ÇUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES

MSc THESIS

Mohid KHAN

AN AUTOMATED COMPUTERIZED SYSTEM FOR SOIL TEXTURE ANALYSIS BY USING LASER AND LDR SENSORS

DEPARTMENT OF COMPUTER ENGINEERING

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We certify that the thesis titled above was reviewed and approved for the award of degree of the Master of Science by the board of jury on / /2017

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Assoc. Prof. Dr. Umut ORHAN	Assoc. Prof. Dr. Zekeriya TÜFEKÇİ	Asst. Prof. Dr. Alper Kamil DEMİR
SUPERVISOR	MEMBER	MEMBER

This MSc Thesis is written at the Department of Institute of Natural and Applied Sciences of Çukurova University.
Registration Number:

Prof. Dr. Mustafa GÖK
Director
Institute of Natural and Applied Sciences

ABSTRACT

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AN AUTOMATED COMPUTERIZED SYSTEM FOR SOIL TEXTURE ANALYSIS BY USING LASER AND LDR SENSORS

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: Assoc. Prof. Dr. Zekeriya TÜFEKÇİ
: Asst. Prof. Dr. Alper Kamil DEMİR

The aim of this thesis to develop a rapid and simple automated computerized system to analyze the percentage of soil particle Which could be used as a tool for evaluating soil quality for better agriculture research. To obtain the soil result we are using Arduino microcontroller device, LDR sensors, Red Laser lights, traditional hydrometer, electronics equipment, intelligent optimization technique and MATLAB software,. We developed an system for determining the particle percentages of sand and silt values on a digital interface without the use of conventional method.

Soil texture, the overall textural defined by relative proportions of sand, silt, and clay in soil. We take the limited amount of soil put into the hydrometer than we put water and mixed it well to differentiate the soil particle. When the soil particles move in the water with different speed due to their density differences. We start out setup and received the signal from sensors and transmit to computer screen. The biggest particle among the others in terms of volume in soil is mainly known as sand and silt. To take the measurement of sand and silt in soil we used Arduino device and other instruments. We made this experiment for almost one and half hour. Between the experiment time's sensor detect the soil particle and give you data in the numeric form on your system screen. After collecting all the data through these process, we used intelligent optimization technique in MATLAB environment to compute soil particle which give the best result.

In this thesis, the experimental results showed that, determination of proportion of sand and silt in a soil data using on computer aided estimation can be useful for agriculture research.

Key Words: Soil analysis, Arduino, Intelligent optimization technique, Linear regression, ANN Computer aided estimation.

ÖZ

YÜKSEK LİSANS TEZİ

TOPRAK BÜNYESI ANALİZİ IÇIN LAZER VE LDR SENSÖRLERLE BİLGİSAYARLI OTOMATİK BİR SİSTEM

Mohid KHAN

ÇUKUROVA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ
BİLGİSAYAR MÜHENDİSLİĞİ ANABİLİM DALI

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Jüri : Doç. Dr. Umut ORHAN
: Doç. Dr. Zekeriya TÜFEKÇİ
: Yrd. Doç. Dr. Alper Kamil DEMİR

Bu tezin amacı, toprak oranını analiz ederek tarımsal araştırmaların daha iyi yapılabilmesi için toprak kalitesini değerlendirmek amacıyla kullanılabilen, hızlı ve basit çalışan bilgisayarlı bir sistem geliştirmektir. Sonuçları elde etmek için Arduino mikrobilgisayar, LDR sensörler, kırmızı nokta lazer ışıkları, bazı elektronik parçalar, MATLAB yazılımı ve akıllı optimizasyon teknikleriyle beraber sinyal işleme metodları kullanılmıştır. Geleneksel metodlar kullanılmadan, dijital bir arayüz ile kum ve silt değerlerini belirlemede kullanılan bir sistem geliştirilmiştir.

Toprak tekstürü kum silt ve kil minerallerinin birbirlerine oransal olarak karışımlarıyla belirlenmektedir. Parçacık ayrımını yapabilmek için belirli miktarda toprak örneği hidrometre kabına su ile birlikte konularak karıştırma işlemi yapılır. Parçacıklar yapısal farklılıklarından dolayı su içerisinde farklı hızlarla çökelmeye başlarlar. Oluşan yoğunluk farkı kullanılarak sensörlerden gelen veriler toplanır. Toprak tekstüründe en iri tane kum iken daha sonra silt ve en küçük parçacık olarak da kil gelmektedir. Kum ve silt tayinini belirlemek için bilgisayara bağlı bir Arduino cihazı kullanılmıştır. Tüm deneyler yaklaşık olarak 90 dakika sürmüştür. Deneyler süresince sensörlerden gelen veriler numerik olarak bilgisayarda kaydedilmiştir. Toplanan bu veriler MATLAB ortamında akıllı optimizasyon teknikleriyle işlenerek çıkan sonuçlar irdelenmiştir.

Çalışmadaki deneyler sonunda, toprak içerisindeki kum oranının tayini için bu şekilde tasarlanacak olan bir sistemin kullanışlı olabileceği görülmüştür.

Anahtar Kelimeler: Toprak analizi,MATLAB yazılımı ve akıllı optimizasyon teknikler, ypay sinir ağları, Bilgisayar destekli tahminleme, Linear regression.

EXTENDED ABSTRACT

Soil is one of the world's most important natural resources like air and water. It is the basis of plants for our food, forest, and wild flowers etc. Because it lies beneath our feet and is often hidden by building and roads we may not often think about how much it affects our lives and how much we depend on it. Most of our food depend on soil – it is where we find the plants and many of the animals which make up our food, it is home for billion organisms. Soil also give support for many of our building and structure. Thereby ensuring that there will be a basis requirement for life. Without soil, the world's population neither would nor could survive.

For effective use of soil its need to be determined because of its mixture of different particles. There are two properties for the classification of soil such as texture and structure. By texture, its determine the size and type of particles that make up the soil (together with the organic but typically stating to the inorganic material). Soil texture is well-defined by relative quantity of sand, silt, and clay. These three are the main particle of the soil. Silt and Sand deliver and manage the airflow of the soil and clay particle to absorb water and other substance into other structure also provide nutrition to plants roots. All particles have different size. The size of sand particle can be simply seen due to its maximum percentage in the soil.

The conventionally used many methods for determining soil texture. Including the hand texture method, separation by sieving, separation by sedimentation but two methods are considered as standard. Pipette method and hydrometer method. These methods determine the percentage of sand, silt, and clay. These methods are simple and low implementation cost. It gives us a rough opinion whether the soil has more sand, silt or clay. The precision is not so sharp. Both have the major drawback as spending a lot of time.

Nowadays, Computer technology is used regularly in many scientific fields to develop the systems and better design. Automatic calculation by such system can be used better prediction and estimation instead of our traditional methods. It is also important for soil science to observe and measure the soil particle during soil textural analyze. Many of other technology methods being used on a determination of soil texture like image processing algorithm, blurry measurement devices, laser beams, like many other studies but none of these technologies got success for better result and portable design.

The objective of this study is to develop a rapid and simple automated computerized method to analyze the percentage of soil particle. Which could be employed as a tool for initial soil-quality assessment for agriculture. We used Arduino microcontroller device, LDR (light dependent resistor) sensor, hydrometer and laser lights, electrical equipment, Intelligent prediction techniques and computer software. With the help of these technologies, our system provides the series of data using light measuring sensor on an embedded microprocessor. After collecting all the data, we make the prediction through intelligent prediction techniques to get the better result. This work assures that there is a possibility to make such a device for soil texture analysis for the better result with less time.

In this study we proposed a system on computer aided estimation for determination of soil particle analysis using Arduino device, traditional hydrometer technique, LDR Sensors, Red Laser light, and some electronic instruments like wires, resistor and breadboard connected with computer environment. Second step to make a connection these hardware with computer using C++ programing language at Arduino platform to make a connection with computer system. This setup can be used as a tool for detecting the signal through moving soil particles in the water and then converting the signal into numerical form provide many rows data of each sensor. With all this data we used one simple and one best classification estimation method in MATLAB environment to provide better result. To make use of data efficiently, we made analysis using several features to extract the best feature from the time series before putting them to intelligent algorithms. we choose two classification method to predict the best result. first one Linear regression technique and second Multilayer Perceptron Artificial Neural Network in MATLAB environment.

We have made 12 experiments with 6 different soil samples. The soil sample is received from Cukurova University, Department of Geology. which include various amount of sand, silt, and clay. The percentage of each particle is also provided by the department. The idea was to use this same sample in this research to make comparison between lab analysis result and our result of soil particles.

MATLAB environment is used for computer aided estimation experiment. To using our experimental data, we change data format into a (.mat) file format. Applying this data.mat file some important feature can be extracted from the sensors signals and it can be used as estimation result. Sedimentation is tendency for particle in the solution of soil-water to remove suspends solid from water. Particles settle down by the time which increase magnitude of light. The measurement of the upper LDR sensors produce high acceleration than the lower LDR sensors. Because the sand is considered the heaviest particle in soil texture. It is settle down in the beaker faster in comparison to (silt and clay). Due to the fast settlement of the sand particle makes thick layer at bottom of the beaker. while designing the device it was necessary to concentrate on where to fixed LDR sensor at the beaker because heavy particle settle down very fast which takes bottom space. So, we have fixed the lowest sensor position a little higher from the bottom of the beaker. As we are using LDR sensors with Red led laser in our experiment we fixed RED led laser light in front of each sensor at the beaker. Using all these instrument in the experiment each signal start to collect the signal. The Arduino device helps to collect the sensors signal and transmit into the computer screen. We modified the collected data to use in MATLAB environment.

We made several experiments using collected data with different feature such as (Standard deviation, Entropy Zscore, Min-max scaling, Variance, Mean, Maximum and Minimum) to extract the best feature to use in prediction technique in matlab.

First, we made analysis with linear regression for sand and silt particle and check the result according to previous research we received quite better low rate of mean square error and the best sensor combination in our studies. With the same soil sample data, we made analysis with MLP ANN to check the result we received far better result from previous research and linear regression as well. We can produce best result with ANN as compare to the linear regression. Another benefit is applying hidden layers with neuron provide you the high success and decrease the error rate.

The equipment we used to make this analysis possible its traditional hydrometer, Arduino microcontroller device, Reg laser light, LDR Sensor to detect the particle which is easy to find equipment and used conveniently to estimate the sand and silt particle percentage analysis. The second main role in the research is programing codes at MATLAB environment using some technique extracted the feature from unconstructed data produced the stable result for soil analysis. The idea is to make this hardware and software combination in future with furthermore research a portable and mobile measurement device can be made for the use of soil particle analysis at any convenient place.

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LIST OF SYMBOLS AND ABBREVIATONS

: Sample Array of Time-Domain Data

: Time Steps

: Array of Frequency Domain Data

: Index of Frequency Spectral Lines

: Size of Data Array

: Pattern Vector

: n^{th} Dimension of a Vector

: Standard Deviation

: Mean

: Total Pixel Amount of an Image

Y : Criterion Variable

: Function

: Predicted Coefficient

: Input Value

: Sum of Least Squares

: Estimation Error

: Output Value

: Net Input

: Weight

: Input Value to a Neuron

: Euler Number

: Error Of Estimation

: Desired Output

: Obtained Output

: Total Error of System

: Learning Rate

	: Change Amount in Weight
	: New Value of Weight
	: Old Value of Weight
$\mu(x)$	: Membership Degree
	: Membership Function of Set A
	: Center of Mass
	: General Output of Neural System
sec	: Second
Π	: Multiplication of Weight and Input
	: Firing Strength
ESD	: Equivalent Sphere Diameter
LDR	: Light Dependent Resistor
LED	: Light Emitting Diode
ANN	: Artificial Neural Network
ANFIS	: Adaptive Neuro Fuzzy Inference System
MSE	: Mean Squared Error

1. INTRODUCTION

Soil is one of the world's most important natural resources like air and water. It is the basis of plants for our food, forest, and wild flowers etc. Because it lies beneath our feet and is often hidden by building and roads we may not often think about how much it affects our lives and how much we depend on it. Most of our food depend on soil – it is where we find the plants and many of the animals which make up our food, it is home for billion organisms. Soil also give support for many of our building and structure. Thereby ensuring that there will be a basis requirement for life. Without soil, the world's population neither would nor could survive.

The characteristics and make-up of the soil play a significant role in the behavior soils and what they are utilized for. The most significant property of soil is texture and structure which formed from hard rock or sediments. The hard rock starts to crumble due to weather condition by which rocks are broken down into the form of soil. There are kinds of weathering condition, for example physical, chemical and biological. In the physical weathering like freezing, melting, wet and dry such kind of process on rocks and other sediments breakdown into various form. Chemical weathering is the decomposition of rocks due to heat and cold condition which is also the reason of fraction and biological weathering is the effect of the living organism on the rags of rock. It effects on plant roots and soil organism. Breathing of carbon dioxide by plant roots make the formation of carbonic acid which chemically attacks rocks and sediments and breaks into soil. These weathering processes have helped to break down the rocks and minerals into the form of soil.

Soil is the mixture of different component it would be wrong to understand of soil is just a collection of mineral particles. Most soil contains four basic particles: air, water, dead organic material, and different kind of living organism. **(Figure 0.1).** The average soil approximately contains 25% air, 25% water, 45%

mineral particles and 5% of organic matter. Organic matter can be separated into roots, humus, organism.

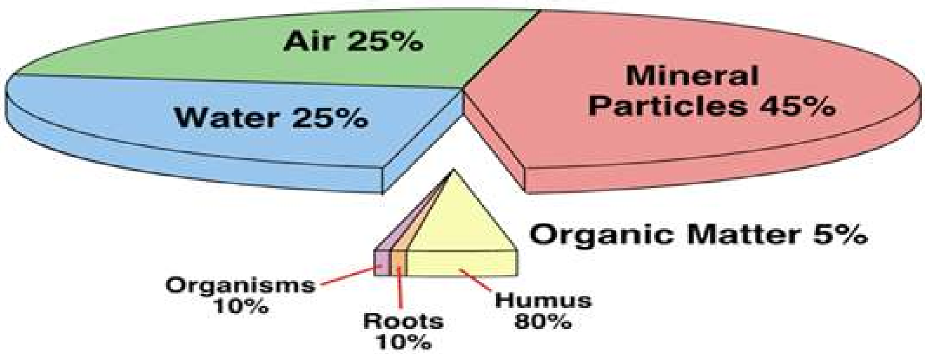

Figure 1.1. The values given above it's just for average soil

Soil profiles in the **(figure1.2)**, have an order of horizontal layers. Generally, five layers' present in a characteristic soil: **O, A, B, C**, and **R** horizons. The **O horizon** is the upper layer of most soil. It is poised mostly of plant debris at several levels of decomposition and humus. **A horizon** is the surface layer, a mixture of mineral soil with the most organic material. **B horizon** also known as subsoil. It contains clay and mineral particle (such as iron, aluminum oxide, and calcium carbonate). This layer collect all the minerals from the A horizon. **C horizon** is a mixture of broken-down bedrock, which feeds upper layers after further weathering and collection of organic matter. The final layer of soil profile is **R horizon** which consists unweathered bedrock. It is the nature and presence of the profile which helps to how soil is classified.

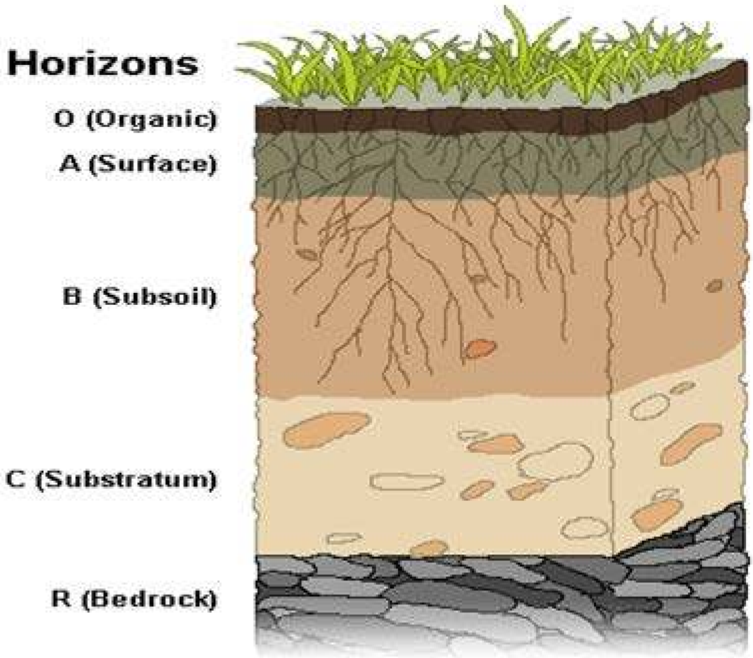

Figure 1.2**.** Different layers found is soil profile.

For effective use of soil its need to be determined because of its mixture of different particles. There are two properties for the classification of soil such as texture and structure. By texture, its determine the size and type of particles that make up the soil (together with the organic but typically stating to the inorganic material). Soil texture is well-defined by relative quantity of sand, silt, and clay. These three are the main particle of the soil. Silt and Sand deliver and manage the airflow of the soil and clay particle to absorb water and other substance into other structure also provide nutrition to plants roots. All particles have different size. The size of sand particle can be simply seen due to its maximum percentage in the soil. but silt and clay are very small particle despite their small size, have a very large surface area comparatively to their size that can’t be seen by the open eye. The size ranges for the soil particle describe below in mm unit.

Table 1.1. The particle size ranges of sand, silt and clay in soil.

Types of Mineral Particle	**Size Range**
Sand	2.0 – 0.06 milimeters
Silt	0.06 – 0.002 milimeters
Clay	less than 0.002 millimeters

The conventionally used many methods for determining soil texture. Including the hand texture method, separation by sieving, separation by sedimentation but two methods are considered as standard. Pipette method and hydrometer method. These methods determine the percentage of sand, silt, and clay. These methods are simple and low implementation cost. It gives us a rough opinion whether the soil has more sand, silt or clay. The precision is not so sharp. Both have the major drawback as spending a lot of time.

