines in all aspects. It also helps in the maintenance of smart machines after their deployment in the world by implementing centralized resource management, diagnostics, and remote updates [3].

2. Speech signal processing

The speech recognition and processing are playing a vital role in various industries including data acquisition, hands-free mobile manufacture for physically challenged, instrumentation field and machine control. For implementing the speech recognition system in LabVIEW platform, the prerequisites include sound card, microphone and other accessories related to the hardware PC/Mobile. In the design of intelligent voice system using LabVIEW [4], Virtual Instrument (VI) can be incorporated to simplify the process of Voice Recognition Technology (VRT). It has been enriched with the features of graphical-based programming, digital data stream and simplified programming model to involve the audio front panel. Even though speech signal of different people may have similar power spectrum, the low frequency band will differ uniquely for each and every user. Therefore, after recording the voice it can be analyzed with the help of sound acquisition module in LabVIEW [4]. Once speech signal is received from the microphone, it is preprocessed and filtered before adding the Hamming window to calculate the power spectrum of each user. From the power spectrum, low frequency peaks can be obtained in order to identify the voice characteristics of individual user. Using Labview PSD module peak frequency is extracted from the spectrum of voice signal.



Recognition Phase



The design can be divided into training and recognition. In the training phase each user's voice is acquired from the input speech device, such as microphone. LabVIEW stores the sound as a waveform arrays. Each waveform in the array represents one channel. Therefore, for stereophonic system two waveform elements will be present in an array. Since each channel plays simultaneously in the stereo system, and the data will be represented in the form of Pulse Code Modulation (PCM). In the pulse code modulated data, each element in an array will be proportional to the pitch or intensity of the signal. Each array will be arranged from minimum to maximum with zero as centered. If the array data type is of 16-bit or 32-bit signed integer, then the values will range from 0 to 65536 for 16-bit which will be centered at 32768 similarly from 0 to 4,294,967,296 for 32-bit will be centered at 2,147,483,648. A buffer of elements each with the value of zero (32768–16 bit, 2,147,483,648–32 bit) represents silence. The recommended hardware for sound and vibration measurement in the category of high performance model includes NI 4461 and NI 4462, high density model includes NI 4495, NI 4496, and NI 4498, low cost model includes NI 4472 and NI 4474 and portable/compact model includes NI 9233, NI 9234, NI 4432 and NI 4431. Using the sound acquisition module the voice signal will be read through PC sound card. The power spectrum will be obtained through hamming window and after identifying the low frequency peaks template for each and every user will be stored in the module. In the recognition phase, the voice of any user can be taken and it will be compared with the template frequency band to verify the identity of concerned person.

3. Labview for embedded systems

LabVIEW, an easier graphical programming environment than GUI based application development platforms like Visual Basic and Visual C++. The conventional instrumentation does not perform analysis and controlling of multiple signals at the same time but LabVIEW with Virtual Instrumentation will do so. The main advantage of LabVIEW is that it can be used for PC-based monitoring and data logging.

The latest processors that have been used for the embedded system design are ARM microcontrollers. LabVIEW has a comprehensive graphical development

environment module for ARM microcontrollers. This has been jointly developed by Keil - An ARM Company and NI instruments for Embedded System design applications. This module will reduce the development cost and fasten the programming part for Embedded System Design. This module includes hundreds of analysis and signal processing functions, integrated I/O, and an interactive debugging interface [5]. These advantages of LabVIEW pays a path for its usage in embedded applications for controlling. There are many case studies for such kinds of applications.

The photovoltaic panel emulator can be designed using LabVIEW interfaces to identify the characteristics of electrical parameters of PV panel. In the model designed by Gurkan et al. [6], four PV panels has been monitored with the help of PV panel emulator and electronic potentiometer. All the panels and modules has been connected to the ATMEGA2560 main control unit. Because of the flexibility and enriched features, LabVIEW is incorporated to provide communication between PC and the main control unit. The serial communication port COMPORT in LabVIEW will be used to send array of strings to and from PC and PV panels. Using the LabVIEW specific interface can be designed to observe the electrical characteristics of PV panel in real time by adjusting the resistance values of electrical potentiometer.

