TEACHING DIGITAL SIGNAL PROCESSING USING SKITS – A CASE STUDY

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Abstract
Digital Signal Processing (DSP) involves acquiring real time signals, digitizing them and mathematically manipulate to extract useful information. Traditionally DSP has been taught in engineering colleges using simulation software to develop interest among students. Connections between abstract signal processing theory and real-world signal processing system design are difficult to illustrate in a packed undergraduate curriculum. We have proposed usage of skits for explaining concepts and employing students to act and interactive audiovisual aids as tools for learning DSP. Based on the pretest and posttest scores, we found that group using Skits and audiovisual tools got better scores than group using only audiovisual tools in their ability to understand concepts by applying to simple real world examples. Hence the usage of these interactive teaching aids helps in increase of student's interest to learn, visualize and understand key DSP concepts.
Keywords: DSP, skits, Audiovisual, questionnaire, interactive

1. Introduction

Instrumentation engineering is an inter-disciplinary branch that includes study of electrical, chemical, electronics as well as computer engineering. Instrumentation has been the fundamental engine for catalysing Research & Development in India. Segments like communication, aerospace, defence, industrial automation, computers and semiconductors, education and academia, and general-purpose electronics also use instrumentation to validate their devices, designs and deployment.

Digital signal processing refers to the use of digital processing, using computers, to perform a wide variety of signal processing operations. DSP applications include audio and speech signal processing, sensor array processing, statistical signal processing, digital image processing, signal processing for telecommunications, control of systems, biomedical engineering etc. Hence learning of DSP has become an inevitable for Instrumentation Engineers.

The breath and depth of DSP makes it impossible for any one student to master all of the DSP concepts that has been provided in the curriculum. DSP education involves two tasks: learning general concepts and application of them. Connections between abstract signal processing theory and real-world signal processing system design are difficult to illustrate in a packed undergraduate curriculum.

2. Literature Review

Diya Joseph et.al., (2017), has presented the use of a Windows Store App which can be used as a teaching aid for an introductory undergraduate DSP course. Furthermore, they have reported that the use of app to teach a course on DSP had a positive feedback from the students.

Dogan Ibrahim (2016), has proposed the usage of a laboratory course on digital signal processing (DSP) for undergraduate students. The primary purpose of the laboratory is a better understanding of the theoretical concepts, and to let the students experience actual DSP happening in real-time, using real devices.

Qiu-feng Shang and Wei Liu, (2016), have developed a experimental system based on

TMS320VC5509 for teaching “DSP system design”, They state that the system not only can be applied to the practical teaching of DSP course, but also can be used as the development platform of DSP system.

Fernando A. Mujica, et.al (2015), has proposed a low-cost and open-source “Stanford Lab in a Box.” This system, with its easy to use Arduino-like programming interface allowed students to see how fundamental DSP concepts such as digital filters, FFT, and multi-rate processing can be implemented in real time on a fixed-point processor.

Nasser Kehtarnavaz and Shane Parris (2014), have developed educational paradigm for teaching applied or real-time digital signal processing courses. It involves the utilization of smartphones to implement digital signal processing algorithms in real-time using ARM processors of smartphones.

All the above researchers have suggested the usage of simulation software’s, hardware platforms, special Apps has methods of teaching DSP. Even though students might be able to learn some basic concepts, but addressing the heterogeneous mixture of students with different thinking level is really a challenging task.

As per the statement of Robert Sternberg, a cognitive scientist, "Learning is any relatively permanent change in the behaviour, thoughts, or feelings of an organism that results from experience." Hence in this context we have proposed the usage of skits and audiovisual aids has learning tools for DSP.

3. Case Study: Convolution

Basic Concept

Convolution is a mathematical operation, just as multiplication, addition, and integration. It takes two signals and produces a third signal. It is used in the mathematics of many fields, such as probability and statistics. In linear systems, convolution is used to describe the relationship between three signals of interest: the input signal, the impulse response, and the output signal.

Mathematically convolution of two signals $x(n)$ and $h(n)$ leading to a third signal $y(n)$ is represented by the following equation;

$$y(n) = x(n) * h(n) = \sum_{k=-\infty}^{\infty} x(k)h(n-k)$$

To obtain the convolution, one of the signals $h(n)$ is folded about origin and multiplied with $x(n)$.