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2. SOIL TEXTURE ANALYSIS

The following topics cover about soil particle, particle-size-distributions (PSDs), relative amount, typically by volume of particle, and interaction reasons between the particle and the measurement of these materials are being used. Most importantly its measures the dimensions of particle sizes of soil are discussed in detail. So far around 400 methods for determining texture classes of soil particle have been proposed (Barth and Sun, 1985). Among them, the hydrometer, pipette, sedimentation and sieving are chosen as commonly used method for calculating and estimating the particle. The starting of the classification of the particle size distribution are based on Attenberg's (1916) which comes from Ritter von Rittinger's studies on sieves and aperture tool and oden' (1915) research about application of stoke's law in the fiels of soil science. The "mechanical analysis" of the soil is standardized as combinational usage of sieving and pipette method by the Society of Soil Science (ISSS) in 1928. The particle which is passed through 2 mm circle shaped apertures are measurable.

The grain size distribution method for classification of soil particles from the mixture of a smaller particle is one of the basic and most accurate method. it's used for soil classification and provides a better estimation of other soil engineering properties. In practice, the GSD of the full-size spectrum of soil grans is determined by integrating data obtained from two different tests, mechanical sieving for the rough grain soil fraction and hydrometer tests for the fine fraction. (Ghalib and Hryciw, 1999). Because of differences in results many comparatively studies of grain size methods have been developed over recent decades. These new methods like, (electro resistance particle counting, time of transition, laser diffraction (LD), optical determination of the particle size distribution (PSD) using image analysis) (Goossens, 2008). It's good to covering of wide range of grain sizes, and research regularly analyzing on small particles.

Over recent decades, most soil researchers have been concerned about the quantity of different particle in soil and given the name of each particles. Like if the soil has sand particle more than others they put the name of this sample is “sandy soil”, if it has silt then it will be silt soil. All these mix particles have different name their quantity which makes soil texture. To describe in better way **(Figure 2.1)** visually demonstrate the texture triangle diagram of soil structure.

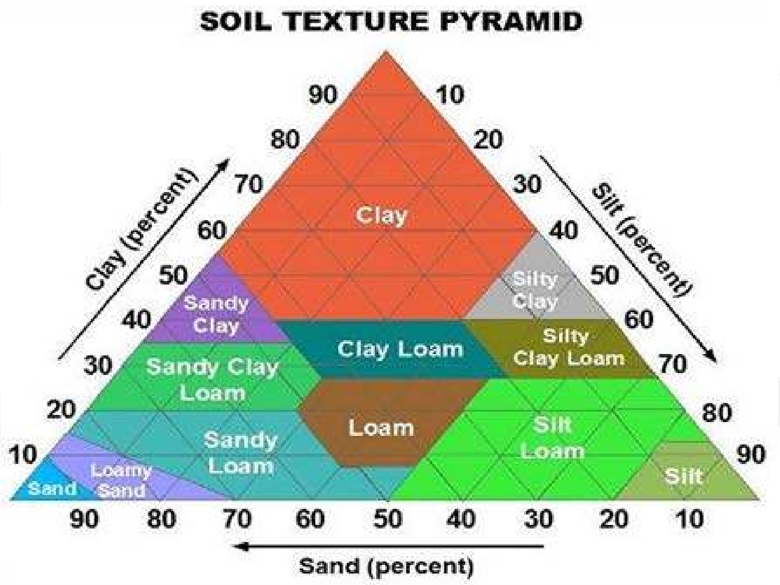


Figure 2.1. Soil Texture Triangle (USDA Classification), using the percentage of sand, silt, and clay.

Soil texture and textural class can be determined by no of ways. If you know the percentage of your soil particle, then you can define its textural class using textural triangle. Above is a figure of soil texture triangle (**Fig 0.1)** its shows that each side of triangle be consistent with a percentage of a soil particle like sand, silt, and clay. It is totally consisting twelve classes of soil texture. Also inside the triangle are a sequence of the grid lines to help one determine the textural class from the percent of soil particle. These methods conventionally used for correctness for analyzing the soil which are extremely subjective. As the all studies says particle are not in the equal form of perfectly sphere-shaped also there is not a common way how to measure these particles and how to get correct accurate rate. Along with that, sensitivity is express how much we succeed by the accurateness so it has become a more thinkable subject. and the calculation of sensitivity is more related about in which condition will be highly suitable for this kind of experiment. Various of studies specify that the soil sample used in experiment has to be suitable for sampling and has to contain mixture of different particle to be measured. The sample should be like which can produce sufficient data to categorized as repeatedly. And it should be also appropriate for other tests. According to research with 10kg mass of soil which has sufficient dominant material very suitable to do more than twenty-five thousand experiments.

The classification of the soil particle is mainly based on the size and the shape. Because it can be representing as a single parameter, all the particle is being expressed in terms of spherical volume according to their size. The study indicates the particles on their spherical situation but in addition to their requirement for experience and hard work, high fluctuation rate of the traditional methods make it tougher and complex to analyze the soil. because to this reason, there are several studies have been done with using technology support on soil analysis. (Grout et. al., 1998; Ringrose-Voase and Bullock, 1984; Tyler and Whearcraft,1992). However, conventional tools for particle size analysis can be expensive and time-consuming. So, it is required to develop a rapid and simple method for soil-quality valuation. It has been seen that with new method using simple sensors and other tools can produce realistic data. Using these new techniques under the several methods below using standardized traditional methods and recent technological developments togethers these methods can be provided an better and reliable estimate of soil texture, which will be very useful in soil quality assessment.

The following method are considered for determine particle size of soil.

- Direct Measurement (ruler, microscope, etc.)
- Sieving
- Sedimentation

  - Pipette Methods
  - Density Methods

- Centrifuge Methods
- Electrical Methods
- Optical Methods

2.1. Direct Measurement

Although the soil scientists are mainly focus on the small particles which passing through a 2mm size of holes' sieve, many soil classification process is characterized according to the quantity of particles by measuring the biggest particles (ASTM,1998d). The particles are considered according to their size between 10cm and 1mm as big particles. because large particle can be sized by sieving method. there are also few practical methods is used like direct measurement which helped to measure the particle by simple tools like ruler, glass, weight scale instead of using any advance method. (Coroni and Maraga, 1983) applied a measurable caliper joined to a punch-lane and succeeded to send the outcomes to the computer properly. (Hodgson, 1997) explained a method which measure the size of the particles larger than the sieving holes using plastic balls. (Laxton, 1980) used some calculation for big-rock particles gathered from a rock quarry via photographic method. (Shiozawa and Campbell, 1991) using a geometric particle diameter and standard deviation proposed that soil texture is one of best method for prediction sand, silt, and clay percentages. (Buchter; HInz; Flühle, 1994) Particle size analysis of soils carrying thick segments need enough quantity of soil material. Which is necessary to find differences between bigger particle and thin soil layers. (Nadeau, 1985) this study proposed a method for thinnest particle to determine by electron diffraction (ED). Then microscopy methods are composed in Allen et. al. (1996)'s work. Even though microscopy is used measured the smallest particles between 1mm to 20µm. it can easily perceive smallest particle under electron microscopy. Electron microscopy techniques details are available in (Tovey and Smart, 1982)'s work. Further standards about the basic detail of microscopy method are also published (AFNOR, 1990; BSI, 1993).

The benefit of microscopy is that it allows fully consideration to see the particles size and shape. Microscopy requires sharp consideration for measuring the different particles to provide statistically result also takes long time and effort. (Griffiths, 1967). Although preparing this process to dissolve the organic materials it caused time a lot. later measuring particles by the microscope when the particles are not in the equal form that is another problem which required too much consideration and effort. But particles with the size of 5µm or below the 5µm can be measured easily by this technique because the size measured with dissimilar particle are readable easily. (Nadeau et, al., 1984). It doesn't matter how much sample you have taken from the soil. It will also present the whole material due to vertical dimension increase of particles in relation to measure in the horizontal plane, because of this reason it increases the error (Allen et. al., 1996). Two section through the particle showing in the blow **Figure 2.2.**

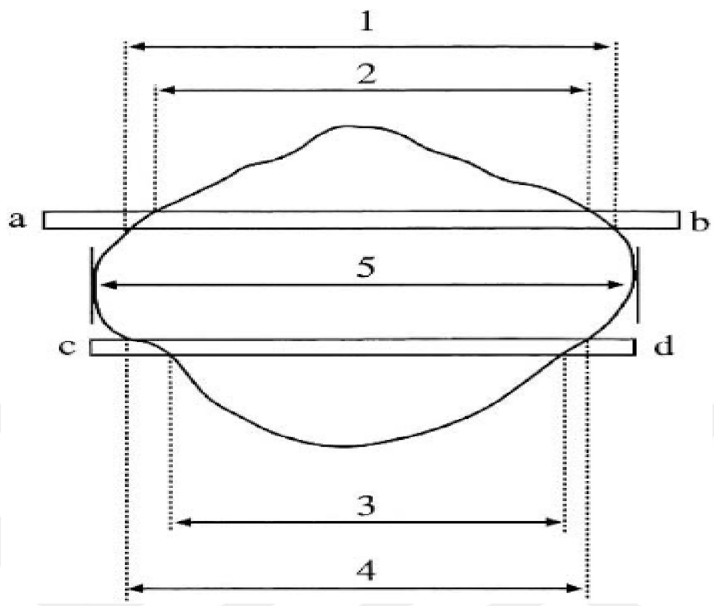


Figure 2.2. Side view of two sections, a-b and c-d from a particle showing the measurement difference depending on the dimensions.

With non-circular, broad, or angular particle, “size” can be measure probably correctly in geometric form when it is in resting position on the bottom of surface **(Figure 2.2).** there particle is very small, but dimension measure is big in relevance to vertical dimension, the error is less. When vertical dimension rises in relevance to dimensions in horizontal plane, the error will be much high (Allen et. al., 1996). Because of this reason, it shows that the particle size under 0.6μm cannot be readable easily by microscopy and result cannot be trustworthy (BSI, 1993).

2.1. Sieving

This method is commonly used since old time for determining the texture of soil by examining the particles found in sample. A soil sieve takes it out the different particles by their relative size. The properties of the sieve having square and circle shape depending on the apertures size between 125mm and 5μm for separating the particles form soil. Circle shaped aperture sieve measure the particle depend on one size, and range. The square shape aperture sieve measures the size in two ways. First one is depending on the range between two parallel facing of the particle and second one is diagonal range between the particle. Sieving can be accomplished using by wet process (washing type) or dry process (AFNOR, 1982). The particle size whose range is under 2mm can be separate by square shape aperture sieve, and the size under 37µm separate by electronically shaped sieve (ISO, 1998). It is made by metallic plate according to required size of aperture. By the shaking of sieve particle passing by a sieve depend on the character of particle. (e.g., particle size and sieve opening shape effect probability of passage) (Gee and Bauder, 1986). If the sieving experiment done by proper way it is still provide a better result not reliable. But for the particle size under 30µm, it will not be most effective tools to get reliable result. Mostly error happens in sieving method due to shaking process. Overfilling the sieve by the sample and broken aperture is extra instance of the error (Metz, 1985; Head, 1992). In the maintainability process of sieve washing and caring are tough process and takes enough time.

2.2. Sedimentation

Sedimentation is the process of determining physical properties of soil texture by their settling rates in a liquid solution using a hydrometer. Texture are characterized by specified class range: sand size from 2000 -50µm; silt size from 50 – 2.0µm and clay < 2.0µm. settling rates of prime particles are built on a principle of sedimentation as define by Stokes'Law and measured using a hydrometer. The soil sample can be taken from a section are air-dried and sieved. The add this material into liquid solution, cover and place on reciprocate flat shaker for sixteen hours and during this process sinking particles settling down into the bottom of the jar. Research stat that the maximum concentration of the solution cannot increase %1 in terms of capacity or %2.5 in terms of mass. This thing can be control by diluting the liquid mixture, but mass value will also be decrease which effect on result and error rate will be high. To get proper result it is necessary to maintain the balance between both arguments. The mixture of the liquid must contain almost 9.5 pH hexamer phosphate alkaline and it probably different from other liquid (Klute, 1986). Some soil having volcanic ashes, acid liquid is used in place of alkaline medium (Maeda et. al., 1977).

Different from the technique, it is considered that each particle in a liquid act in an order by Stokes'Law. Stokes'Law describe that settling down prime particle in a sequence if equivalent sphere diameter (ESD) is used (Whalley and Mullins, 1992). (Allen et. al., 1996) displayed that stokesian behavior is acceptable for 61µm spherical shaped particles. The more process of this method detail is mention below.

1. Tiny and straight shape particles settle as zigzagged form it makes the particle slower to reach until bottom part than it got readable position.
2. The particle size 1µm ESD or below this is still unreadable due to Gravitational sedimentation.
3. Electrical interface with dilute electrolytes and soil section doesn't effect on the particles value' so it can be neglect.

These all process and method are based on Stokes'law, in further study is stated that some more method like pipette, density, centrifuge method is very common method to be used. Further details are mention below.

2.2.1. Pipette Method

This is a procedure of sedimentation research in this particle size is measured by the frequency at which particle sink in a solution. Take a sample of soil put it into the jar and add water and mix it well to make a solution of this sample and wait for few moments. After that from the top of 10 cm of the suspension take the solution of sample and put it into another jar and remain it same until it become dry. This method also known as macro pipette method, process of this experiment need to repeat few times then the value of settled particle can be measured and a calculation can be made based on their differences. The pipette method is considered as a most preferable method after the sieving method for particle below 63µm (ISO, 1998; U.K. BSI, 1998; Germany DIN, 1983: France AFNOR, 1983c). It is also chosen by U.S. Soil. Conservation service (USDA, 1996) and Agriculture Canada (Carter, 1993).

Gee and Bauder (1986) is used the simple pipette method in their work. (Coventry and Fett, 1979) is also stated important features about his work which is used in each phase of the experiment process. (Smith, 2001) is his work he introduced a programmable device which mix the soil particles easily and reduce the time consumption. By the help of pipette method with proper process of the experiment it provides you quality result (Gee and Bauder, 1986). But below 2µm ESD particles, this method may get some difficulties. (Burt et. al., 1993) introduces with a new method known as micropipette in comparison to macro pipette method which is discussed above, and represent the relative result in his work.

2.2.2. Density Method

Density, depending on the proper way of any kind of mass M and volume V, it is explaining the correct ratio of M to V under definite condition. Soil is typical multiple porous system which in its general form. The soil particles are smaller dense when they are extremely pored or carry enough organic material. Adversely soil is holding iron (hematite, ferrihydrite etc.), manganese (pyrolusite, birnessite etc.) or titanimum (Ilmenite, titanomagnetite, etc.) all this material having different densities because of this it helps to have an idea about the materials from the above definition the stokes diameter after mixture and calculating from the specified depth or the ready solutions intermittently. To define about dry soil density there is well known method that is bouyoucos-hydrometer method. in this process, firstly dried soil is sieved from 2mm sieve then take 50 grams of soil sample and take care about if the clay ratio is too high or it is sandy then 100 grams will be sufficient. Then take this sample and put it into the 500ml jar and add 200-300ml fresh water also H_2O_2 is added to spread the sticky particle of organic material. After mixed it well all things together. Then put this into a 1130ml size of bouyoucos hydrometer. Approximately 40 second later the values can be read from the hydrometer which provides the clay and silt ration in soil. Without mixing the sample keep it remain in the same position around 2hrs until the particle settle down at bottom of hydrometer then the percentage of sand particle in soil can be taken. It gives you approximate idea of soil particles sand, silt, and clay. After subtracting the percentage of silt and clay particles sand amount in soil can be measured. Standardization and further information about this process is available in the standards (ISO, 1977; ISO, 1998).

Density method is being used commonly but it has some drawback as well. Head (1992) is explained about some issues of using hydrometer. While taking the value of the particle percentage through hydrometer mistake can be done by misreading the value from the hydrometer scale. This misunderstanding problem can happen specially when the organic material will be in the solution. Even with the correct oxidation method, bubbles come on the surface which cause error. It can be stop through including a few drops of octan-2-ol. Entan-1-ol (amyl alcohol) or pentan-2-ol (izoamyl alcohol) to holdup. Then adding another thing into the prepared solution which makes solution more complex due to its chemical reaction. Soil holding dissolvable salt which change the reliability of the method because it effects on density of particle. To get reliable result there must be s material having different density which can used easily with solution. In one research done by (Gee and Bauder, 1986) stated that 40 grams of soil with 1 liter water produce a better result. It also mentioned that it doesn’t whether soil contains much silt or clay it would be work with all the particles. Allen et. al. (1996) explained that the big particle of material provided the two-different density at the same time which cause error. Sur and Kukal (1992) presented some method about make fast hydrometer process. Stabinger et. al., (1967) used first time an ultrasonic method for suspension density. He discussed about by the help automaton process like signal process can be used to detect particle. In his works, he made an experiment at soil research laboratory, an important contingency found between the suspension density and particle quantity below 2μm ESD which comes from the pipette method (Smith, 2001).

2.2.3. Centrifuge Method

Centrifuge is further development process of sedimentation. Here they have used spinning tubes or cups and joined them with a high rotation speed engine. The idea is used for reading the soil particle value which is less than 1μm. Tanner and Jackson (1947) explained in his work about relevance between the sedimentation of particles and centrifuge time. the research mainly concentration about recognize the particle under 0.2μm ESD (fine clay) and this work acknowledged by Avery and Bascomb (1982) and USDA (1996).

There is other centrifuge, circular sedimentation is known as disk centrifuge. They used in their work empty and orbital spinning tubes. This tube has thicker around a few cm as compare to previous one and the radius is also high about 20cm. There is another machine known as long-arm centrifuge, in this inside area of surface is higher and the sedimentation direction of the particles are equivalent.

The disk centrifuge method start the process with pipette sample and homogenous-start method, the sedimentation of the particles having different size with the help techniques which is mention above it can reduce the density of the sample particle and can be measured easily. the liquidation and sedimentation of the particles should be in spherical speed and the solution outcome must be checked to measure the size and difference of the particle. The exact measurement of the outcomes is quite complex but method come from the stokes' diameter as 1: √2 (Allen et. al., 1996). No of studies explained that it is the very reliable result which will be more suitable to fir the data into a mean or standard deviation curve. The mathematical research about this process are available in Syarovsky and Syarovska (1975)'s work.

