a.

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Our team, Team Radical, is comprised of five undergraduate electrical engineering students.  The members include Alexander, Bryce, Hieu, Norman, and Rocky.

b.

Project title

"Touch-Tone Recognition"

c.

Project description

* Detailed description of your project ALEXANDER

            The set of sounds associated with touch-tone dialing, or dual-tone multi-frequency signaling (DTMF), is both simple and ubiquitous.  When a person dials a phone number, the sound associated with it is additively generated by two signals, each chosen from a group of four unique frequencies.  Each combination is unique, allowing the telephone-switching center to determine which number was dialed by interpreting the multi-frequency signal.

            Our project aims to build a working frequency filtering system that functions just as a switching center does: by passing the touch-tone signal through a series of band pass filters, we should be able to determine the exact sequence of numbers and other signals sent over a telephone line (or sounded off locally by the dialing unit) in real time.

* Relevance to Linear Systems HIEU

Our touch-tone recognition project will utilize concepts of linear systems to process touch-tone waveforms, with relevance to communications and signal processing.  A linear system has the important property of superposition—if an input is the weighted sum of several signals, then the output is the weighted sum of the system responses to each of those signals.  Similarly, the touch-tone’s DTMF signals possess the additivity and the scaling properties of linear systems, as their components are summed and scaled together.  The DTMF signal serves as the input to the linear system, and its output is the combination of several band pass filters.

   Our project will involve several linear systems concepts including sampling, frequency response, filtering, approximation, and convolution. Specifically, we will be dividing the time signal into short time segments representing individual key presses. Then, the samples will be filtered to extract and isolate the sinusoidal components. By measuring the size of the output signal from all the bandpass filters, one can determine which two frequency components are present in each time segment, and thus, determine which key is pressed by converting the frequency pairs to their specified key names.

* Software/ hardware requirements ALEXANDER

Hardware Requirements

* + One (1) computer
  + One (1) input device (microphone or audio input jack)

Software Requirements

* + Matlab
  + Audacity or other audio recording suite
* Brief literature survey HIEU

Because DTMF tones are the standard method for telecommunication signaling over analog telephone lines, there is an extensive collection of existing literature and research on the topic. Most of the published and unpublished work in the processing of DTMF signals comes from academic institutions such as Bucknell, the University of Delaware, and Memorial University in Canada.  Some have even assigned a similar project in the classroom as a laboratory assignment. These projects are similar in scope because they aim to filter DTMF signals. However, we plan to implement touch-tone recognition in a more creative, Matlab-intensive way by analyzing DTMF waveforms in real time, and perhaps developing a memory database for other applications. For the implementation in Matlab, there are some m-files on the MathWorks website that claim to decode DTMF waveforms. Learning how to build filters in Matlab will be challenging, so we will look to published source code and tutorials to figure out how to complete our project. The most readily accessible documentation can be found on the internet.  These sources provide important background information to understanding how dual-tone multi-frequency signals are produced and decoded.

Among the most useful sources are the following:

<http://www.dialabc.com/sound/>

[http://www.eg.bucknell.edu/~kozick/elec470/des1/des1.html](http://www.eg.bucknell.edu/%7Ekozick/elec470/des1/des1.html)

[http://www.ece.udel.edu/~barner/courses/eleg212/laboratories/Lab\_04.pdf](http://www.ece.udel.edu/%7Ebarner/courses/eleg212/laboratories/Lab_04.pdf)

<http://www.mathworks.com/matlabcentral/fileexchange/3785>

(d) Applications BRYCE

The biggest and most used application for touch-tone recognition using DTMF is in telephone technology and communication.  Dialing numbers, transferring calls, and answering machines all uses tones to communicate through the system in order to reach a desired event, such as a call or to start recording a message.  The listener can always hear this by the tone that is played when you touch a number or the “beep” just before a message is recorded.  Because of the way that the tones are generated, it makes it very easy to tell the difference between which number was pressed and the tone it produced.

DTMF was a revolutionary switch in telephone communication technology as it allowed for a better system for phone number recognition.  It proved to be much more cost and speed effective, and became available for not only phone companies and operators, but also consumers.  No longer did people have to call long distances through an operator, they could use their own phones and could be sure that the signal would go through.  It sends its analog signal through telephone lines within the voice frequency band but differs frequencies from the existing protocols used by operators so as to avoid any interference.  This technology may seem more widespread application, but for now it has been the dominant system used in telephone technology and has been very successful to this day.