3.1 Skit for explain Convolution concept

a) Introduction to Technical Skits

Constructive alignment is a principle used for devising teaching and learning activities, and assessment tasks, that directly address the intended learning outcomes in a way not typically achieved in traditional lectures, tutorial classes and examinations (Biggs and Tang, 2011). The teacher's job is to create an environment that supports the learning activities appropriate to achieve the desired learning outcomes. A technical skit is proposed as a method of constructive alignment to make students learn by participating and experiencing.

b) Skit Members

Sl No	No of Students	Role	Identification	Implication
a	Three	$x(n)$	Yellow Shirts	Length of the signal $x(n)$ is Three
b	Four	$h(n)$	Red Shirts	Length of the signal $h(n)$ is Four
c	Seven	n	Black Shirts	Time Index ranging from -3 to +3

Table 1 Skit Organisation

c) Skit Flow

Initially x(n) is alone displayed. We have used students with yellow shirt to represent the signal. Three members were made to stand corresponding to the time index 0,1 & 2. (Figure 1)

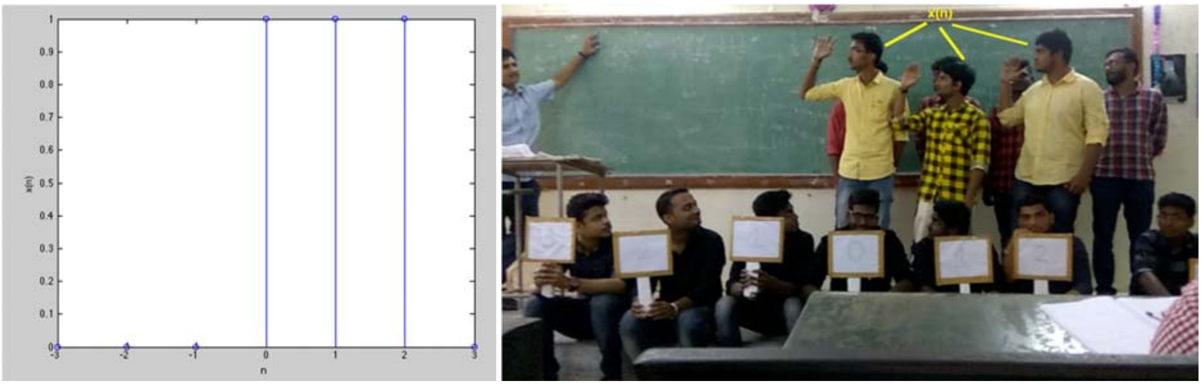

Figure 1 Representing First signal x(n)

Following x(n), the second signal h(n) was highlighted by raising their hands. Both signals have their origin point at ‘0’. We have used students with red shirt (standing behind) to represent the second signal. Four members were made to stand corresponding to the time index 0,1,2 & 3. (Figure 2)

Figure 2 Representing Second signal h(n)

First step in enabling convolution operation is folding the h(n) about origin. To illustrate these students with Red shirt were described about the folding operation and retaining the student in ‘0’ position, students from position ‘1’ moved onto position ‘-1’ and so on. (Figure 3)

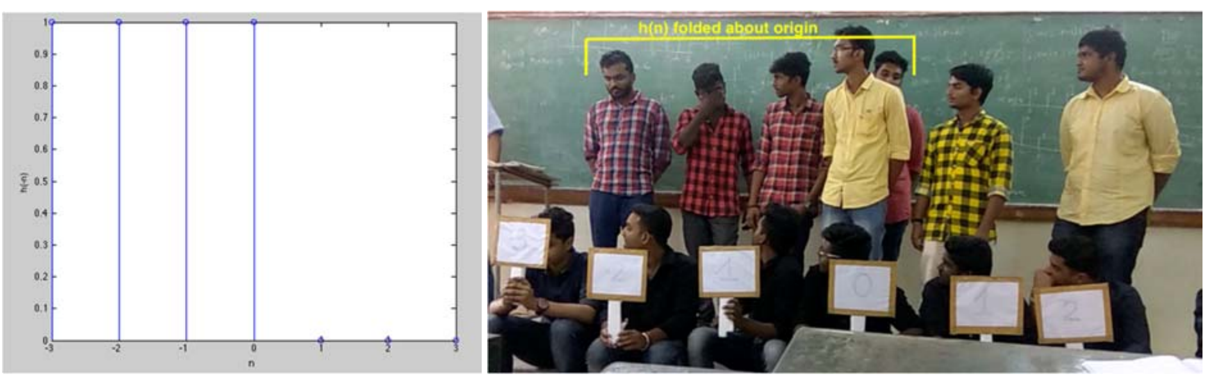

Figure 3 Folding of Second signal h(n)

Followed by folding operation, signals in same time index are multiplied. As illustrated in Figure 3, only in position ‘0’ both the signals have values and hence both the magnitudes are multiplied. Later the h(n) signal will be shifted to the right by one instant, thereby x(n) and h(n) will overlap in two time indexes as shown in Figure 4.