One more centrifuge technique is known as x-ray and photosedimentational is used for observing the radiation transmission by these techniques due to changes happens regularly in the suspension. X-ray researchers and centrifuges are shared the similar ideologies as the usual gravitational x-ray sedimentation.

Photosedimentational centrifuge with visible radiation is a commonly used technique for particle size determination. With the help of light which is helpful to detect big particles using in this method provide a better response as compare to x-ray technique because of shaking clay particles are visible for x-ray. The clay particle below 2µm carry fragment which are smaller and bigger as compare to visible light spectrum, because of dispersion of light it causes the size difference to get the measurement of the particle must be adjusted for photosedimentation data. Related detail about this process are available at (Whalley et. al., 1993)'s research.

In homogeneous method, it divided the research into three following range from 20mm to 0.1µm, 0.1µm to 2µm and 1 µm to 10µm to make more operative simultaneously (Whalley et. al., 1993). As it's a mixture of all small and big particle, in this process smaller particle dispersed more light than bigger. The size of the smallest particle in solution will be high. $10gdm^{-3}$ is appropriate for particle range between 20mm to 0.1µm although $0.3gdm^{-3}$ d very appropriate for particle range between 1µm to 10µm.

In line-start centrifuge method, the particle of soil swiftly-flow on the bottom of rotating solution, during the particle settling process it can be measure from start point to bottom point. The outcomes form this procedure characterized the particle difference range by mass.

For standardization process of the light dispersiveness affect to the data which are getting through the test needs must attention and much more process therefore it can be considered as a drawback for the photosedimentational centrifuge.

2.3. Electrical Method

Electrical method is also known as electrical sensing zone method. it about on Coulter principle (Merkus, 2009). Coulter principle introduces a method for counting and measuring the size of particle using effective resistance of an electrolyte solution. This method was mainly established to characterize the particle according to volume speedily by determining the changes in electrical conductance solution passed through a small aperture. Coulter principle is used in different sector for example: drugs pigments, fillers, toners, foods, abrasive, explosives, clay minerals construction material, coating materials, filter material, and so many kinds of research have been conducted with this principle. The size of particles between 0.2µm to 1600 µm in diameter can continuously measure using the latest multisizer 4e method. using this electrical property with soil particle analysis. When electric field is applied in the container in which particle are dissolved. The effective resistance between the electrodes is create the sensing zone then it can be measurable by passing them through the aperture. The result can be useful for describe about the size and more accurate value of the particles.

2.4. Optical Methods

Several researched has been done in the electronic method to determine the soil particle analysis but digital image processing with computer application have been chosen as one of the best among others as compare to previous studies. The process of this technique it divided into two parts. The first one contains deterministic technique it is used for edge detection or gray scale thresholding for "particle" division and "particle" pixel measurement. These techniques have effectively resolved not only the particle size but also the size distribution (Shin and Hryciw, 2004).

Recent progress in digital field along with the possibility of effective digital image processing application has introducing the means for the new technique of a suitable alternative process for soil particle analysis based on image processing (Hryciw and Raschke 1996; Raschke and Hryciw, 1997). In soil analysis, the image processing technique is also used for particle color recognizing and edge detection (Czachor and Lipiec, 2004). In another paper, they have explained about that it is suitable for root analysis for plants (Kimura et. al., 1999), organic material determination (Chen et. al., 2000), dissolvable material research (Forrer et. al., 2002) and the reaction of water and soil (Persson, 2005b). Ghalib and Hryciw (1999) used a special morphological segmentation method to divide contacting soil particles. This technique was based on "watershed analysis" explained by (Beucher and Lantuejoul, 1979). This paper explained that soil particle does not need to separate for image processing to analyze particle determination. To determine the soil texture by image processing is totally depend on the image quality. The process starts by concentrating of exaggeration appropriate for capturing the smallest necessary features which provide the composite image representing in a view of all area of example. Zhang et. al., (2012) concentrate on actual parameters in image processing and scheme is provide better result for the soil characterization particle analysis.

The image processing is considered more suitable and accurate method which provides best result for particle size analysis. Overall the image texture analysis techniques offer several improvements over existing method, but the result of success is highly depending on the quality of the image which can be taken by high resolution pixels' camera machine and special camera lenses. The cost of all this equipment are considerably expensive. This is may be one of the reason that image procession in not commonly using for experiments. Some drawback come from the complicated calculation which cause the result.

3. SIGNAL PROCESSING

Signal processing is one of the most powerful technology. We all now deals with signals and images (carrying a big amount of data). Anything which has information is a signal. By the processing of signal, it enclosed with basic theory, application, algorithms and implementation of processing or transferring detail contained from individual physical quantity which is considered as signal. It uses mathematical and special techniques to present the signal, which was very helpful to get information for processing the system some example is: communication, medical imaging, radar, sonar, sound. Thus, we get no of signal from these sources and several ways to transfer this information from one destination to another. The signal is handled by mechanical system, which produce the enough outcome using the differences on the signals. Because signal processing operation involved various functionality. Signal processing can be implemented into two main different ways.

1. Analog signals
2. Digital signals

Analog signals are a continuous wave designate by sine wave in signal strength (amplitude) or frequency (time). This wave is represented like higher and lower points in the graph to measure amplitude value of the wave. There are so many examples available to collect real life data to explain about analog signals. For example, the sound from human voice is analog signal when we talk on the phone the sound goes into a microphone which transfer our voice in the form of radio waves. This wave known as analog signal when we joined this with digital signals, it starts transferring data with the phone line. All kind of analog signals are frequent-time signals. Frequent-time signals ae explained in each point of a definite time interval. To convert signal into digital form through computers for evaluation.

There are two processes is to digitalize the analog signal first one in known as **discretization**. It is the process of transferring the signals value convert into a discrete form and represent information as data. Let's assume you have regular time analog signal which is regular with time and amplitude. When you transfer it. we received discrete values each Ts seconds. Now you have discrete signal in time all of this can take to regular values in amplitude. This is generally denoted to as discrete signal (discrete in time but regular in amplitude). And the second process that is necessary in digital process is **quantization**. Firs process is sample and divide large data values into countable smaller set. For example: assigning the value between range like 0 – 30 as "low", 30 – 60 as "fair", and 60 – 100 as "good". The signal which having range between 0 -100 is a procedure of quantization and it decreases the signal amplitude. The set of input value may be too large or may possibly having continuously values. It may be uncountable therefor there is three more class for uncountable values. Rounding and truncation are also another classes which is mostly used for quantization.

Digital signals belong to an electrical signal which is constructed into a pattern of bits. A digital signal has discrete value at each sampling point. The assumption of the signal is calculated by how many value can be measured by the time. Below in some graph shows about analog and digital sign with respective order.

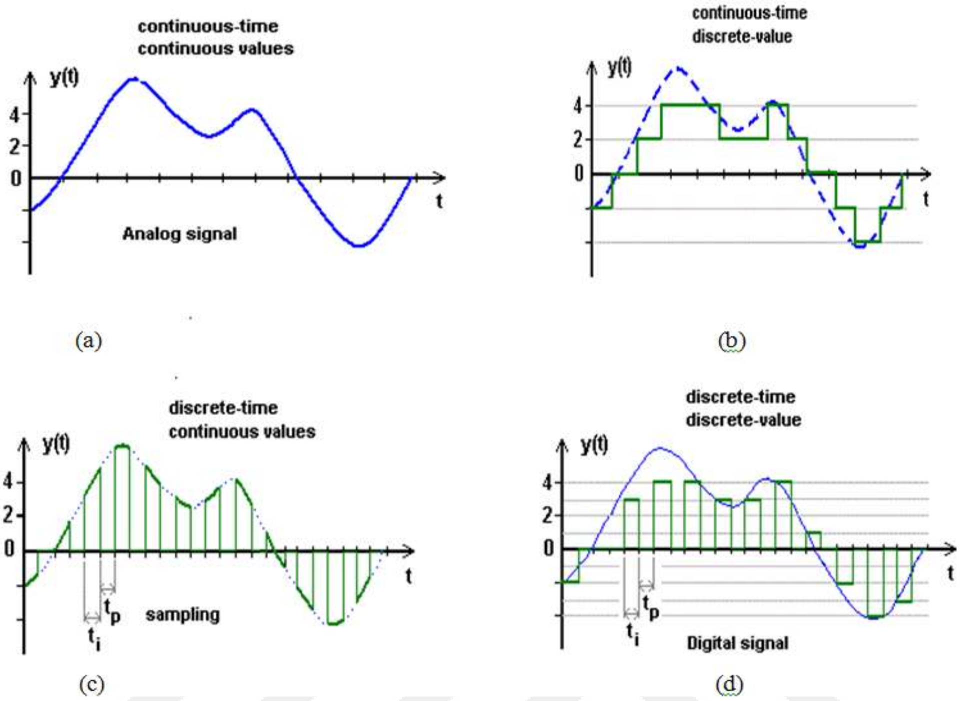


Figure 3.1. (a) continuous-time and continuous-value, (b) continuous-time and discrete -value, (c) discrete -time and continuous-values, (d) discrete-time and discrete-value.

Figure 3.1. The difference between **analog** and **digital** is like the difference between continuous-time and discrete-time. Continuous values are explained at each point on its axis while discrete values need only important points to be examined.

3.1. Digital Signal Processing

A digital signal is must for computer processing. it can only understand binary digit (0s and 1s). signal having information in the form of analog signal which must be transformed into digital form to understand through computer system. **Digital signal processing** is the procedure of applying some tricky mathematics operation and quantization digital signal. This method is commonly used in the field of data compression (Nelson and Gilly, 1996), amplification of the audio in sound system, improving of self-learning robots (Mondada et.al., 2009) transmission of large data (Sun et. at., 2005) tele communication, fingerprint identification, face recognition, etc. The application of digital signal processing allows for many benefit over analog processing in many areas.

- High interference immunity.
- It is easy to store data.
- It can be modified easily with just a little bit code and flexible processing.
- it has various transmission options.
- It is more suitable because it can be evaluated efficiently by the computers and electronic machine.

Analog signal is strongly acceptable for interference: for example, error is caused even a small error can be disturbed the signals. When the signal disturbance ratio is higher than the normal signal ratio then digital transmitted information will be disturbed. There are several methods exist to reduce the noise from disturbed signal. The most convenient method which takes the dominant frequency and stop the weak one. To applying this method first signal needs to change into the frequency domain. Discrete Fourier method is considered as most suitable for this work. It can be represented ad mathematical form as:

of the signal which is transmitted into occurrence domain, that can be detected loose and supreme occurrence. An instance of the power spectrum is given below.

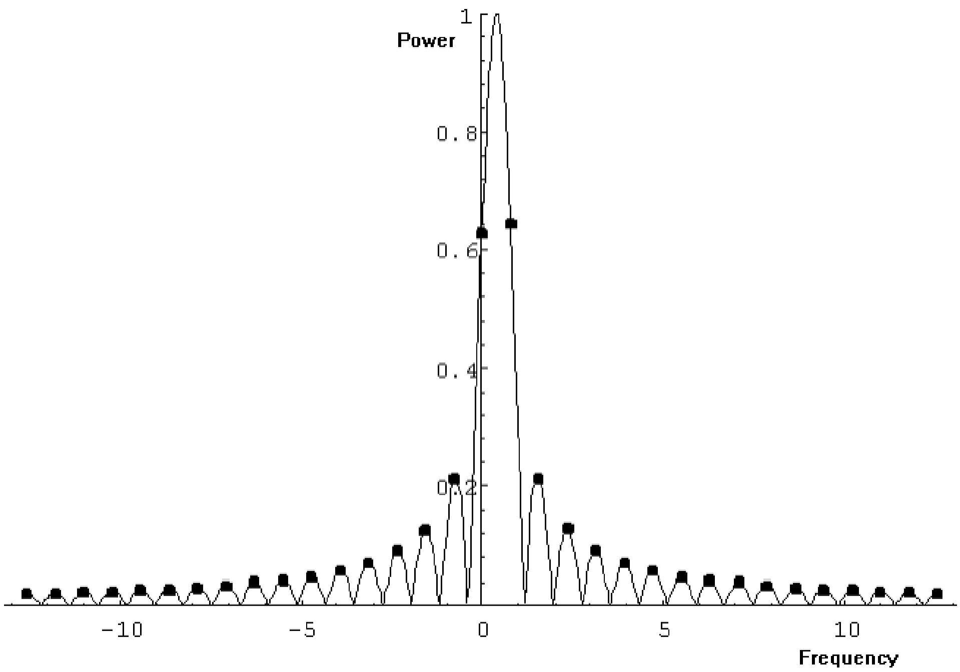


Figure 3.2. Graph image of a power spectrum.

In example above representing that the supreme occurrence are denser around [-5 5]. There is possibility to clean the signal by a channel filter for the signals if the supreme occurrence of the signal is detected. Second thing is if there is a chance to lose important information or some useable noise which known as (50Hz power grid frequency) in this case it can be stop filtering if there is requirement. But in some areas if there is no requirement of accurate measurement like our work, then disturbance data doesn't effect much on useable information. Working with noise reduction in condition like this is meaningless. Instead of collecting the accurate information from the normal signal which will be more sensible.

3.2. Feature Extraction

You don’t have to be fully concentrating while signal processing is being done to get collect features of signal. Feature detection is play the big role in this field. There are several very good reasons for prominence of features detection in signal processing. Feature detection are used commonly for mathematical analysis of problems and numerical analysis of data. This technique offers a best illustrative information into some numerical feature instead of the using fully information. It is reducing the noise and other pointless feature from complex or disturbed data and represent the required information. In some example, it is representing a simple sinus function with some statistical feature (mean, maximum, minimum, standard deviation, entropy, zscore, variance min-max scaling etc.) will be enough. this technique also used in some more important areas like sound file the peak feature can be useful as well as important color feature in an image file. Which can be useful in medical research filed to detect some points to categorizing the disease.

The feature of colleting the important data from raw information has increases process with current developments. It is quite clear feature detection is highly considered very useable feature in all others works as well. It is included also in modelling phase (Wark et. al., 1998). In one research, it is used in pre-processing phase (Indahl and Tormod, 1998). Pre-processing phase is depended on kind of methods some general process in mentioning below.

Let’s suppose we have an

Non-linear expansions: Decreasing the dimension to avoid the unrequired information can be useful most of the times, but in few cases, we may have to enlarge the information to higher dimension as well. If the information is not sufficient and unfruitful for the problem then it is required (David, 1982).

Feature Discretization: Some procedures are not much suitable on regular data. In this kind of conditions, the regular data should be changed into a finite set of discrete features by using discretization. This procedure not only makes the system appropriate but also make simpler the understandable relation between the points (Liu and Motoda, 1998).

Preprocessing is very necessary and critical task step in data research area, natural language processing, statistics, machine learning. Data preprocessing used for extracting important and non-important information from unconstructed data. Information extraction importantly a matter of deciding which data should be retrieved to satisfy user's need for information and which information not to lose when this process applied. In feature selection must be carefully decided whether which information is necessary or not.

3.3. Feature Selection

Feature selection methods help you to make a correct predictive model. They help you by choosing features that will provide option to select for good or more better accuracy. It can be used to recognize and removed not useful, irrelevant and redundant attribute from information that do not contribute to the accuracy of a predictive model. It has so many advantages which is mention below.

- Less attributes are advantageous because it decreases the complexity of a model and make simple model to understand.
- Make better the prediction performance of the predictors, providing fast and more cost-effective predictors.

- A good understanding of the underlying methods that generated the information.
- Providing better space to save the information by speeding the algorithm up with data reduction.
- Reduce the required source and make better time preprocessing step for the next data collection step.

The performance can be measured by mentioning the above features to predict method as inputs. But evaluate the prediction success is not simple with limited number of training set. There are two methods to deal with this process is known as “in-sample” and out-of-sample”. In In-sample method used for all the training sets by predicting method. then the prediction success is calculated by using a statistical method. in out-of-sample method, it also knows as “machine learning”, it is separated into two division like training set and test set. The generalization is commonly used method of machine learning is also knowing as cross-validation. Further illustration about cross-validation is explained in coming chapter.

4. COMPUTER AIDED ESTIMATION

An exciting development in computer-based automated estimation is emerging. Within the estimating classification methods, some software method is standard-based, and some are engineering based in computer technology. The estimation program can automatically recognize the part feature develop a suggested result for the part. Computer estimating technology is using regularly in many scientific fields. Several researches have been done for estimation process in the specific areas like electronics, robotics, machine learning, chemical industry, medical science, economy, etc. with the help of computer estimated method almost every area is having desirable and correct result by taking benefit of power of estimating in high speed. Ellis (2002) provided a method, system, and computer program device for cost estimation involving to utility usage utility billing. (Carbone et, al., 1992) proposed a research on electronic images of accidents vehicles imported to a computer by using a color using digitizer for insurance company to estimate accident cost of repairs. (Wakelam et, al., 2005) introduced with a computer-implemented automated building design and modeling and construction project cost estimating and scheduling method. (Frisch et, al., 1996) described a computer-aided prediction system of bone age by the help of Greulich-Pyle and Tanner-Whitehouse methods. In 1991, Ford motor company had started deployment of Computer-aided parts estimating system to produce, analyze, and price automotive parts for production plans (Cunningham, 1993).

(Saeidi et, al., 2005) this research about knitted fabric defect-detection encountering defect and evaluate of the performance by the help of computer vision-aided fabric inspection method on s spherical knitting machine. This study also explained same evaluation off-line process by the help of discrete Fourier transform and the wavelet and Gabor transforms. (Xu et, al., 2006) computer-aided classification detection procedure used to detect interstitial lung diseases based on multidetector row CT by the help of lung image data sets. (Kyprianou, 1980) this research reported a system for classifying shapes is identifying and extracting shape characteristics by modifying the current systems and discussed its application on machine tools like metal shaping for manufacturing and metal cutting by numerically-controlled machine tools. (Turgut et. al., 2014) describing about nutrition evaluation with the use of image processing in so many areas like agriculture field, bacterial safety, food quality, size and form of meat, vegetables and bakery stuffs.