(e) Future improvements NORMAN

       Based on dual tone multiple frequency, we can add some functions which will be used to indicate if a specific sinusoid is present in a DTMF signal segment. Given a dual frequency segment and the impulse responses for a specific low-pass, high-pass, or band-pass filter, it will return a decision indicating if there is a sinusoid wave with frequency equal to the center frequency of the band-pass filter defined by the impulse response, present in a certain range of segment.

Another improvement we could make is to recognize a text string corresponding to the keys represented in the dual tone multiple frequency signal. It will utilize the other provided and written functions.  We could also use touch tone recognition to decode function that would be able to determine which key was pressed based on an input tone.

(f) Feasibility Study ROCKY

Time-line: Divide the project into phases

* 2/14-2/20

-Brainstorm Ideas

* 2/21-2/27

    -Be familiar with the project and research necessary information

* 2/28-3/6

-Start MatLab Coding (DTMF Implementation, Filter Design, etc.)

* 3/7-3/13

-Continue Matlab Coding

* 3/14-3/20

-Spring Break

* 3/21 -3/27

            -Analyze data from the project

* 3/28 - 4/3

-Include improvements to improve the project

* 4/4 - 4/10

-Start the write-up for the project

* 4/11 - 4/17

-Continue write-up for the project and make any necessary changes

* 4/18 - 4/24

-Complete Project (Experiment and write-up)

* 4/25-5/1

-Practice Presentation

    -Final Presentation (in class)

Work Sharing: Present the work distribution like analysis, coding, documentations etc.

* Coding: All members
* Analysis: All members
* Presentation (PowerPoint, Posters, etc): Each member will make a slide for each section that they're responsible for in the write-up.
* Final Report (Each section is assigned arbitrarily and is not set in stone)
  + Cover Sheet: Undecided
  + Index of Sections: Undecided
  + Index of Figures: Undecided
  + Introduction: Rocky
  + Project Description: Alexander
  + Discussion of Main Results: Hieu
  + Applications: Bryce
  + Scope for improvement: Norman
  + Conclusion/Summary: Rocky
  + Details of Contribution of each student:  Each student writes a page of their own contribution
  + Appendix (Matlab codes/simulations): All members

(g) Conclusion

\*\*\*\*Matlabe coding fm Norm \*\*\*\*

clear all; close all; clc

global fs T fr fc

fs=8000;                                      % Sampling Frequency is 8 KHz

T=100e-3;                                                  %Signal Duration

fr=[697 770 852 941];                                     % Row Frequencies

fc=[1209 1336 1477 1633];                              % Column Frequencies

digits\_entry=input('Enter digits to dial: ','s');

l=length(digits\_entry);

dialed\_number=[];

for i=1:l

    d=digits\_entry(i);

    switch d

        case '1'

            r=fr(1);c=fc(1);

        case '2'

            r=fr(1);c=fc(2);

        case '3'

            r=fr(1);c=fc(3);

        case 'A'

            r=fr(1);c=fc(4);

        case '4'

            r=fr(2);c=fc(1);

        case '5'

            r=fr(2);c=fc(2);

        case '6'

            r=fr(2);c=fc(3);

        case 'B'

            r=fr(2);c=fc(4);

        case '7'

            r=fr(3);c=fc(1);

        case '8'

            r=fr(3);c=fc(2);

        case '9'

            r=fr(3);c=fc(3);

        case 'C'

            r=fr(3);c=fc(4);

        case '\*'

            r=fr(4);c=fc(1);

        case '0'

            r=fr(4);c=fc(2);

        case '#'

            r=fr(4);c=fc(3);

        case 'D'

            r=fr(4);c=fc(4);

        otherwise

            r=0;c=0;

    end

    encoded\_digit=dtmf\_encoder(r,c,T);

    dialed\_number=[dialed\_number, encoded\_digit];

end

soundsc(dialed\_number, fs);

wavwrite(dialed\_number,fs,'dialed');

ld=length(dialed\_number);

a=fftshift(fft(dialed\_number,ld));

f=(-ld/2+1:ld/2)/T/l;

plot(f, abs(a));

figure(2)

plot(f, abs(a));

axis([0 2000 0 max(abs(a))\*1.1])

grid

function y=dtmf\_encoder(r,c,T)

global fs

t=linspace(0, T, fs\*T);

y=cos(2\*pi\*r\*t)+cos(2\*pi\*c\*t);