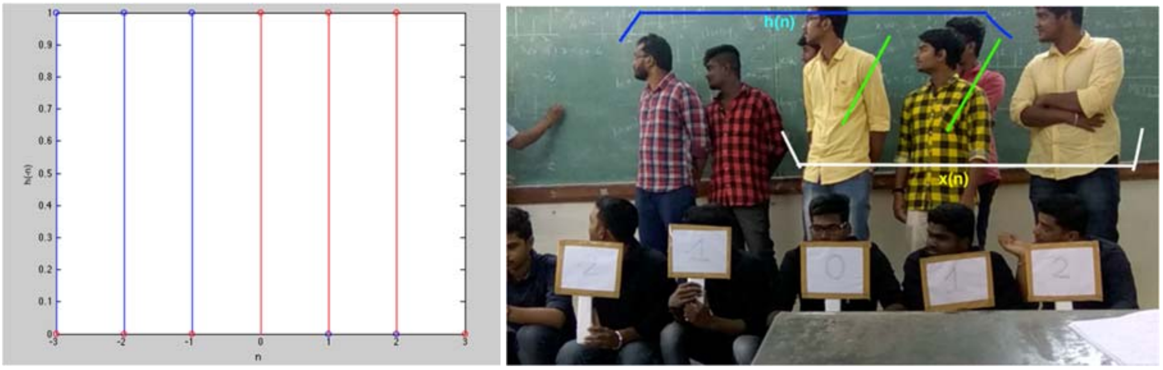

Figure 4 After First shift, x(n) and h(n) overlapping in two indexes

The shift will be continued till the last student of h(n) overlaps with the last student of x(n). At each shift the multiplication of corresponding time indexes are obtained and the result is stacked.

d) Implication

In signal processing, the basic assumption is that signals and impulse responses are time series, with a non-zero constant time-duration, called the sampling rate separating consecutive samples. Using the skit, it was possible to visualize geometrically, the output y(t) as the sum of an infinite number of copies of the impulse response, each shifted by a slightly different time delay and scaled according to the value of the input signal. For example, considering a sine wave as input to a multiplier, one can change the device performance by simply varying parameters of h(n).

3.2 Audiovisual Demonstration for convolution

Audio Visual demonstration of convolution was done using the simulation software MATLAB.

a) Audio demonstration

1. Students were provided with a sound of Church Bell (Impulse Response) in WAV format
2. Now the students were instructed to open the file in MATLAB using WAVREAD and play the signal using SOUND command.
3. Next the students recorded their own voice by repeating a word ‘HI’ two times for a period of Three seconds using WAVRECORDER command
4. Following that convolution of the two signals was done using CONV command

b) Visual Demonstration

The signal of Church bell, recorded voice and the convoluted result were displayed in Time plot using PLOT command. The result of convolution was illustrated in Figure 5.

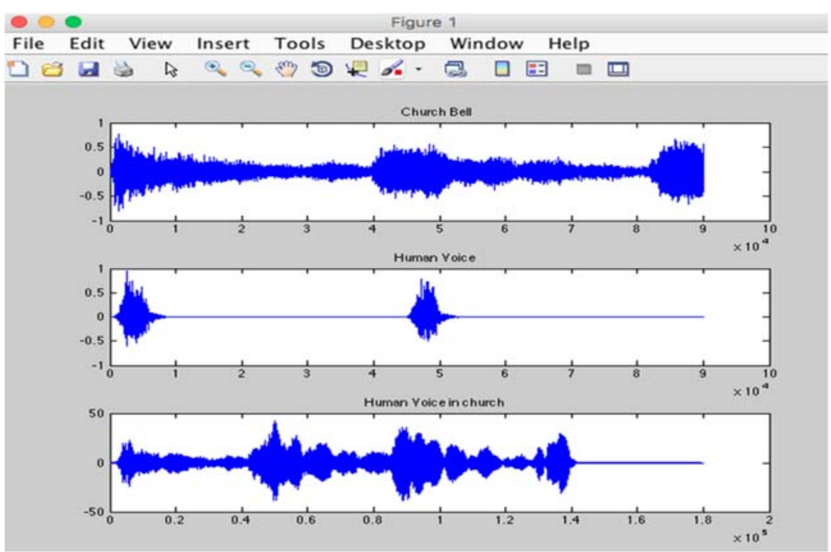

Figure 5 Result of Convolution

c) Students Observation

It was observed by students that A 'dry' speech recording is altered to sound as if were recorded in a church by the convolution operation. Furthermore, the result of convolution is also visually seen from Figure 5. Any dry sound convolved with the church Bell – Impulse Response (IR) will sound as if it were performed in the IR space. Also it can be noted that the 'dry' dog bark file and the IR file were 2 seconds long, whereas the resultant convolved file, by the time the reverberation dies away is about 4 seconds long.