A smart turf harvesting machine (ProSlap 155) has been designed using a CompactRIO controller by FireFly in 2014. The CompactRIO has been used as hardware for the machine and LabVIEW used as software. To perform the parallel operations, the FireFly has combined traditional fluid power systems with a servo-electric system on the machine using the LabVIEW and CompactRIO. The LabVIEW has been used to program 80 different sensors and 100 digital outputs of the hardware and provide a secure Internet gateway to remotely monitor and control the turf harvester. The ProSlap 155 turf harvester increases the harvesting speed to 20% and reduces the fuel consumption up to 50% and this increases farm productivity [7].

LabVIEW is one of the best software used in the production process control system applications. It has been used to remotely control the Crude Oil Separator in Crude oil industries. Wireless connectivity through TCP/IP protocol has been established between the LabVIEW and the PIC microcontroller for controlling and automation of crude oil separators. It has used to control the pressure and level of a Gas and Liquids in the crude oil separator (**Figure 1**) [8].

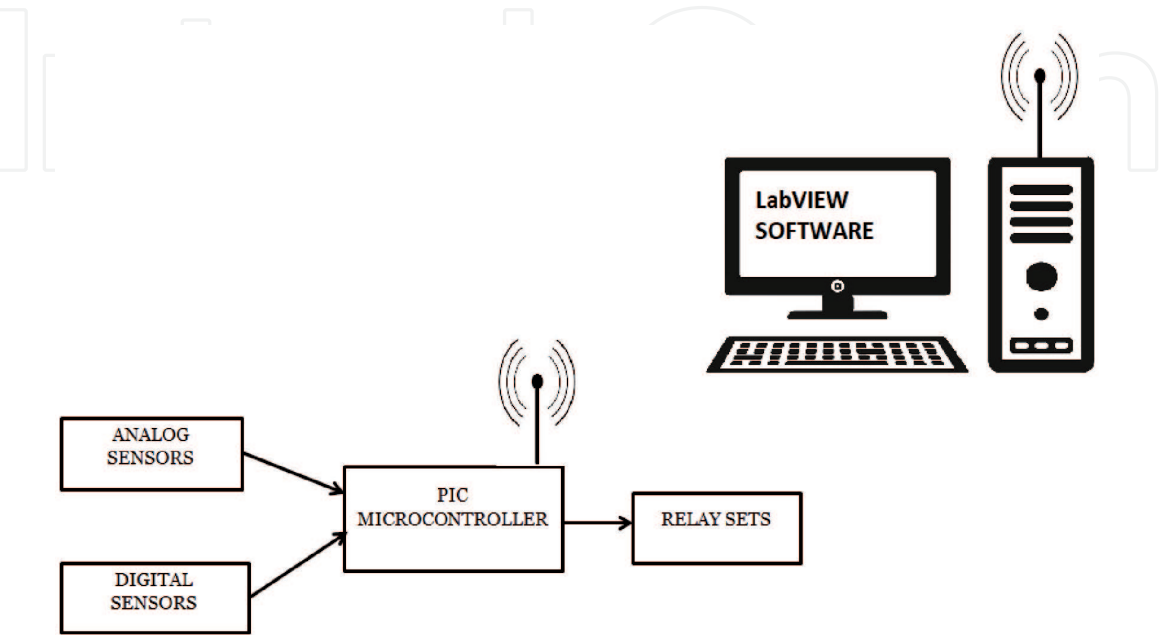


Figure 1.
System Block Diagram of Crude Oil Separator.