In above research, various method has been used for classification and estimation. In our research, we concentrated on a method which can provide a continuous valued outcome and estimation can be made easily to get result. In our research, the experiments we did it consist of famous and effective estimating method such as linear regression, multilayer and artificial neural network.

4.1. Linear Regression

Linear regression analysis is most basic type of regression analysis and commonly used for statistical technique to define the relationship between variable and observed the data. The whole idea of regression is to predict the value of variable from the score on a second variable. There is two kind of variables value one is dependent which is called ad single variable regression and another one independent variable multi variable regression. To put a linear model to examine the data. It should be checked that whether there is connection between the variables of interest or not. It is not obligatory indicate that one variable cause the another one (for example, maximum SAT result do not cause highest college grades). But there is important relation between the two variables. Finding the connection between variable and observed the data can be examined with linear regression analysis. For example:

- An actor might want to relate the weights of person to their heights using a linear regression model.

- In schools, they may like to check success rate between absence rate of the students.
- In climatology, relation between the pressure and the temperature,
- In agriculture, relation between the food requirement according to increasing animal counting can be found using regression analysis.

Regression models are important due to its modelling type between the variables. That is categorized into linear and nonlinear regression to define its complex relation. Linear regression simpler and accurate to understand it can produce curved lines nonlinear in not familiar with curved lines. It easy to use and easy to explain. Generally, if you don't get a better fit by linear regression then you need to try by nonlinear regression.

A scatterplot is very common method to determine the strength between multiple variable. It can be categorized as independent variables on x axis plane and dependent variable y axis plane. Which is indicate the position of the complex of predicted data for multiple variables. The value to be predicted is called as criterion variable (that is also present as Y) and the value used for prediction is defined as predicted variable. Multiple linear regression is to be used several independent variable equation and simple linear regression to be used for single independent variable equation. In simple regression, the Y prediction points it is represent on linear line which depend on X. A X variable has a regression on variable Y on **(Figure4.1)** below.

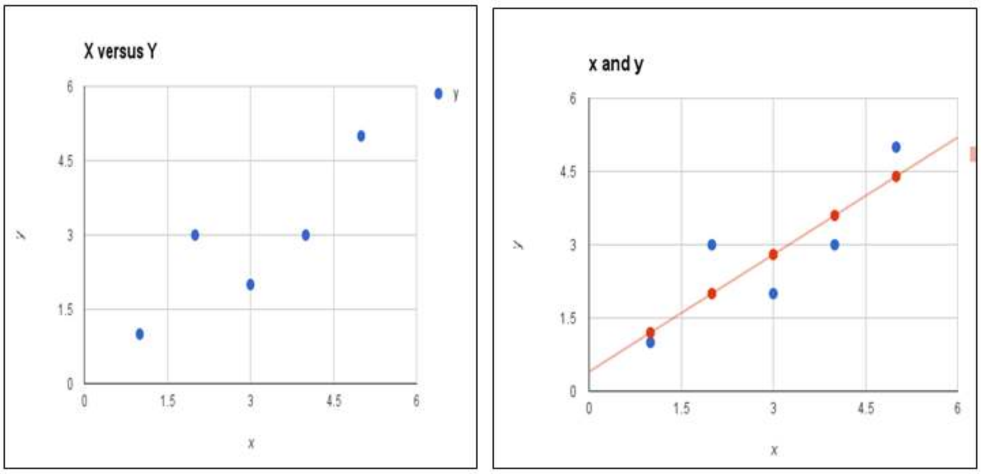


Figure 4.1. Plot of simple linear regression.

In Figure 4.1. we can see the connection between X and Y axes it is representing the linear regression. In right side image, line is drawn diagonally from the down side of plot to top right to showing the relation between the data. It is a better indication that using linear regression with equation values taken from the regression plot. With simple linear regression, we put our data as follows.

$$y = B_0 + B_1 * x \tag{4.1}$$

in this equation, there is Y which is the output of the value which we want to evaluate. X represent as input variables and B0 +B1 are the predictor we need to examine.

B0 is indicate the intercept because the point measure where it intercepts with y axis. It is known as bias in machine learning. It joined to balance all examined which we make. B1 is known as the slope as it shows the slope of the line or how x interprets into a y value until we put our bias. This method is known as simple linear regression because it has only one input value (x). if there would be more input then it would be multiple regression.

Linear least square regression is used for checking the approximate errors and modeling the method. this is most commonly used method for "regression", linear regression or least square to define the data on plot. It has major underlying role in other modeling method as well. Applying directly with the suitable data it might be used to fit the data with several forms.

$$f(x;\vec{\beta}) = \beta_0 + \beta_1 x + \beta_{11} x^2 \tag{4.2}$$

In which every explaining value in the function is multiplied by an unidentified limit. There is highly one at a time with no consistent explanation value because all different form is joined to provide last function variable. In statistics form if one single function which meet with this condition will be known as "Linear regression".

The drawback of linear least square have limited in the shape which linear model can be might be an overlong range. There is chance little extra error and sensitivity to less accessible. Our concentration in solve this fractional difference explanation issue from some of square method find out the point where slope start with zero (Fox, 2008). With this relating issue, there is another equation as follows:

$$\frac{\partial s}{\partial \beta j} = 2\sum_i rj \frac{\partial ri}{\partial \beta j} = 0, \quad j = 1,\ldots.,m \tag{4.3}$$

In this equation, if it erased then β will be single, and there is an equation which consist this information.

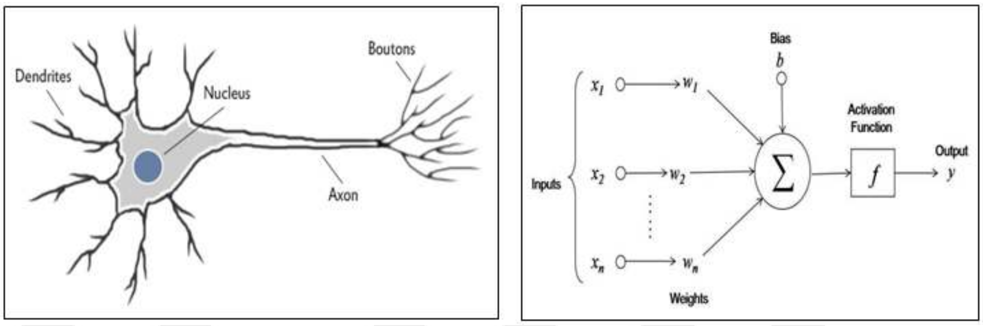
$$\hat{\beta} = (X^T X)^{-1} X^T \mathrm{y} \tag{4.4}$$

Finally, while the method using this equation which is made by β values, prediction can be evaluated depending its x input. Prediction success is generally measure by using the mean of square changes between original outcome and the estimated result that is also named mean square error.

4.2. Multi-layer Perceptron's Artificial Neural Network

Neural network more accurately Artificial neural networks are broadly similar methods with multiple numbers of interrelated simple procedure. This technique deals with new and unidentified condition and tackle them very reasonably alike learning mechanism of human mind. There is method to learn and replicating human mind. It is designed by taking help from the human mind into the account. As you can see it is very similar from electrical communication of the neuron between layers in the mind. this idea is taken and feedforward of human mind on to the computer that can be discover new technologies (Hill et. al., 1994).

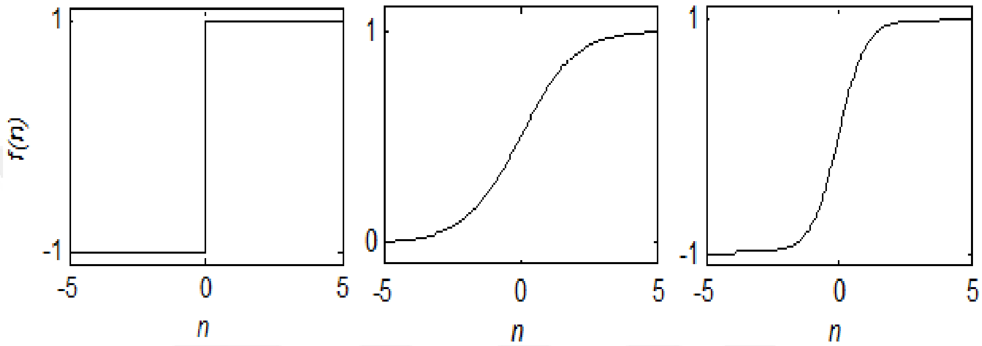
ANN's are commonly used in various condition as prediction, classification, simplification, association, etc. ANN's is easily learn and understand through the collecting samples and save it into the network. It can learn and manage his moves by their own. As we know it's totally depend of our feature it works according to the instruction not human behavior. After completing all instruction there might be a chance to get unexpected error or improper information while applying this for practical. It may keep continue the program with few defected neurons. This is always accepting to use for solving the issues which it is receiving from composite multiple-dimensional data or due to some mathematical technique. Apart from its benefit, it has some negative points as well. As it is complex version of computer science, mathematics, and another complex science. It is dependent on these technology, does not have any particular way to find the best network structure and regularly need to change it into numerical data since it would not work with external instruction (Tu, 1996). Let's look of an image of artificial neuron and a biological brain design as follows:



(a) (b)

Figure 4.2. (a) Design of biological brain neuron (in the left (b) Example of artificial neuron (in the right).

Our brains are the best example of this extremely interconnected network of neuron to processing the information and design the world where we live in. In above image, biological neuron example is showing all the brain neuron appearances which is very imitative in the artificial neuron. Artificial neurons also interconnected with the artificial neural network as similar biological neurons. It receives electrical signal, going through the neuron network and transfer into another neuron similar like the biological brain neural system. Incoming information from the any source is shows from the outside of the world or different neurons. In some cases, before it transfers into the next core weight of incoming information shows how the or function can be handled. The quantity of function measures the total effort by modulating the recovered data which is being processed earlier. It is not significant rule which aggregate system to be used and would be better to find by try and defect. The various type of activation function is being used like addition, multiply, maximum, minimum, accumulative addition and majority. Starting function is give you output according to the total incoming data. Outcomes shows the detail of starting function. During selecting activation functions process in all cases non-linear activate function are choose. Mostly use activation function are: linear, threshold, step, sigmoid, sinus, tangent activation functions. From all of them three have been selected for common used which is (step, sigmoid and hyperbolic tangent) are showing as follows.



(a) (b) (c)

Figure 4.3. Activation functions: (a) step, (b) sigmoid, (c) hyperbolic tangent

In the (**Figure 0.1**.) showing x axis it has limit until infinite and put it into the plot as [0 1] or [-1 1] interlude through the activation functions. In my studies, I am concentrating to explain a simple model to explain about artificial neural network (ANN). The architecture of the ANNs consists of many layers of neuron which has input, output and various hidden layers that is represent in the **(figure 4.4)** below.

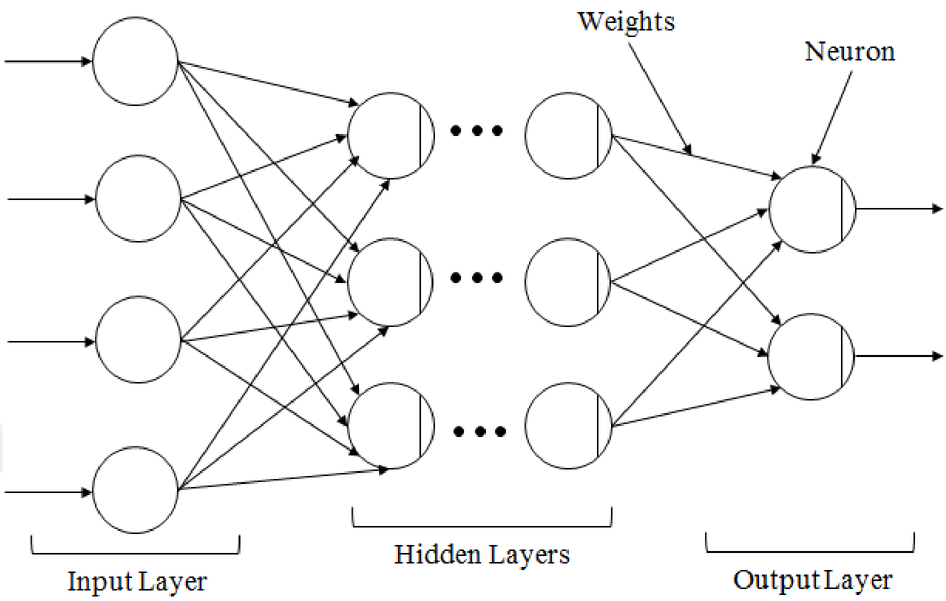


Figure 4.4. The ANN architecture multi-layer neural network.

As this Figure 4.4. is representing the process of the system how the information is flowing in one direction from input to output. Any information which comes to system to get an output need to be processed through this system. Which helps to make the decision according to the situation. First if we get any action value from the any outer source it goes to our system as an input layers. Then it divided into subsequent layers to transmitted the information. Neuron in the same layer does not have any connection between hidden layers. Neuron connection can be describing as according to its quantity by the help of various of matrices which should be equal to number of hidden layer. Maximum quantity of hidden layers and neuron are more considerable for better outputs. when you deal with complex system it requires several decision-making calculation and time which count as drawback. By processing the information which is coming from the hidden layers then it transfers to the output layer which is responsible for producing the system final output.

In the ANNs process of input output are considered network of many cycle because of that network finding the correct combination of input and output. The ANNs have the two kind of characteristics one is feed-forward and back propagation network which are arranged in layers. Feed-forward networks to removing nonlinear connection from the input data by the help of non-parametric statistical model (Rumelhart et al, 1986). This network is famous for its simple and hierarchical structure and accurate result. It's the regular process Every single layer connects themselves with other or step by step. System works when you input some action at the input layer it goes to hidden and from hidden to output layer.

However, the automatic efforts are necessary for handling the complex learning problem. The back-propagation are considered for minimizing the error function in weight space using some better algorithm. When it reduces the error, it is considered as solution of learning issue. We need to concentrate on regularity and differentiability of error process. These processes are very similar as like human brain does to finalized any decision. Firstly, we use activation process on getting information from the outer source. If it has multiple activities, the weight of neuron is modified then it provides you accurate result. When we get desired output by ANNs in contradiction of complicated action. Which shows it accuracy for learning the function. Our information goes through in different validation like training and testing. In some cases, it is necessary to ignore error. To make sure about this issue in collected data some method has been used for ignoring the error. This process has done by the help of cross-validation technique.

Supposed the network above in **figure 4.4** take the single layer of hidden and output neuron. When you get input value from the outer source it goes through the network if it has more W weights ratio which need to be adjust so that difference between expected output and needed output will be reduced. We needed a mathematical operation that decrease the error. In this formula, we add the all getting weight values from the neuron process as follow:

$$net = w_1 i_1 + w_2 i_2 + ... + w_n i_n \tag{4.5}$$

In the process of reducing error with the help of activation process we received the output of the neuron from the calculated value. if we use sigmoid function in the activation function, the neuron output will be represent using such equation.

$$y = \frac{1}{1 + e^{-net}} \tag{4.6}$$

Here e represent as Euler number. To calculate the total error from neural network process following formula can be used.

$$err_j = d_j - y_j \tag{4.7}$$

This equation is used to differentiate the result between expected result and obtaining result. Here err shows the result, d belong to expected result and y is obtaining result. Mathematical programing in the system is belong for minimization of the such equation.

$$E = \frac{1}{2} \sum_j err_j^2 \tag{4.8}$$

To adjust the weights such that E should be minimized. Back propagation is such a decent algorithm which is very helpful for minimization. In the process of minimizing total weights need to be calculated. To check what effect is changing the weight we use the partial differentiation and the chain formula as follows:

$$\Delta w_{ij} = -\eta \frac{\partial E}{\partial w_{ij}} = -\eta \left[\frac{\partial E}{\partial y_j}\right]\left[\frac{\partial y_j}{\partial net_i}\right]\left[\frac{\partial net_i}{\partial w_{ij}}\right] \tag{4.9}$$

Here η is representing as learning rate. To check the calculated result differences the following formula considered.

$$w_{ij}^{new} = w_{ij}^{old} + \Delta w_{ij} \tag{4.10}$$

Increase the weights process in the system the expected result can be taken or an ending principle which is named as "epoch" is reached. These algorithm above is used with aim reduce the minimizing error.

5. AN AUTOMATED SYSTEM FOR SOIL PARTICLE

Computer technology is used regularly in many scientific fields. It is also important for soil science to observe and measure the soil particle during soil textural test. With the help of automated method, we can get best result and reduce time efficiency and in soil analysis. The determination of soil texture especially with a computerized infrastructure to allow a system concentrated on portable design. Which could be used as a tool for evaluating soil quality for better agriculture research.

Previously some research has been made at Cukurova University Computer Engineering department by (Gök and Orhan, 2015). In this study, they have proposed a computerized method which is about Computer Aided Determination of Proportion of sand in soil. They have made a few experiments in their research which provide you specific result there was a requirement to make a system such as useful. It is required more suitable design with low error rate and low time efficiency. Another research made by (Kilinç and Orhan, 2016) in this study, the intention was to get closet result for soil particles analysis by using various mathematical methods and intelligent machine techniques they also proposed an algorithm in MATLAB environment which is used for transferring your numeric values into the useable form which shows the Graph of the produces MSE values by all sensor combinations in each signal segment for different durations. Although designing a system with such low error rate required much more suitable setup and need more experimentation data from different types of soil to make a perfect analysis to provide a portable system which can be used in regular soil particles analysis.

