# Stretched Vibrating Circular Membrane - Resonance based Laser Projection

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***Abstract*-** The paper proposes a new method of laser projection where instead of using galvanometers to scan the laser on the screen , the laser is shined upon a controlled vibrating stretched circular membrane. The reflecting laser hits a screen and the desired image is scanned on the screen.

***Index Terms***- Laser projector, Vibrating drum head projector, Circular membrane resonance projector, Resonance Projector.

1. Introduction

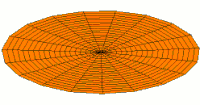
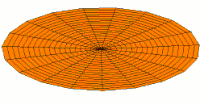
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ormal laser projector systems/scanning systems include two fast moving motors with separate mirrors on them called as galvanometers ,these are oriented perpendicularly in two planes, laser shines on one of the mirror , gets reflected to the next and hits a screen afterwards, by the rotation of the galvanometer precise control of the spot on the screen is achieved, these motors need special closed internal feedbacks for accuracy, are very hard to implement and are very expensive. This paper proposes a system where instead of galvanometers to sweep the screen we are using stretched rubber diaphragm to project images onto a screen, by feeding in a crafted audio stream, we are able to control the patterns at which the membrane oscillates , thus able to scan the laser through specific points on the screen.

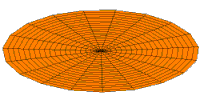
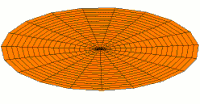
Unlike galvanometers we are not using any closed feedback mechanisms, making it less complex and easy to implement, To implement this paper only a handful of cheap off the shelf - components are required. The size of existing laser projection technologies can be reduced drastically as no motors or heavy actuators are used in the design this fact also yields to the reduced power consumption of the device.

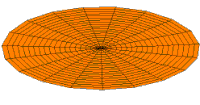
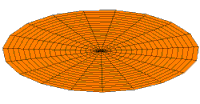
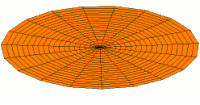
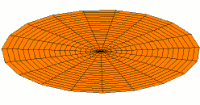
1. literature study and elaboration

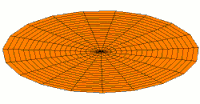
***Circular Membrane*** *-* A stretched circular membrane will vibrate at resonance when the correct frequency is applied, the membrane will move up and down in special pattens according to the mode frequency it is driven at. There are a total of 9 usable mode frequencies for any stretched diaphragm.

[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode01.gif)(1s) {\displaystyle u\_{01}} {\displaystyle \alpha \_{01}=2.40483}[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode02.gif) {\displaystyle u\_{02}} (2s){

\displaystyle \alpha \_{02}=5.52008}

[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode03.gif){\displaystyle u\_{03}}(3s) {\displaystyle \alpha \_{03}=8.65373}[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode11.gif) {\displaystyle u\_{11}}(2p) {\displaystyle \alpha \_{11}=3.83171}

[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode12.gif){\displaystyle u\_{12}}(3p) {\displaystyle \alpha \_{12}=7.01559}[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode13.gif)(4p) {\displaystyle \alpha \_{13}=10.1735}[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode21.gif) (3d) {\displaystyle \alpha \_{21}=5.13562}[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode22.gif)({\displaystyle u\_{22}}4d) {\displaystyle \alpha \_{22}=8.41724}

[](https://en.wikipedia.org/wiki/File:Drum_vibration_mode23.gif)

Mode {\displaystyle u\_{23}} (5d)

Modes of vibrating circular membrane.

All the patterns are periodic, so any linear combinations of these 9 patterns will create yet another periodic pattern, the oscillation of these are directly depended upon the applied frequency.

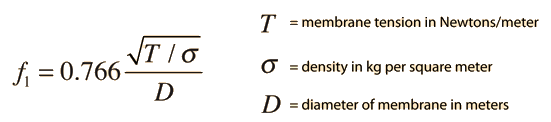
The wave equation describes the displacement of the membrane as a function of its position and time .