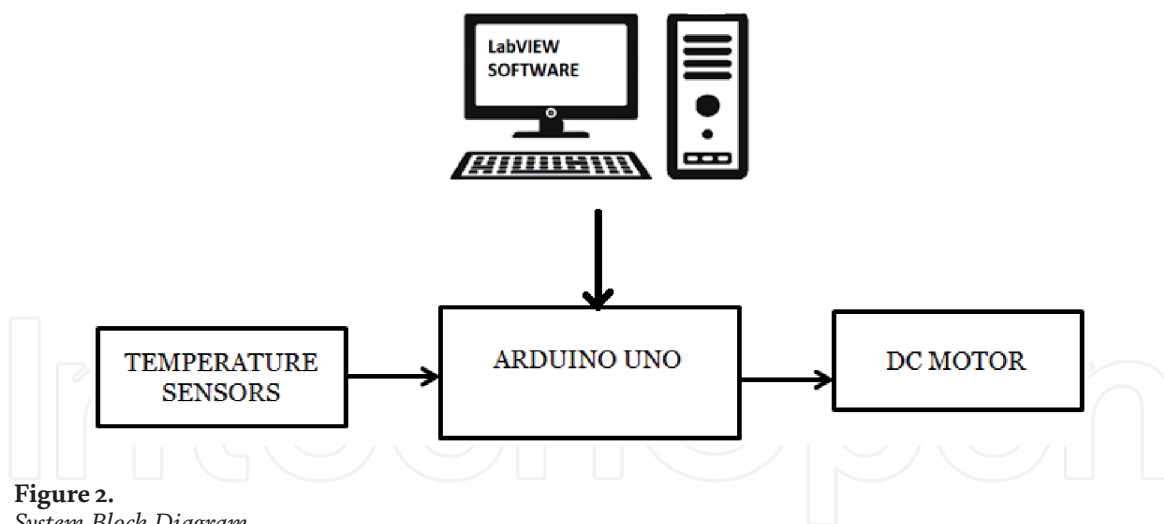


Figure 2.
 System Block Diagram.

LabVIEW is also used to control a device. In this case study, the LabVIEW is used to control the speed of the DC motor based on the temperature in the devices like CPU, Air Conditioner, etc. The temperature sensor is used to measure the temperature in the environment of the system. The DC motor is connected with the Arduino board. The board will send the PWM output to control the speed of the motor. The duty cycle of the PWM output is decided by the LabVIEW based on the temperature value from the sensor. As the temperature varies, the speed of the motor will also be varied (Figure 2) [9].

4. Applications of LabVIEW in robotics and VLSI

Present world is looking for high throughput fast processing system with features that meets ideal specifications. As we know, a system complexity increases consequently the system hardware and software must be complicated to attain the desired target within the time specification. As we are going through the era of artificial intelligence and machine learning so that it is necessary to add technological improvements in our system designs to compete with latest market trends. In the field of robotics, software and hardware have equal responsibility and functionality to attain the accuracy while take part in a certain action. In order to create a stable perfect system, the designer can choose graphical based design rather than conventional system design.

LabVIEW can easily use as a flexible environment for the robotic design. LabVIEW is a development environment that will provide flexibility for automated product design validation and monitoring of a machine status. Here the designer can use the language “G” for the system coding and drag and drop option of appropriate functional blocks will generate a working system according to the specifications.

Industrial machine builders [10] are forced to deliver machines that meets several demands. It is necessary to hold their unique position in the respective field with respect to the competitors. LabVIEW is mainly used for building a graphical user interfaces for systems and also it is utilizing inherent parallelism for instrumentation, control system and robotics. If the designers are looking for a simple design in the hardware and software LabVIEW is the best option for that. Robotic arm control mechanism needs more accuracy to work in the fields such as of medical electronics and chemical industry. The processor will run according to the program coded using lab view and the processor will generate the control signals to control and monitor the movement of robotic arm.

LabVIEW is applicable for standalone as well as moving system design. Wherever the application of a mixed system comes then the design complexity will increase and monitoring will be more complicated. Here the graphical user interface [11] will be more useful to control the action of the system and its programming.

5. Medical applications

Jung et al. [12], integrated the flexible multimodal sensor based E-Skin which will mimic the skin in human beings. The sensors like temperature, pressure, flow and humidity everything has been included to create the characteristics of human skin. To measure the varying resistance in the hair sensor they customized the PC-Controlled Servomotor LabVIEW Tower Pro SG 90 and PC-recordable acquisition board NI USB-6218. The E-Skin plays vital role in soft electronics to enhance the Human-Machine Interface (HMI) for analyzing the ECG, EMG and other parameters. The wearable and flexible electronics [13] paves the way for comfort in using these devices.