So, in this study first we updated some hardware instrument which was required to make our device to get more suitable result we designed a simple computerized setup using Arduino device, Hydrometer, LDR Sensors, Red Laser light, and some electronic instruments like wires, resistor and breadboard connected with computer environment. Second step to make a connection these hardware with computer using C++ programing language at Arduino platform to make a connection with computer system. (**Fig 5.2** Experimental Setup Image is below) This setup can be used as a tool for detecting the signal through moving soil particles in the water and then converting the signal into numerical form provide many rows data of each sensor. With all this data we used some prediction technique in MATLAB environment to provide perfect result. To make use of data efficiently, we made a analysis using several features to extract the best feature from the time series before we feed them to intelligent algorithms. we choose two classification method to predict the best result. first one Linear regression technique and second Multilayer Perceptron Artificial Neural Network in MATLAB environment. We have made 12 experiments with 6 different soil samples. The soil sample is received from Cukurova University, Department of Geology. which include various amount of sand, silt, and clay. The percentage of each particle is also provided by the department which are listed below in (**Table 5.1**). The idea was to use this same sample in this research to make comparison between lab analysis result and our result of soil particles.

Table 5.1. The amounts of clay, silt and sand in the soil samples used in experiments.

Soil Sample	**Clay(‰)**	**Silt(‰)**	**Sand(‰)**
#1	550	344	106
#2	100	680	220
#3	680	240	80
#4	390	460	150
#5	364	511	125
#6	400	556	44

The color visualization the values of **Table 5.1** in **Figure 5.1** below it represents the percentage of particle in color form which is taken from lab.

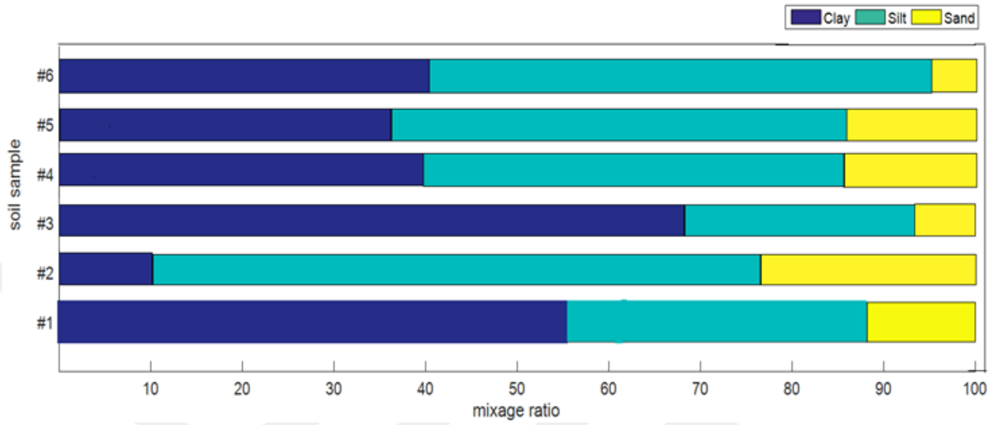


Figure 5.1. Percentage of clay, silt and sand in each soil example.

In the above Figure 5.1 as we have mostly three particles of soil in our sample which is Clay, Silt, and Sand. In the comparison, the amount of silt is more than two other particles, then clay has highest percentage and sand is carrying has low percentage.

5.1. Experimental Setup

Experiment setup is made up by Arduino microcontroller board, Hydrometer, Sensors, Red Laser light and some electronics instruments like, breadboard wires, connectors, resistor. The laser light passes through the beaker and other side sensor is placed. Both laser light and sensor are connecting with Arduino board using wires through the breadboard. A Few resistors are used to manage the voltage power supply and A big USB cable is connected one side of Arduino port and another side of computer USB port. In the **(Fig 5.2.)** as it showing there are 5 laser lights and 5 sensors placed on the beaker from 1 to 5 from top to the end. Sensor and light are placed on the beaker at opposite direction of each other.

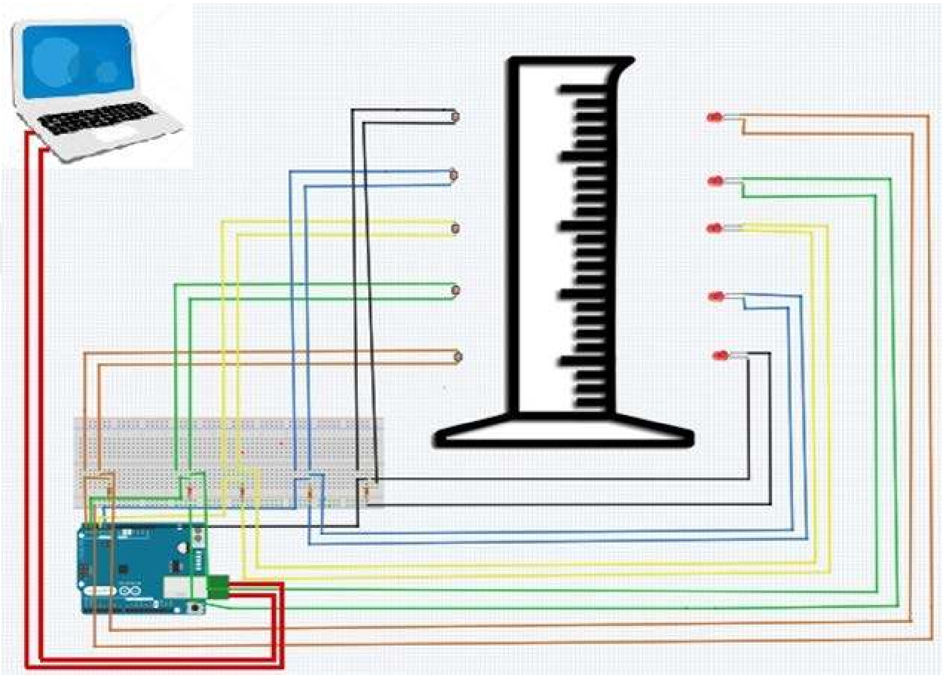


Figure 5.2. Experimental setup

Arduino is one of our microcontroller device, a microcontroller is a circuit board that has chips on it: photoresistor, LDR (light dependent resistor) which is sensitive to light and Motion sensors for the detection. An Arduino hardware can be programmed with C++ language to make some specific and simple task in Arduino software (IDE). According our soil texture requirement we made a program which make connection between Arduino setup and computer. When we start our setup to provide electricity through our computer. Sensor starts detecting the value sent to the system screen by the help of Arduino board. In our experiment, according to our Arduino program code we take two numbers values in a single second in the digital form. It can be decrease according your requirement but taking two values in one second give best result. As we are using LDR sensor and Red led laser in our experiment it is most important while doing experiment that another light should not affect the sensor. Only it should be catch red led laser light. Because of that we made all our experiment mostly in night. After all setup is ready to work we proceed to start our experiment to get the valuable data.

We used a hydrometer it allows to figure the specific weight of liquid. In our experiment, we put 1-liter pure water in the beaker after we put limited amount of dry soil in the water from our sample and mix it well by stick. Now we start the program by giving them electricity through Arduino using breadboard. Now light sensor starts detecting the particles and give the values on your screen. The magnitude of the light which is passing through the beaker is measured by programmed Arduino Controller by 2 Hz with 5 LDR sensor. We run each experiment until 90 minutes. We received around 5 rows and 10800 columns data unstructured form from each experiment. We structure the data in usable form and stored it into the excel file. We used serial port monitor software to make connection with system port to save the data. When we finish the experiment, we clean the beaker properly to start new experiment. For the best result, we made the experiment two times with the same soil to compare data from with the first one. In my study, We have made 6 soil sample and repeat it two times that’s makes total exactly 60 rows and 10800 columns data to finalized the result.

5.2. MATLAB Environment to Calculate the Data

MATLAB environment is used for computer aided estimation experiment. To using our experimental data, we change data format into a (.mat) file format. Applying this data.mat file some important feature can be extracted from the sensors signals and it can be used as estimation result. Sedimentation is tendency for particle in the solution of soil-water to remove suspends solid from water. Particles settle down by the time which increase magnitude of light. The measurement of the upper LDR sensors produce high acceleration than the lower LDR sensors. Because the sand is considered the heaviest particle in soil texture. It is settle down in the beaker faster in comparison to (silt and clay). Due to the fast settlement of the sand particle makes thick layer at bottom of the beaker. while designing the device it was necessary to concentrate on where to fixed LDR sensor at the beaker because heavy particle settle down very fast which takes bottom space. So, we have fixed the lowest sensor position a little higher from the bottom of the beaker. As we are using LDR sensors with Red led laser in our experiment we fixed RED led laser light in front of each sensor at the beaker. Using all these instrument in the experiment each signal start to collect the signal. The Arduino device helps to collect this signal and change into the numeric values. We modified the collected data to use in MATLAB environment. In the MATLAB, we have written the program in matlab environment which helps to extract the feature from sensor signal. After running the program with collected signal in the **Figure 5.1**. below it can be seen in five subplots how each LDR sensor collected the signal in 900 second duration. Each sensor produces different signals due to settling the soil particles speed in the water solution by the time.

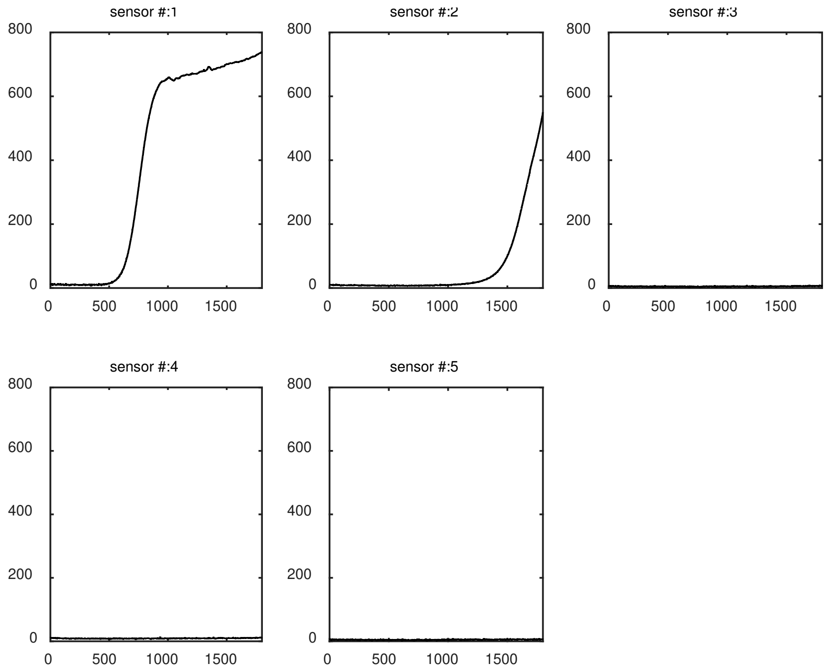


Figure 5.3. Collected signal from soil sample no #4 in 900 second with 5 LDR sensors.

In the subplots above is representing that the 1st and 2nd signal has collected the most signal as compare to 3rd, 4th, and 5th in soil sample #4. it can be changed according to soil sample because soil vary different kind of particles. it can be also changed by the time depend on the particle settling speed. The chart of all the experiments are given in the Appendix part.it shown signal detection from all the experiment. While doing the experiment it was very necessary to take care about light source as we are using LDR sensor. We did all experiment in night in the darkness because if there would be any other light source would be available except than red light LED. It can affect the result. Applied all this condition we done all experiment. We tried to calculate the sand and silt amount in soil sample using linear regression, multi-layer perceptron artificial neural network with hidden layer and neuron.

5.3. Feature Extraction From Sensor Signal

We used many feature selection method such as (Standard deviation, Entropy, Zscore, Mean, Maximum, Minimum, Min-max scalling and Variance) to select the best feature selection method for feature extraction for this research. Using collected data we made number of anlysis in matlab environment to find which can be the best feature selection combination for feature extraction.. As we have used 5 LED sensors and 5 Red Laser Light in our experiments. It was the main challenge to find out that which is senor will be the most useful So we made the sensor combination to the calculate that which sensor will be given us best detection values and which will be the most effective as compare to other sensors. This feature also helps for the combination of the sensor. Which sensor combination is more effective for producing the best result. We used a logic in our codes for checking the sensors activity we used '1' and '0' indication symbol to understand by our system. Here '1' represents as open sensor and '0' represents as close sensor. Using this technique, we applied the sensor data for the calculation. The data which is already modified for the use in MATLAB environment. So According to the experiment each 5 sensor produce two values in a second the total running time of the one experiment is 10800 seconds around in 90 minutes. As we have made 12 experiments with the 6 different soil samples. That's means we did experiment two time for each soil. Now the total calculation of experiment is around 12 experiments multiply by 5 sensors which is become 60 rows and the time is in the form of 10800 columns. We have total data is 60 rows and 10800 columns. Total chance for the sensor combination is 2^5 -1 (31) for the single experiments.

The source we used about statistical functions like minimum, maximum, mean, standard deviation and entropyt etc. extract features from the studies of (Ocak, 2009; Subaşı, 2007a, 2007b; Übeyli, 2008, 2009). In previous study made by (Kilinç and Orhan, 2016) they used standard devivation and entropy function but In this study we used number of combination of functions to make comparision between the best one. The further details about the feature extraction process in the experiments described below.

- *Step 1: As we have used five sensors in the experiment we described above that at starting position in our algorithm sensors value will be 11111 that's means now all sensor is open. We have taken all the data from the open sensor. Now we used this data for feature extraction. When we begin the algorithm in MATLAB environment to extract the feature. We used as first sensor will be on other will be in the off position. It will be like 10000. We apply this condition for specific time after that the second sensor will be open (01000) other will be close. This process will be continued until it reached to the last sensor for the specific time.*
- *Step 2: For the time limitation. we done each experiment for 90 minutes for all the experiments. According to previous researched which explained that starting 15 minutes data is considered more effective to get the best result. We did it 90 minutes to compare with all the collected data. So now we have selected 15 minutes data to use in the experiments.*
- *Step 3: We have used total 6 soil samples data in the experiments. We used 5 sample as train data 1 data set as test data to apply the regression function. The function presents the error between the predicted result.*
- *Step 4: After received the MSE (mean squared errors) calculate those error which bring you an output. As we applied this process for all the sensor to produce the best sensor combination result. As we have total combination for all the sensor is 2^5-1.*
- *Step 5: We checked the best combination which combination produces the minimum MSE as compare to others.*

5.4. Calculation with Linear Regression

Linear Regression is considered one of the best method in computer-based automated system to deal with the data. By the help of cross validation method which produce efficient result for the data. Using k-fold method, first linear regression is used with data set (5 training data 1 test data of soil samples). As in (**Figure 5.4**) below which is taken after running the algorithm in MATLAB environment. it takes all the sensor combination in each signal segment until the specific time (900 seconds) for sand particl. According to the study sand is the heavies paticle in among other which settled down fast in the water as compare to other that's why we have choosen first 15 minutes signal for sand reaming until 90 mintues for other particles. After process all these signal data in matlab environment using lineaer regression It provides the MSE (mean squared error) values, from the Sensor combination and the duration of the experiment with 3D graph which are given below.

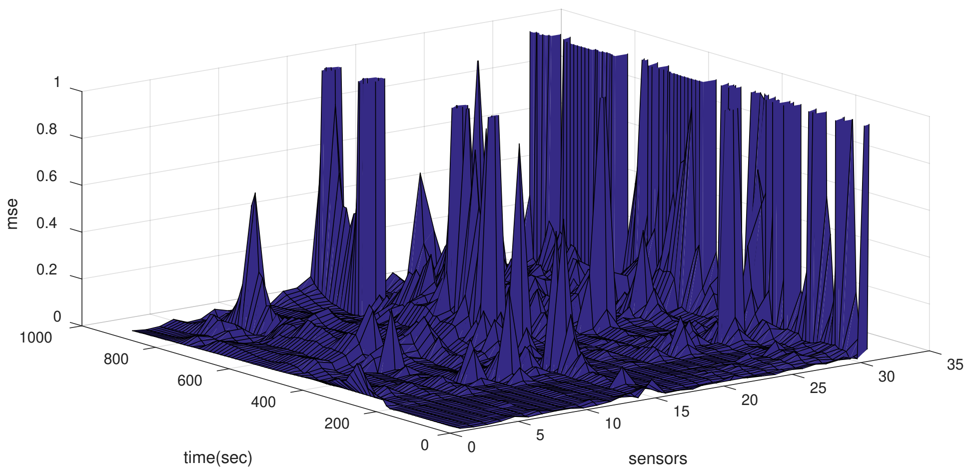


Figure 5.4. 3D view of MSE for sand ratio in soil for all sensor combinations for 900sec.

After checking the graph result from all of the perspective, it is considered that sensor values are not in order with linear regression method are it supposed to be and error rates is also high but time dependent variation seems more stable. To check the minimum point of error with respect to time axis, we used the (**Figure 5.5**) below shows time and MSE axes from this prospective we can see the minimum error we got of MSE, and check the sensor combination values, time duration.

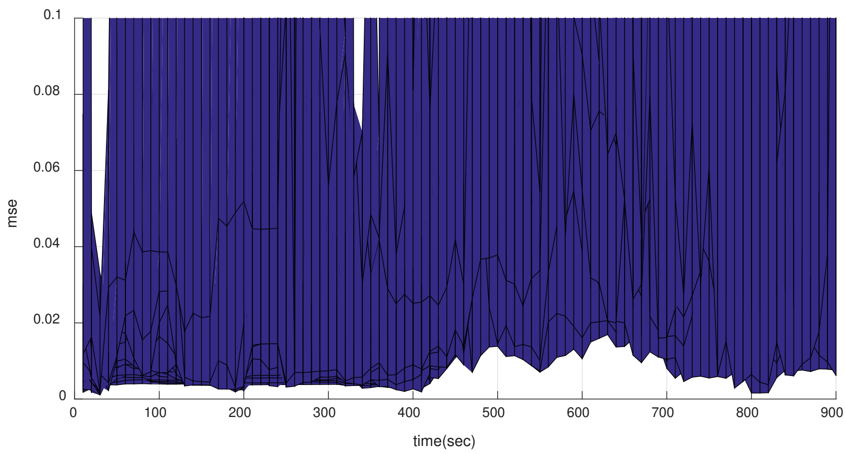


Figure 5.5. 2D view of MSE for sand ratio in soil with the sensor combination and time values.