For an ordinary circular drumhead the imposed boundary conditions are :

The wave equation is solved through a method of separation of variables and produces the solution:

The index j is needed because the wave is supposed to satisfy the boundary condition of being zero at the radius a. When so that is the radius of the circle, and the boundary condition essentially becomes:

{\displaystyle \alpha \_{23}=11.6198}Only a discrete set of ωj can satisfy the above equation. To determine these allowed frequencies, you can use BesselJZero. The fundamental angular frequency . is determined the characterestics of the medium which is given by:



***Audio and Processing -*** The main function of a sound card is to play audio, usually music, with varying formats (monophonic, stereophonic, various multiple speaker setups) and degrees of control. The source may be a CD or DVD, a file, streamed audio, or any external source connected to a sound card input. A sound card can also be used, in conjunction with software, to generate arbitrary waveforms, acting as an audio-frequency function generator. The main limitation of such generators are the sample rate output , the amplitude output and the bitrate.

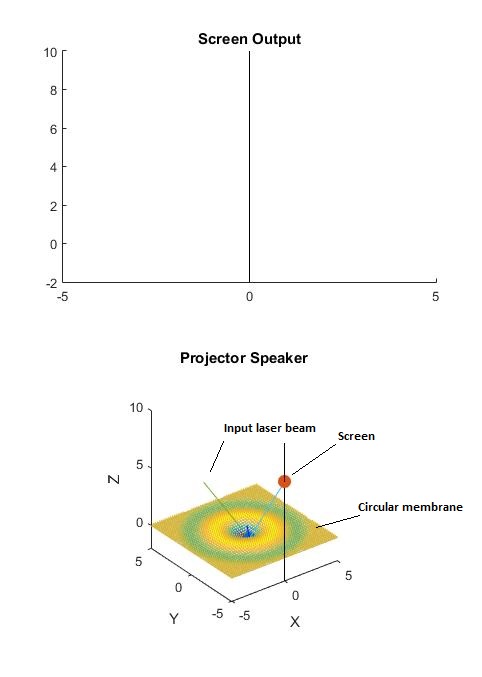
Raw sound is stored as PCM digitally, PCM refers to pulse code modulation where the instantaneous amplitude of a signal is stored relative to time, the resolution of the sample that is collected per sample during recording is called as bitrate, this can be 8 bits per sample, 16b/s,32 b/s, This determines audio clarity while playback. Sample rate refers to the speed at which the bits are sampled out/sampled in , When on recording if more samples are collected per seconds while playing back the original waveform can be reconstructed pretty similarly, thus sample rate determines the fidelity of audio. There are two channels in modern audio devices , the left and right channels are ran by individual DAC’s (Digital to Analog Converter) these can be programmed independently to produce different sounds at the same time. This paper makes use of both channels to implement the device. The main limitation of most DAC’s are their limited amplitude output thus we are using a class AB amplifier to simply amplify the output to drive our load.

***Laser signaling and Hardware -*** Lasers are best driven using current sources than voltage sources due to their thermal runover issues. Thus the paper leverages a voltage controlled constant current source to amplitude modulate the laser source.

***Projection to Screen -*** Most laser printers use line based scanning methods similar to old CRT tubes to display an image to a screen, this method requires the motor to traverse to undesired portions of the screen . The method employes splitting the image into N number of lines , getting luminance value at each pixel and making the laser scan through each individual line and turn on the laser whenever it landed on a pixel that needs to be displayed. Another more modern method employs giving a vector input to the laser projector which inturn scans the laser through only the position where the laser needs to be visible. In this paper we are going for a hybrid approach combining both of these methods , we will be turning on and off the laser whenever required just like conventional laser devices.

1. Research and ELABORATION

The idea of the research revolves around the fact that a vibrating circular membrane when driven with a frequency show certain patterns of oscillations, A mirror is embedded onto the membrane’s centre and when a laser beam is projected targeting the mirror, several consistent repeatable patterns are reflected onto a screen. We are taking advantage of this concept to draw images on to the screen, by controlling the frequency of audio stream that drives the circular membrane.



Here a line was drawn using the mode 3s, The screen was the plane , And the source laser beam was from

targeting .

## A. Combining the modes

The vibrating circular membrane is able produce an angular movement in all direction, 9 modes were at our diposal apart from these 9 patterns ,if we need new patterns we can simply combine the driving frequencies of the modes together and drive the membrame.

was added in to factor the amount of a mode added into the mix thus:

By taking the combinations of these 9 modes we were able to generate:

patterns

All these pattens were of constant amplitude mode ,

ie:

The patterns where able to sweep through most of the points on the screen, thus it as evident for sweeping through a particular point on the screen, the right mode and the right coefficients were required at a particular point in time.

It was found that the fundamental angular frequency .for a stretched latex sheet (balloon rubber) over a diameter of 5cm was around the range of 60 - 90 Hz ,regardless of the strength being it tightened at.