6. Education

Many real time remote –based laboratory models have been constructed to help the students in schools and higher education institutions to perform the research and gain the knowledge from their own location itself. Several laboratories including the light sensing experiment designed by Singh et al. [14] using LabVIEW, LDR and LM35 sensor, the phasor estimation algorithm using NI ELVIS kit designed by Mondal et al. [15], operational process monitoring application using SHRIMP VL application, analog electronics experiment using “RedPitaya” [16] etc. The LabVIEW has been effectively and efficiently included in many studies in literature to enhance and boost the research community. Polat et al. [17], designed the Distance Vocation Education and Training D-VET to monitor the lighting levels of LED lamps in remote laboratory with the help of PID controller, Sensor, Actuator, NI-IMAQ software and CompactRIO DAQ.

Azenova et al. [18] designed an e-learning course for second year industrial students under the category of laboratory experiments in electronics. The LabVIEW is incorporated in the Goodyear e-learning model they have adopted for implementing to their students. The basic laboratory experiments like clipper, clamper, inverting and non-inverting amplifier, summing and differential amplifier were simulated with the help of virtual instruments front panel in LabVIEW.

7. Miscellaneous applications

The fault detection in analog circuit can be easily analyzed with the help of LabVIEW interfaces using deep forest learning method. Zhen et al. [19] have designed the fault diagnosis scheme with the Waveform generator Agilent 33250, Data acquisition module NI 1042q, LabVIEW, Digital oscilloscope Agilent 54853 along with power supply and testing circuit. The outputs of testing circuit are collected by data acquisition module and stored in the LabVIEW and used for further diagnosis.

For assessing the quality of water to ensure the living of aquatic species like fishes in a healthy environment. Othman et al. [20], proposed a system using the sensors to measure the pH level and temperature of the water in the tank. The data

collected from the sensors are given to the Data Acquisition System (DAQ) NI myRIO-1900. Then the data will be analyzed periodically in the workstation to ensure the safety of aquatic animals. The interface between DAQ and workstation is created with the help of LabVIEW software. The temperature and pH measurements are displayed in the front panel of LabVIEW.

Ahmed et al. [21] discussed the implementation of LabVIEW software to control the FESTO MPS PA compact workstations as part of remote laboratory. In the paper they designed the Easyport USB data acquisition card based on activeX elements to interface with LabVIEW and control the applications in Fluid Lab. To obtain the real time information from the Sensors and actuators of MPS-PA station various VI were included. To incorporate remote monitoring web server of LabVIEW is required. With the help of the VI the user can adjust the parameters of Controller and with help of IP camera and web server the MPS PA compact workstation can be monitored remotely. Proportional-Integral-Derivative (PID) and ON/OFF controllers these two experiments as part of laboratory course were implemented using the system designed by Ahmed et al.

Mikhoylov et al. [22] aimed to monitor the specific content from the broadcast channels using the help of Cognitive Radio (CR). For the real time data analytics, particular subset of channels from the selective frequency range will be chosen and the significant information in the subset will be relayed for monitoring in the remotely using the VI from LabVIEW. For monitoring Software Defined Radio (SDR) technology USRP 2900/2901 and LabVIEW were utilized in the design. The key factor in the application is to either receive & process or transmit the subset of signals in the digitized format with the help of the packages available in the LabVIEW.

8. Conclusion


The applications of LabVIEW in electronics and communication field has been presented in this chapter. The role of LabVIEW in Speech signal processing, Photovoltaic cell emulator, Fault diagnosis scheme, Cognitive radio signal analysis, FESTO workstation control, Water tank surveillance, Embedded system like the Crude Oil Separator, smart turf harvesting machine and robotics applications were discussed briefly. The demonstration and exploration of laboratory courses for school and college students are in reach of hand because of the interface provided by the LabVIEW and source of the Internet.

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