In the (**Figure 5.5**) above we have presented minimum error of MSE with sensor combination and time. we have selected 3 least error by the help of MATLAB environment. Firstly, we present the least result which is taken from sensor value 17 (10001) and with the sensor combination of 5-1 with MSE error 0.00186 MSE in first 190 second signal segment. The Second least result we received from the sensor no 22 that is 10110. The combination will be 5-3, 3-2 with MSE error 0.00265 in first 400 second signal segment. Third least result error we received from the sensor of 4 (00100) which means the sensor combination is 3rd with the MSE error is 0.00371 in the first 210 second. The following figure present the error rates which we received in sensor base calculation with linear regression. Now in the (**Figure 5.6)** below we checked the least error from the different angle we received the same result.

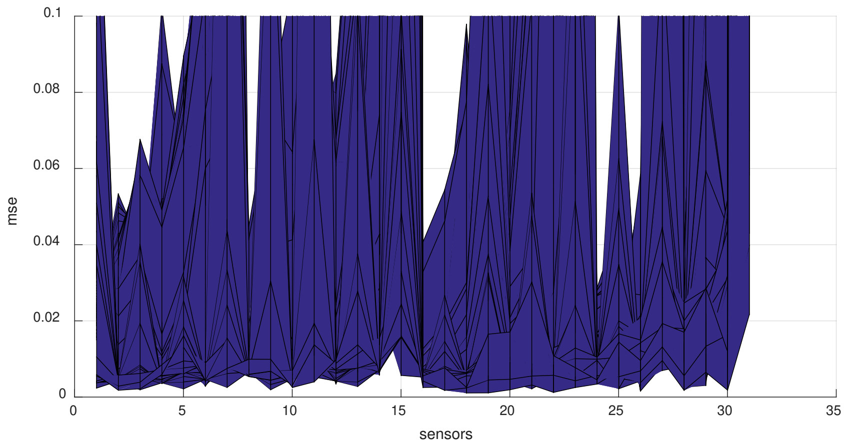
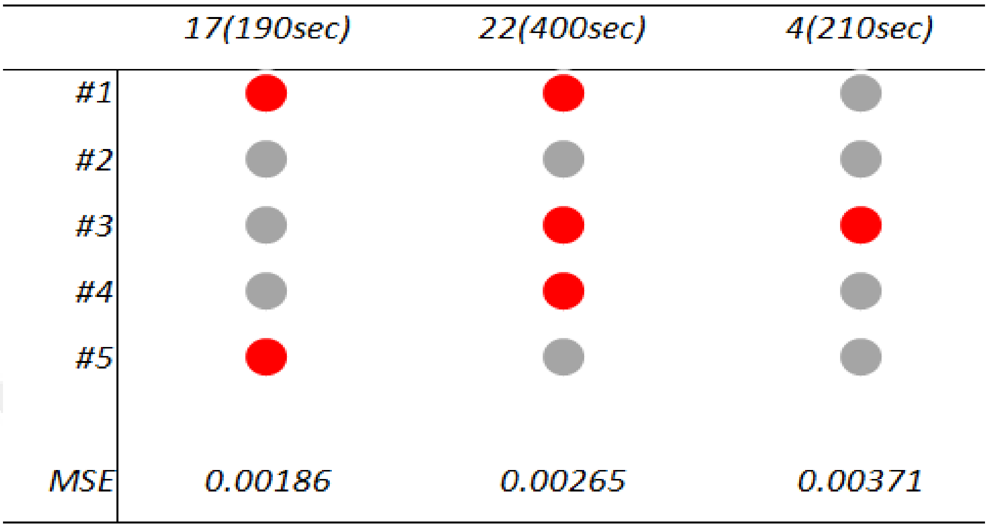


Figure 5.6. Least error of MSE with different angle with sensor combination values and time.

In the (**Figure 5.6**) we tried to find out that if we change the angle of the graph will it effect on the result after checking from different angle comparing the least error from the first one we received the exact one. Now the second we did present all valued in a very simple way. We prepared the table below to present MSE, sensor combination, time values result with the help of color combination. Here easily can be read that which sensor combination is producing least error at which time.

Table 5.2. On and Off Sensors scenario with the minimum MSE values and time.



In the (Table 5.2) we represented the sensor numbering from above to end (1 to 5) with sequence. The second is color balls red and gray in the table. The red color balls represent the sensor is in on position. The gray is in off position. Below we written the 3-least errors from the sand calculation with linear regression. Above we put the sensors value with time. Now easily can be seen that 1st, and 3rd, is on position in all three result which we take out from the experiment. That's is good sign it shows that we can use this sensor combination for getting best result. But the other hand what we received with linear regression that MSE value is high that shouldn't go more than 0.0015. To checking the sensors that gives minimum error rates in general mean of MSE value for every single combination we used the plot image showing the mean of MSE.

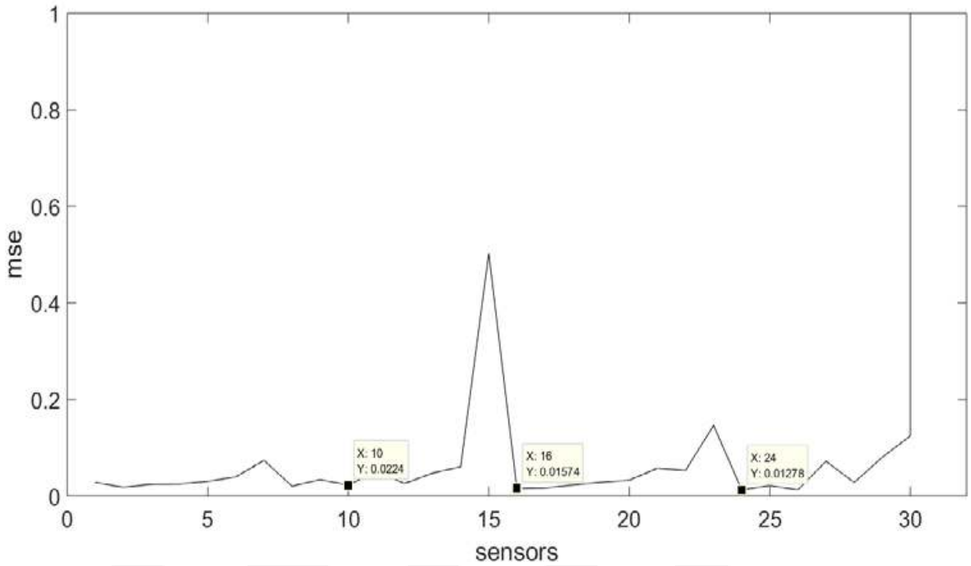


Figure 5.7. For sand ratio: Mean of MSE values with sensor combinations.

It can be seen in this plot image we checked the mean of MSE for sensor combination. we pointed out the three least values. The firs one is 01010(10), 10000(16), and 11000(24) in sensors combination which produced the least error in total. Comparing (**Figure 5.7**) and table 1-2, and 2-3 number sensors are useful to getting the best result with linear regression. This is all we have done with 2 extracted feature (Mean and Maximum) as a input in Linear regression we also made number of experiment with number of extracted feature combination such as (Standard deviation, Entropy Zscore, Min-max scalling, Variance, Mean, Maximum and Minimum). Comparable results using linear regression with different combination of extracted features are presented in table below.

Table 5.3. Sand Particle estimation results using Linear Regression with different features.

No:	Extracted Feature Combination	Mean Square Error 1	Mean Square Error 2	Mean Square Error 3
1.	**Standard deviation and Entropy**	*1(800sec)0.0037*	*1(40sec)0.00238*	*1(560sec)0.00351*
2.	**Mean and Minimum**	*8(60sec)0.00464*	*24(400sec)0.00517*	*2(440sec)0.00571*
3.	**Mean and Maximum:**	*17(190sec)0.00186*	*22(400sec)0.00265*	*4(210sec)0.00371*
4.	**Standard deviation and Zscore:**	*17(280sec)0.00631*	*26(720sec)0.00743*	*17(860sec)0.004671*
5.	**Min-Max scaling and Zscore:**	*17(280sec)0.00631*	*26(720sec)0.00743*	*17(860sec)0.004671*
6.	**Entropy and Zscore:**	*05(30sec)0.0024*	*25(690sec)0.00468*	*4(800sec)0.003752*
7.	**Standard deviation, Entropy, Zscore, Min-max scalling:**	*19(550sec)0.00453*	*25(690sec)0.00468*	*6(780sec)0.00494*
8.	**Standard deviation, Zscore, Min-max**	*17(280sec)0.00631*	*26(720sec)0.00743*	*17(310sec)0.004088*
9.	**Standard deviation, Zscore, Minimum, Maximum, Entropy, Mean:**	*31(50sec)0.00347*	*25(620sec)0.00443*	*19(550sec)0.00453*
10.	**Zscore, Minimum, Maximum, Stdandard deviation and Variance**	*17(280sec)0.00631*	*26(720sec)0.00743*	*17(310sec)0.004088*
11.	**Zscore, Min-max scalling, Variance**	*17(280sec)0.00631*	*26(720sec)0.00743*	*26(720sec)0.00743*

We applied the same rules to find out the silt amount in soil samples. Which we have described below. The (**Figure 5.8)** is showing the result of MSE (mean squared error) and the sensor combination in each segment up to the 900 second.

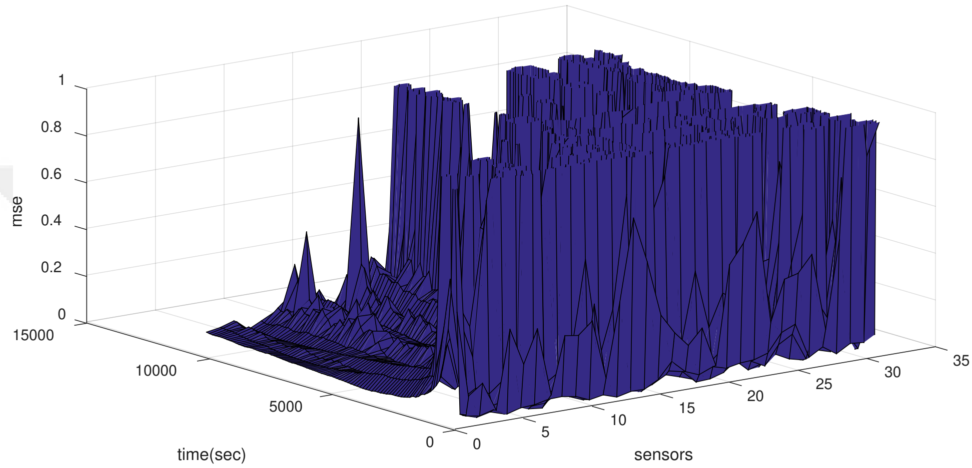


Figure 5.8. 3D view of MSE for silt ratio in soil for all sensor combinations for 900sec.

After checking the image result from all of the perspective, it is situation which we faced above in sand estimation that sensor values are not in order with linear regression method as it supposed to be and error rates is also high but time dependent variation seems more stable. To check the minimum point of error with respect to time axis, we used the (**Figure 5.9**) below shows time and MSE axes from this prospective we can see the minimum error we got of MSE, and check the sensor combination values, time duration.

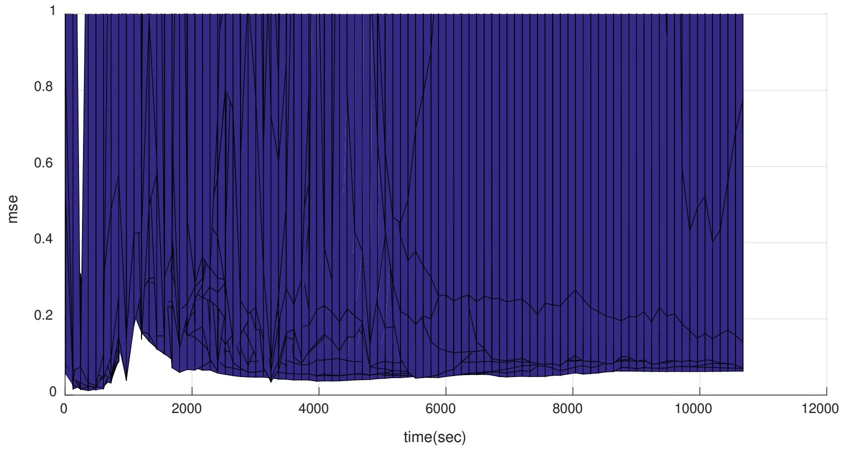


Figure 5.9. Silt amount in soil: 2D view of MSE with sensor combination values and time.

In the (Figure 5.9) we received the first MSE minimum error for silt particles (0.051mse) at 18 no sensor combination 1-4 in 6121 second. After we checked the second minimum error rate (0.0608) we got in 8521 second with the sensor combination no 10 (2-4). Third minimum error (0.01303mse) in first 481 second with the sensor combination 1-4-5. Now in the (Figure 5.6) below we checked the least error from the different angle we received the same result

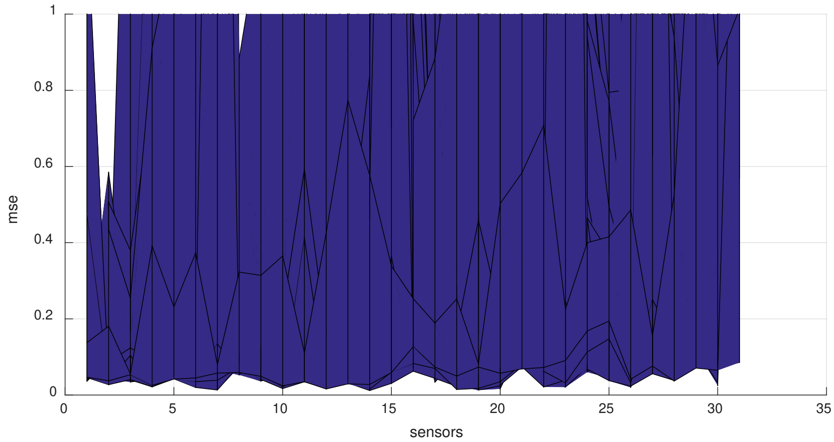


Figure 5.10. Least error of MSE with different angle with sensor combination.

In the (Figure 5.10) we changed the angle of the graph checking from the different angle and compared the least error from the time axes above received the exact one. Now the second we did present all valued in a very simple way. We prepared the table below to present MSE, sensor combination, time values result with the help of color combination. Here easily can be read that which sensor combination is producing least error at what time.

Table 5.4. On and Off Sensors scenario with the minimum MSE values and time.

	18(6121sec)	*10(8521sec)*	*19(481sec)*
#1	●	○	●
#2	○	●	○
#3	○	○	○
#4	●	●	●
#5	○	○	●
MSE	*0.051*	*0.0608*	*0.01303*

Now it can be seen in the (**Table 5.3**) that 1st and 4th is on position in all three result which we take out from the experiment. which is good sign it shows that we can use this sensor combination for getting best result. Here we received the error rate for silt particle with linear regression is quite good. We still required the minimum error which shouldn't go more than 0.015. To checking the sensors that gives minimum error rates in general mean of MSE value for every single combination we used the plot image showing the mean of MSE.

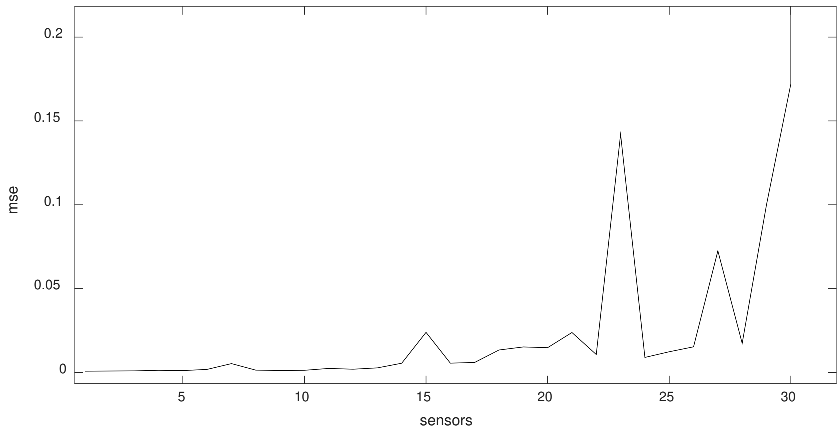


Figure 5.11. For silt ratio: Mean of MSE values with sensor combinations.

In the figure 5.11 we take highest zoom position to check the minimum axes point. We pointed out the three least values. As we compared with the previous plot in this plot we did not get effective point which is not considerable. In the (**Table 5.3**) 1st, 2nd, and 3rd are all in on position producing the least error which is very useful to getting the best result.

we also made severial experiment with number of extracted feature combination such as (Standard deviation, Entropy Zscore, Min-max scalling, Variance, Mean, Maximum and Minimum). Comparable results using linear regression with different combination of extracted features are presented in table below.

Table 5.5. Silt Particle estimation results using Linear Regression with different.

N0:	Extracted Feature Combination	Mean Square Error 1	Mean Square Error 2	Mean Square Error 3
1.	**Standard and Entropy**	*4(121sec)0.029*	*2(5041sec)0.0243*	*27(1008sec)0.01435*
2.	**Mean and Minimum**	*4(3961sec)0.095*	*8(2161sec)0.1044*	*4(7081sec)0.0843*
3.	**Mean and Maximum**	*18(6121sec)0.051*	*10(8521sec)0.0608*	*19(481sec)0.01303*
4.	**Standard deviation and Zscore:**	*5(8401sec)0.0314*	*30(5161sec)0.02063*	*5(7681sec)0.02073*
5.	**Min-Max scaling and Zscore:**	*2(7201sec)0.01585*	*30(5161sec)0.02063*	*5(5361sec)0.02117*
6.	**Entropy and Zscore:**	*07(7801sec)0.0473*	*7(8401sec)0.0484*	*14(9961sec)0.0611*
7.	**Standard deviation, Entropy, Zscore, Min-max:**	*1(6121sec)0.0323*	*6(5521sec)0.0351*	*14(121sec)0.02486*
8.	**Standard deviation, Zscore, Min-max**	*5(8401sec)0.0314*	*2(7201sec)0.01585*	*30(5161sec)0.02063*
9.	**Standard deviation, Zscore, Minimum, Maximum, Entropy, Mean:**	*1(121sec)0.0286*	*1(6121sec)0.0323*	*6(5521sec)0.0351*
1(	**Zscore, Minimum, Maximum, Stdandard deviation and Variance**	*2(7201sec)0.01585*	*30(5161sec)0.02063*	*5(7681sec)0.02073*
1	**Zscore, Min-max scalling, Variance**	*2(7201sec)0.01585*	*5(6361sec)0.02117*	*30(5161sec)0.02063*

We did the experiments also with another method which we called Multi-Layer Perception Artificial Neural Network. We compared this result the error rate little high as compare to MLP ANN. We can produce best result with ANN as compare to the linear regression. Another benefit is applying hidden layers with neuron provide you the high success and decrease the error rate.