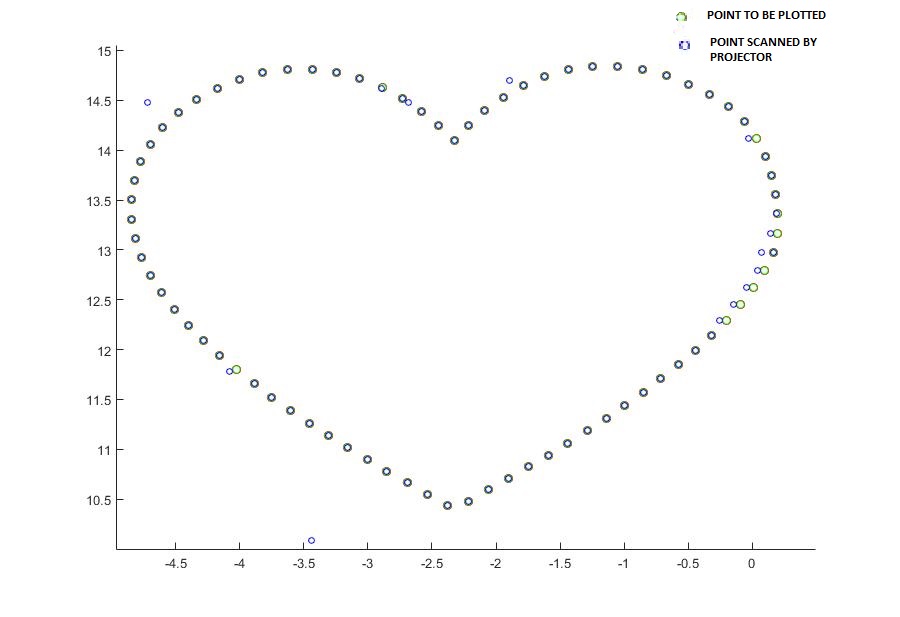
## B. Use of Simulation software

Simulation was done on Matlab, a mesh grid was created at XY plane and was ran through the mesh grid to produce the corresponding displacements. Then a ray was projected targeting origin , the intersection was calculated and reflection matrix was applied at the intersection point to find the reflecting beam, which was used to calculate the intersection point on the ,lets call this the projection function.

This simulation was made such that it required time and the nine coefficients as parameters to produce a point on the screen showing where the reflected point was at, now we have reduced our parameter domain as ten variables. Now all is set we simply have to find the nine coefficients and the time at which the laser will pass through the points.

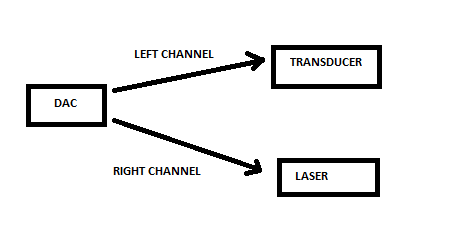
To find the input parameters ,we take the list of points that we want to be displayed on the screen, then we simply run it through an algorithm that takes each point to be displayed and finds the variables such that the coordinate from projection function is the least distant to the point to be displayed, this is done for all points to be displayed. Thus we get a matrix of 9 coefficient and the time that the scan will occur , for every point to be displayed on the screen.

Then we interpolate these coefficients to produce continuous line. We turn on the laser only when we hit the time mark found out by the 10th time variable, Thus we are able to display any variable on screen.



Here shown a demo of scan created by the projector, the input was a heart shaped figure.

1. Hardware Implementation



We are generating to different two different waves as output. The first wave output goes to the transducer that drives the stretched circular membrane, This output is made from the 9 modes which have corresponding frequencies multiplied through their respective coefficients we figured out earlier and added together. This is generated out through the left channel of the audio device.

The 10th parameter time, is used to generate when to turn on and off the laser , whenever the time mark hits for the corresponding coefficient array we turn on the laser displaying the point intended.

1. GET PEER REVIEWED

***Pending***

1. IMPROVEMENT AS PER REVIEWER COMMENTS

*The current approach is a time consuming approach the example HEART figure took 21 hours to find the coefficients ,better algorithms needs to be developed.*

**Pending**

1. CONCLUSION

The paper can be built easily, thus reducing the cost of laser projectors , reducing its size and making it easily portable. Further optimizations to find the coefficients are required.

Acknowledgment

**Pending**

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