d) Implication

The actual mathematical basis for convolution, called direct convolution is rarely used in its practical audio implementation. Moreover, it is possible to take a convolved output file and deconvolve it into its constituent input files by knowing the structure of at least one of the component files or being able to estimate it. Some signals, such as noise or hum, can be roughly estimated, and de-convolution procedures for removing them can be easily done.

3.3 Implementation of Interactive methods

A class of 60 students was divided into two groups SAV (Skits Audiovisual) & AV (Audiovisual). For both groups initially the concepts were explained using conventional black board (BB) teaching, followed by a pretest.

Observation

Later for Group SAV, concepts were demonstrated with use of skits and interactive audiovisual aids, whereas for group AV, interactive audiovisual aids alone were employed. Following the activity, a posttest was conducted for both the groups.

Common Questions for both groups SAV & AV

1. What is Convolution?
2. Mention the mathematical expression for convolution?
3. What is the physical meaning of convolution?
4. Mention the typical application areas?
5. How convolution operation acts as a means of filtering?
6. How the convolution operation is done?
7. Obtain the convolution of two signals x(n) = {1, 2, 3}, and h(n) = {1,2}
8. Mention a practical application of Deconvolution?

Additional Questions for group SAV

1. Role of the student in the skit
2. Was the basic concept understood?
3. Any costumes or objects were used
4. What thing can be added or changed in the skit?
5. On a Scale of 5, 5 being best, 1 being worst. Rate your views on the skit

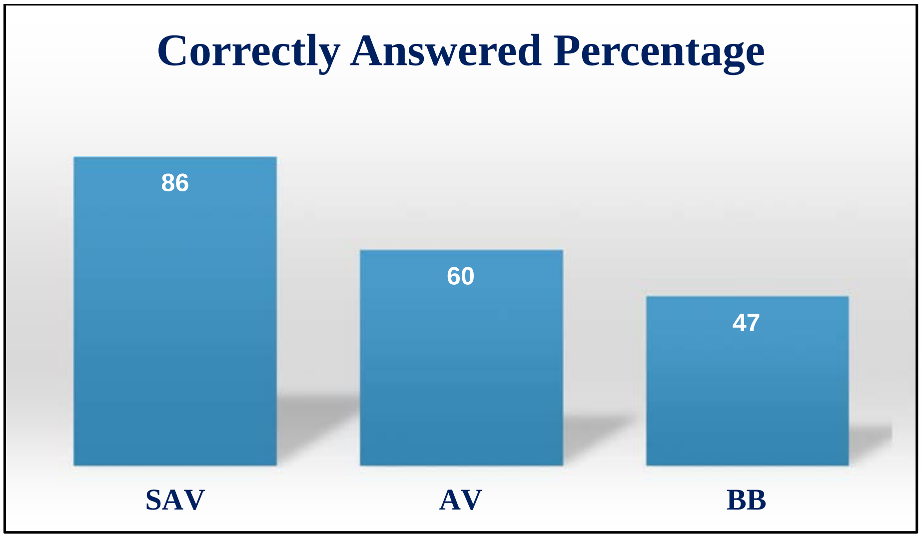

Figure 6 Comparison of SAV, AV & BB

The results from Figure 6 indicate the effectiveness of using Skits and audiovisual aids for teaching convolution concept. Based on the pretest and posttest scores, we found that group SAV got better scores than group AV in their ability to understand concepts by applying to simple real world examples. Furthermore, the skits were short, to the point and delivered lots of fun to the students. It made the students to effectively participate and understand the concept of convolution better. It helped the students to visualize the actual process.

4. Conclusion

The study was aimed in determining the effectiveness of using Skits and audiovisual aids for teaching DSP concepts. In this context, A unique questionnaire was developed to evaluate the effectiveness of usage of proposed teaching aids. Based on the scores obtained by the students, and their eagerness to participate in skits it was found that the skits and audiovisual aids play an important role in increasing the students' interests towards understanding concepts. Hence the usage of these interactive teaching aids helps in increase of student's interest to learn, visualize and understand key DSP concepts.

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