5.5. Calculation with Multi-Layer Perceptron Artificial Neural Network

With the help of Multi-Layer Perceptron Artificial Neural Network, we made analysis for sand and silt particles amount in the soil samples. We applied this method with 2 different ANN structure with single hidden layer with 5 neurons and single hidden layers with 10 neurons. 2 extracted feature is used as input for each chosen sensor. Previous research they used 3 different ANN structure with no hidden layer and single hidden layers with 5 neurons and single hidden layers with 10 neurons which is done by (Emre Kilinc, Umut Orhan 2016). Using no hidden layer does not provide good result we used only 2 ANN structure with single hidden with 5 neurons single hidden layers with 10 neurons which is able produced best result in MLP. In all our ANN stuructures, using cross validation, 5 soil data set as for training and 1 for test data set, to interchanging each others. To avoid overfitting, the validation set for stopping condition is chosen randomly from the training set by 1/3 ratio. Hyperbolic tangent is used as a activate function in neurons and Leyenberg-Marquardt algorithm is used for system's training. We run the program after this all rules. What we received as an extracted feature with ANN, single hidden layer with 5 neuron. The **Figure 5.2** below having the MSE (mean squared error) and the sensor combination in each segment up to the 900 second for sand particle. We have described further details below about all the minimum errors and sensor combination.

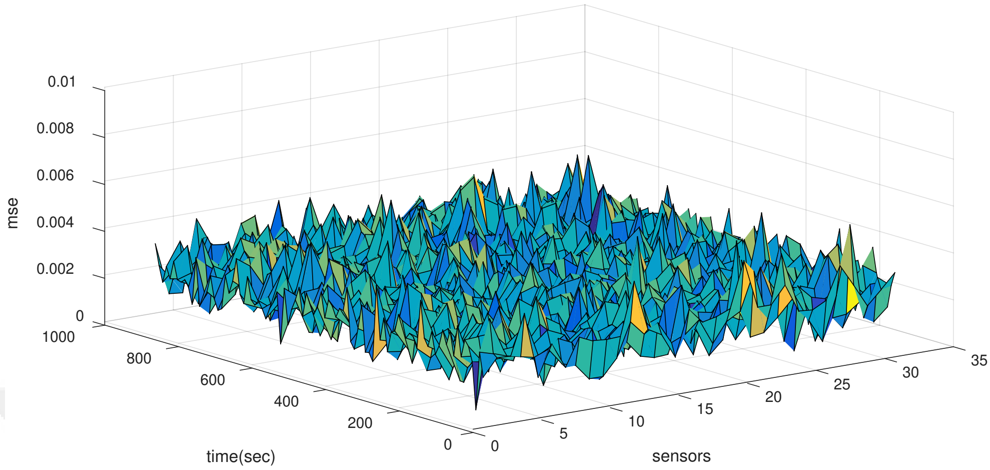


Figure 5.12. 3D graph view for sand particle calculation having MSE, sensor combinations and timen single hidden layer with 5 neurons in ANN.

As compare to the linear regression method, we received the better result with MLP by ANN with single hidden layers and 5 neurons. Here with the MLP, MSE error is quite low which is good sign for stable result. In the **Figure 5.13**. below shown time and MSE axes from this prospective we can see the minimum error we got for MSE in MLP with ANN, and check the sensor combination values, time duration.

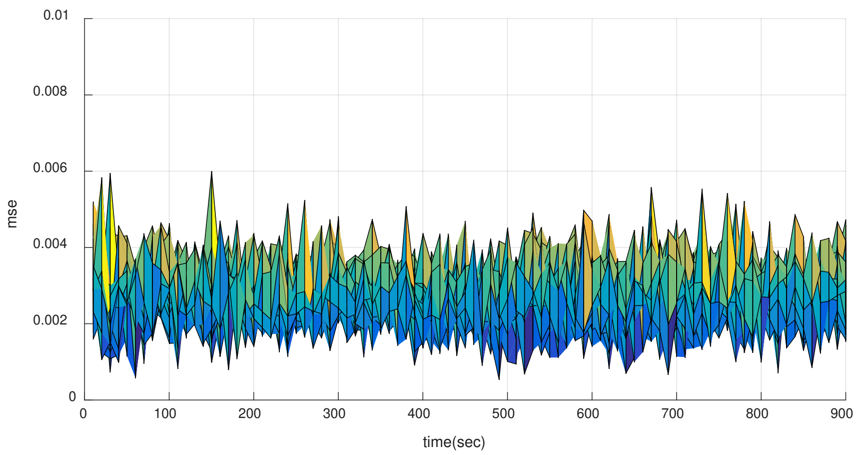


Figure 5.13. Least MSE with sensor combination values and time using ANN with single hidden layer with 5 neurons.

In the figure above we received the MSE minimum error (0.000667 mse) which we got in first 690 second with sensor number 27(11011) and. After we checked the second minimum error rate (0.000686 mse) we got at 520 second with the sensor number 25 (11001). Third minimum error (0.0005344 mse) in at 490 second with sensor number 13(01101). The most important thing we received the quite low mse as compare to previous study. To checking the result withdifferent ANN structure with 10 neuron we made the another experiments to make comparision between both of them. (**Figure 0.14**) below.

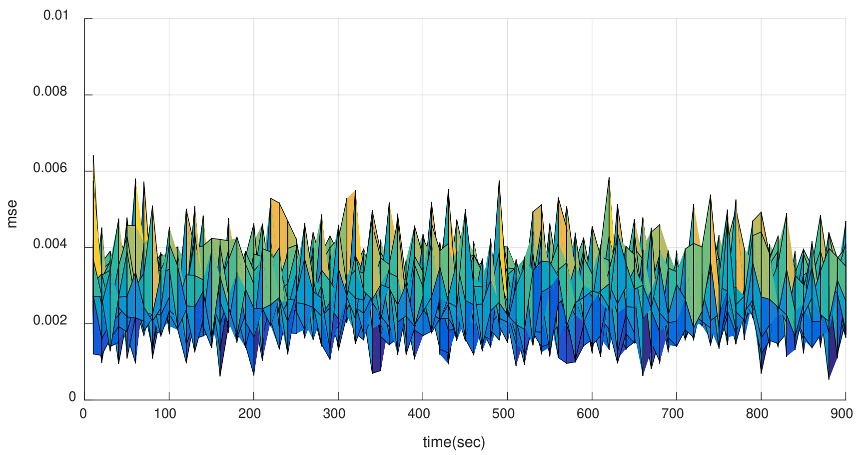


Figure 5.14**.** Least MSE with Sensor combination values and time using ANN with single hidden layer with 10 neurons.

In the figure above we received the MSE minimum error (0.000699 mse) which we got in first 340 second with sensor number 7 (00111) and. After we checked the second minimum error rate (0.0005431 mse) we got at 840 second with the sensor number 26 (11010). Third minimum error (0.0006309 mse) in first 160 second with sensor number 11 (01011). After comparing both result if we pay close look both result it can be seen tha ANN produced the best result over linear regression. And another point is using hidden layer with nuron increse the success by decreasing the error rate. Making it in clear scenario we put this information in the (**Table 0.4)** below which explain about sensor combination, minimum error of MSE and time.

Table 5.6. The best scenario for sand ratio using ANN with 5 neurons.

	27(690sec)	*25(520sec)*	*13(490sec)*
#1	●	●	○
#2	●	●	●
#3	○	○	●
#4	●	○	○
#5	●	●	●
MSE	*0.000667*	*0.000686*	*0.0005344*

Table 5.7. The best scenario for sand ratio using ANN with 10 neurons.

	7(340sec)	*26(880sec)*	*11(160sec)*
#1	○	●	○
#2	○	●	●
#3	●	○	○
#4	●	●	●
#5	●	○	●
MSE	*0.000699*	*0.0005431*	*0.0006309*

As it is seen in the table above, the error is quite low as compare to the linear regression. Using ANN method with single hidden layers with 5 and 10 neuron we got the best result. Here the best point is we recived the result from all sensor combinaton it can cleary say that all five sensor is good to detect the good signal. To checking the mean of MSE values with neurons counts what result we get by sensor combination in the experiments are mentioned in given plot image below.

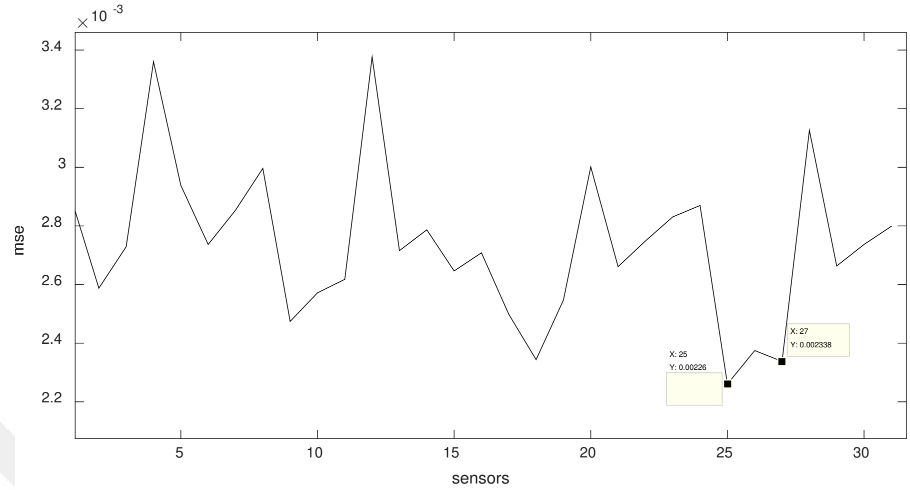


Figure 5.15. Mean of MSE values having sensor combinations with ANN single hidden layer and 5 neuron.

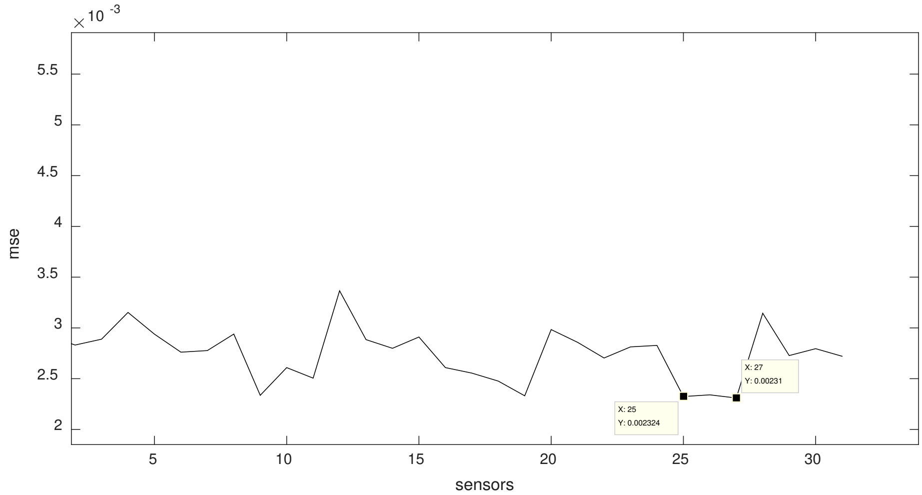


Figure 5.16. Sand estimiation Mean of MSE values having sensor combinations with ANN single hidden layer and 10 neuron.

In the figure above, the average successes of the sensor combination are mentioned. The best result we received using ANN with single hidden layers and 10 neurons. The following the combination are inspected with 5 neuron is 11001(25), 11011(27), and with 10 is also recived the same 11001(25), 11011(27).

Which is point out in the plot image. Here we have got the same sensor combination with common in all and all five is producing the best result. These sensors produced the minimum error and very fruitful result for the soil particle estimation.

After made one analysis with such extracted feauture as (Mean and Maximum) we find the best result. Also we used number of extraced features to make the comparision between them to check which can be produced more fruitful result detials is available in table below.

Table 5.8. Sand Particle estimation results using ANN with different extracted feature.

Number	Feature Combination with MLP for sand particle	Mean Square Error 1	Mean Square Error 2	Mean Square Error 3
1.	**Mean and Minimum**	*16(660sec)0.0005881*	*23(880sec)0.0006853*	*3(480sec)0.0008525*
2.	**Mean and Maximum:**	*07(340sec)0.000699*	*26(880sec)0.0005431*	*11(160sec)0.0006309*
3.	**Standard deviation and Entropy**	*10(3200sec)0.000846*	*30(160sec)0.000921*	*15(640sec)0.000931*

We applied the same rules to find out the **silt amount** in soil samples. Which we have described below. The **Figure 5.16** below shows the result MSE (mean squared error) and the sensor combination in each segment up to the 10800 seconds from 90 minutes experiments data. silt particles settling down in water takes long time as compare to sand particle that’s why we run the program until 90 minutes and used in the ANN structure to check the result.

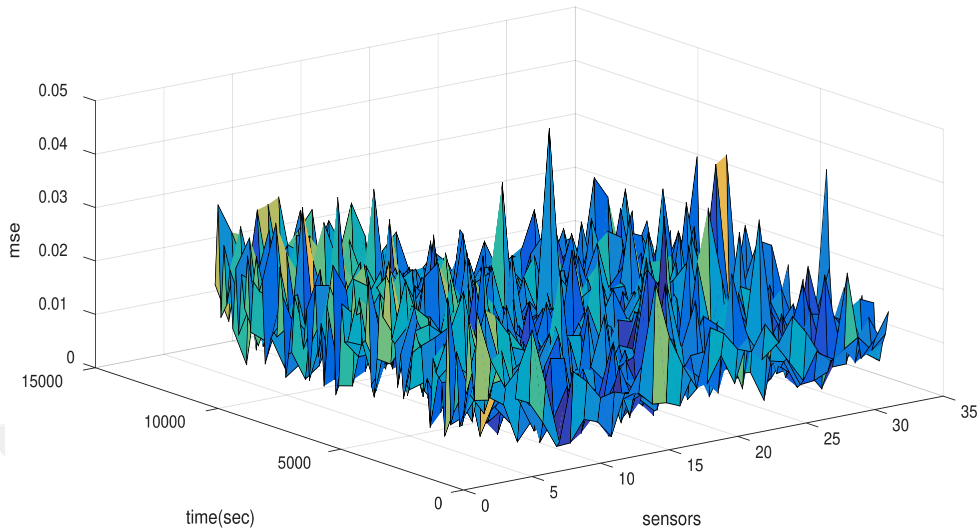


Figure 5.17. Least MSE with sensor combination values and time using ANN with single hidden layer with 5 neurons for silt particle.

We checked the result for silt amount using the same ANN structure with single hidden layers and 5 neurons. The MSE error is also quite low with silt amount as well. which is good sign for stable result. In the **Figure 5.17** below shows time and MSE axes from in 2D graph view we can be seen the minimum error we got for MSE in MLP with ANN, and checked the sensor combination values, time duration.

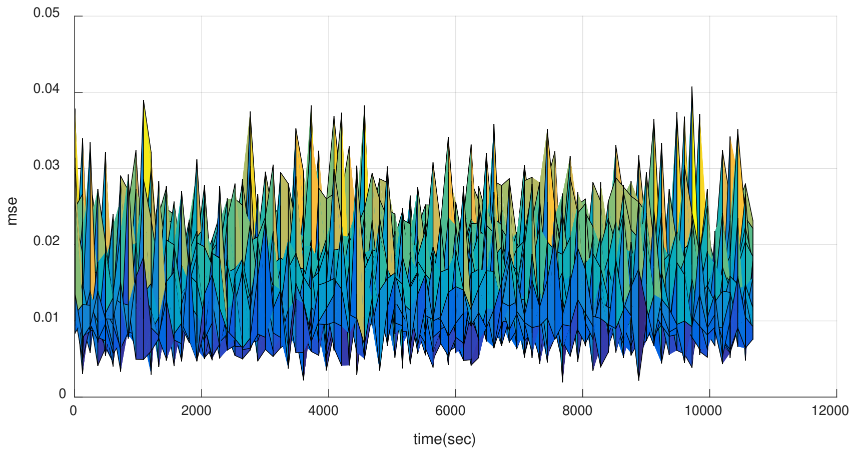


Figure 5.18. Silt estimation with MSE, sensor combination values with time using ANN with 5 neurons in single hidden layer.

In the above, with single hidden layer and 5 neurons we received the MSE minimum error (0.00296 mse) which we got in 4441 second with sensor combination of 00001 (1). After we checked the second minimum error rate (0.001998) we got in at 7681 second with the sensor combination of 01110 (14). Third minimum error (0.002199 mse) in 8881 second with the sensor combination of 11110(30). We compared this result with linear regression. We can clearly say that using ANN we can produce the least error and best result as compare to the linear regression for silt particle ratio as well. Another benefit is applying single hidden layers with 5 neurons provide you the high success and decrease the error rate then we tried with single hidden layer with 10 neurons to checking the result we took the following image below.

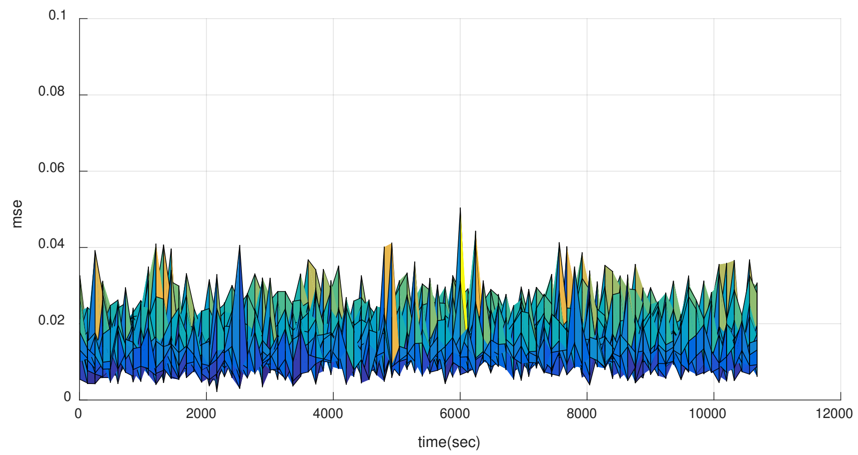


Figure 5.19. Silt estimation with MSE, sensor combination values with time using ANN with 10 neurons in single hidden layer.

In the above, with single hidden layer and 10 neurons we received the MSE minimum error (0.004 mse) which we got in 8041 second with sensor combination of 01101 (13). After we checked the second minimum error rate (0.00347) we got in first 2881 second with the sensor combination of 10111 (23). Third minimum error (0.002235 mse) in first 2161 second with the sensor combination of 10000(16). We compared this result with linear regression. Applying single hidden layers with 10 neurons provide you the high success and decrease the error rate.

In the above we compared the result with previous we got the same point. Making it in clear scenario we put this information in the (Table 5.10) below which explain about sensor combination and minimum error of MSE and time.

Table 5.9. The best scenario for silt ratio using ANN with 5 neurons.

	1(4441sec)	14(7681sec)	30(8881sec)
#1	○	○	●
#2	○	●	●
#3	○	●	●
#4	○	●	●
#5	●	○	○
MSE	0.00296	0.001998	0.002199

Table 5.10. The best scenario for silt ratio using ANN with 10 neurons.

	13(8041sec)	23(2881sec)	16(2161sec)
#1	○	●	●
#2	●	○	○
#3	●	●	○
#4	○	○	○
#5	●	●	○
MSE	0.004	0.00347	0.002235

As it can be seen in table above, the error rate is quite low for silt particle calculation as compare to previously study. But the sensor value is quite differing in each result it occurs due to particle settling speed situation. To checking the mean of MSE values with neurons counts what result we get by sensor combination in the experiments are mentioned in given plot image below.

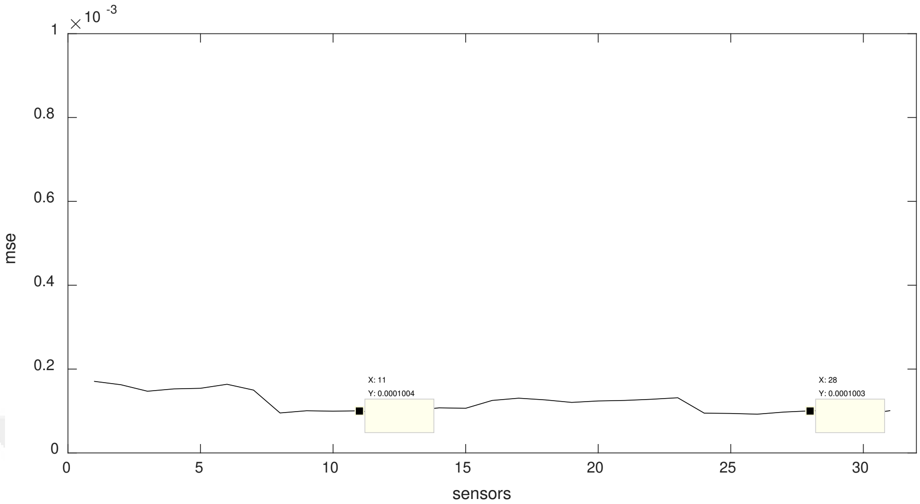


Figure 5.20**.** Silt estimation Mean of MSE values having sensor combinations with ANN single hidden layer and 5 neuron.

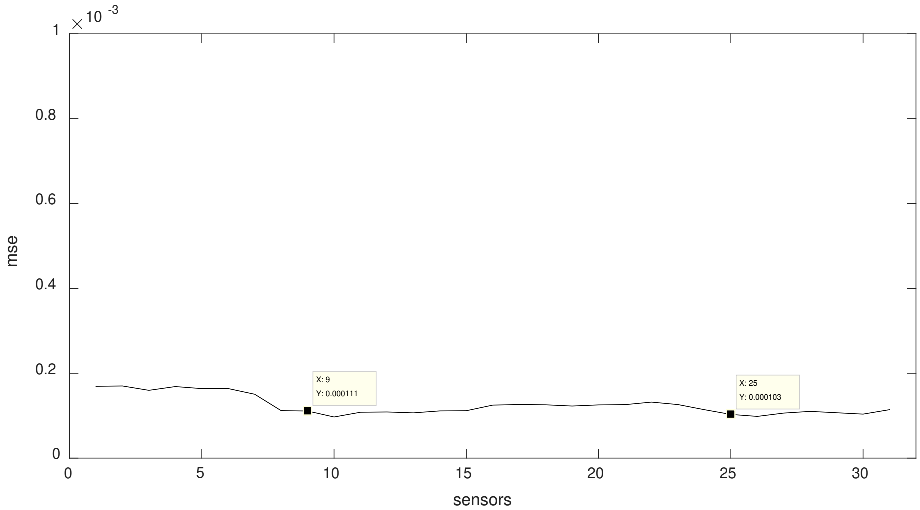


Figure 5.21**.** Silt estimaton Mean of MSE values having sensor combinations with ANN single hidden layer and 10 neuron.

In the plot image above we took the success average of the sensor combination. Here we received sensor combination with 5 neurons are 01011(11), 11100(28), and with 10 neurons 01001(9), 11001(25). If we take a look in this result the best combination is 1st and 2nd, 5th are common sensor which is producing the best result. Sensor 1st is also quite good for other two results. Using ANN with hidden layers and neuron after getting all the result it's very clear that we can get the best result as compare to the linear regression.

After made one analysis with such extracted feauture as (Mean and Maximum) we find the best result. Also we used number of extraced features to make the comparision between them to check which can be produced more fruitful result detials is available in table below.

Table 5.11. Silt Particle estimation results using ANN with different extracted feature.

Number	Feature Combination with MLP for silt particle	Mean Square Error 1	Mean Square Error 2	Mean Square Error 3
1.	Standard deviation and Entropy	19(10032sec)0.00363	4(5881sec)0.00428	16(1441sec)0.00532
2.	Mean and Minimum	13(8041sec)0.004	23(2881sec)0.00347	16(2161sec)0.002235
3.	Mean and Maximum:	19(2881sec)0.0069	9(6361sec)0.0041	28(9001sec)0.00605

5.6. Comparision Between Linear Regression and ANN

In comparision part we demonostrated all the result In aboves tables form. As It mentioned above parts that we collected the soil samples from the Cukurova University, Department of Geology engineering. Its include various amount of sand, silt, and clay. The percentage of each particle is also provided by the department which are listed in (**Table 5.1**). Here we have the silt particle which has the more percentage as compare to others and sand particles which has less percentage. The same sample is used in this research to compare both the percentages of the particles.

We started using with an automated method using few techniques which we explained briefly above. In the Table 5.6, 5.7, 5.8, and 5.9 it is demonstrated the experimental result for sand and silt particle analysis in soil by automated method. All of the visual demonstrations of sensors with best estimation results are given in the following tables.

According to above tables it can be said that the sensor combination which is common in in tables that 2nd, 3rd, 4th much more effective than others. In the table 5.7 and 5.9 the 3rd sensor no is produced the best result using ANN with minimum MSE as compare to linear regression MSE result. which is quite high in table 5.6 and 5.8. In this total experiments we ended up here with linear regression and ANN. This method can be used for futute work for that we rquired more research to calculate the exact percentage of the particles by using automated method.

5.7. Comparision Between Previous Work

Table 5.12. Sand estimation comparison with linear regression.

This Research Soil Sample (6) with 5 sensors		Previous Research Soil Sample (10) with 9 sensors	
Sensor value (Time in sec) MSE	Sensor combination	Sensor value (Time in sec) MSE	Sensor combination
17 (*190*) *0.00186*	(10001)	162 (10) 0.02159	(01010010)
22 (*400*) *0.00265*	(10110)	443 (130) 0.01568	(110111011)
4 (*210*) *0.00371*	(00100)	113(700) 0.01508	(001110001)

We have made comparision between this study and previous research which was about only sand particle analysis in soil by an automate system (Kilinç and Orhan, 2016). We took the result from previous work for sand particle with linear regression. After made several changes using different features and setup equipment we got succeed to receive quite better sensor combination as well mean square error with respect minimum time. It can be said easily this research about soil particles analysis could be used with computer automated system in future to make better assumption for particle analysis. As we used two estimation method to compare the result we made the same process with artificial neural network. The result is mention in the table below.

Table 5.13. Sand estimation comparison with ANN.

This Research Soil Sample (6) with 5 sensors		Previous Research Soil Sample (10) with 9 sensors	
Sensor value (Time in sec) MSE	Sensor combination	Sensor value (Time in sec) MSE	Sensor combination
27(690)	(11011)	250 (10) 0.0163	(011111010)
25 (*520*) *0.000686*	(11001)	367 (590)0.0136	(101101111)
13 (*490*) *0.0005344*	(01101)	480(610)0.0150	(111100001)

Here we also found three least mean square error with ANN which has quite difference (Table 5.13) as compare to previous research. One thing is important that using ANN we get quite better result as compare to linear regression now it can be said that ANN produced far better result as comapre to linear regression. The all experimental detials is mention above in brief details about all the experiments.

6. CONCLUSION AND FUTURE WORK

In this study, we proposed an automated method for soil particle analysis. we developed a rapid and simple automated computerized system to analyze the percentage of soil particle Which could be used as a tool for evaluating soil quality for better agriculture research using hydrometer, Arduino, LDR Sensor, Red laser light, intelligent optimization technique and computer software. We developed an system for determining the particle percentages of sand and silt values on a digital interface without the use of conventional method. The result would be computer generated displayed on the user interface using the percentage of sand and silt. Inspecting all the result for sand and silt particles apart from Sand, Silt Particles we also made experiment with blue Clay particle using LDR sensor did not get precise signal for this kind particles using sound sensors can be detect the more useful signal which can be used in computerized technique. It may give more precise result.

The equipment we used to make this analysis possible its traditional hydrometer, Arduino microcontroller device, Reg laser light, LDR Sensor to detect the particle which is easy to find equipment and used conveniently to estimate the sand and silt particle percentage analysis. The second main role in the research is programing codes at MATLAB environment using some technique extracted the feature from unconstructed data produced the stable result for soil analysis. The idea is to make this hardware and software combination in future with furthermore research a portable and mobile measurement device can be made for the use of soil particle analysis at any convenient place.

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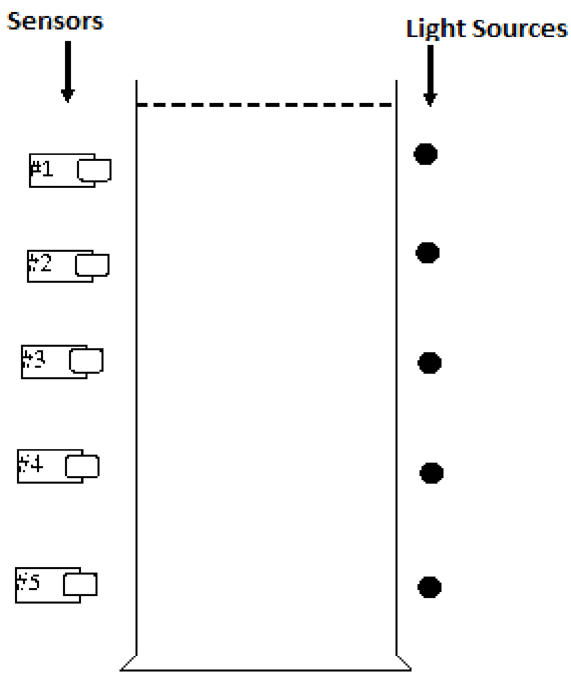
CURRICULUM VITAE

Mohid KHAN was born in Aligarh, India in 1991. He graduated from the department of Computer Science of Dr, Bhim Rao Ambedkar University, Agra, India in 2012. Since 2014 to 2017, He has completed his Master degree in department of computer engineering of Cukurova University in Adana, Turkey.

APPENDIX



The 900sec signal collection of each soil samples taken with 5 sensors and 5 red laser lights are given in the following figures.

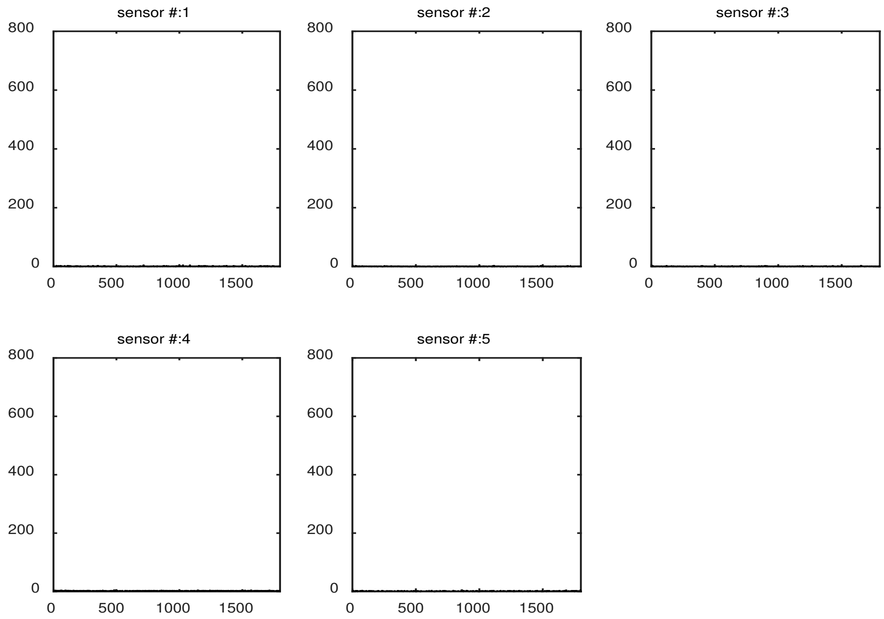


Figure 7.2. 900sec measurements for soil sample #1 with 5 LDR sensors and 5 red laser lights.

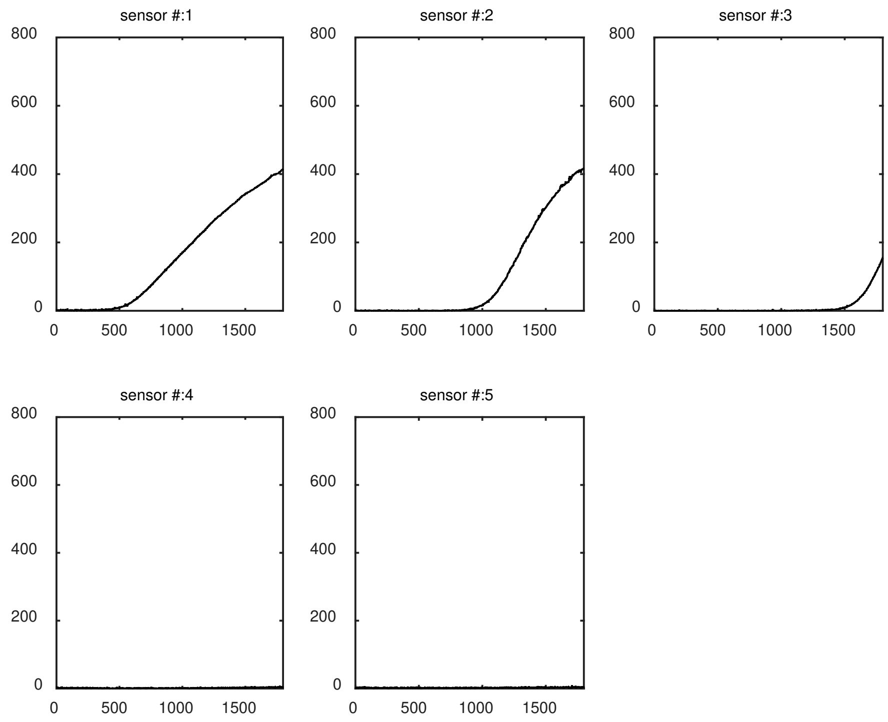


Figure 7.3. 900sec measurements for soil sample #2 with 5 LDR sensors and 5 red laser lights.

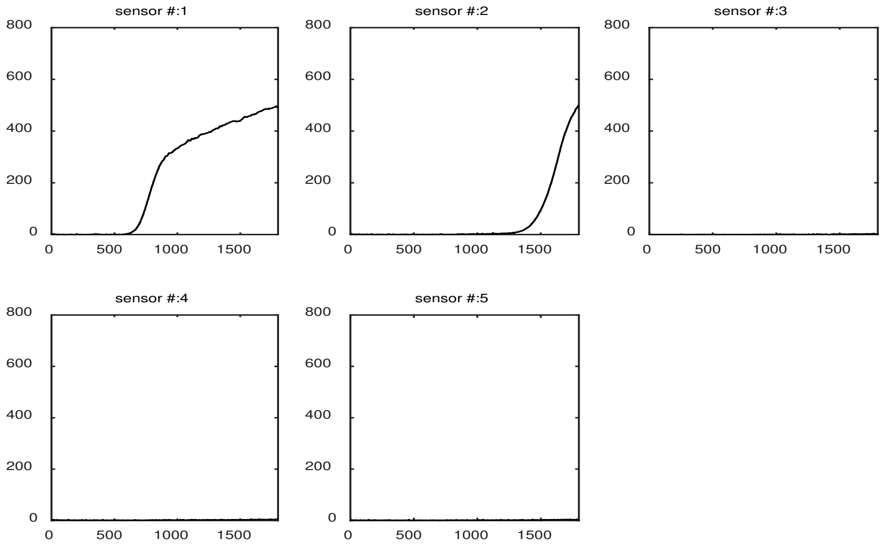


Figure 7.4. 900sec measurements for soil sample #3 with 5 LDR sensors and 5 red laser lights.

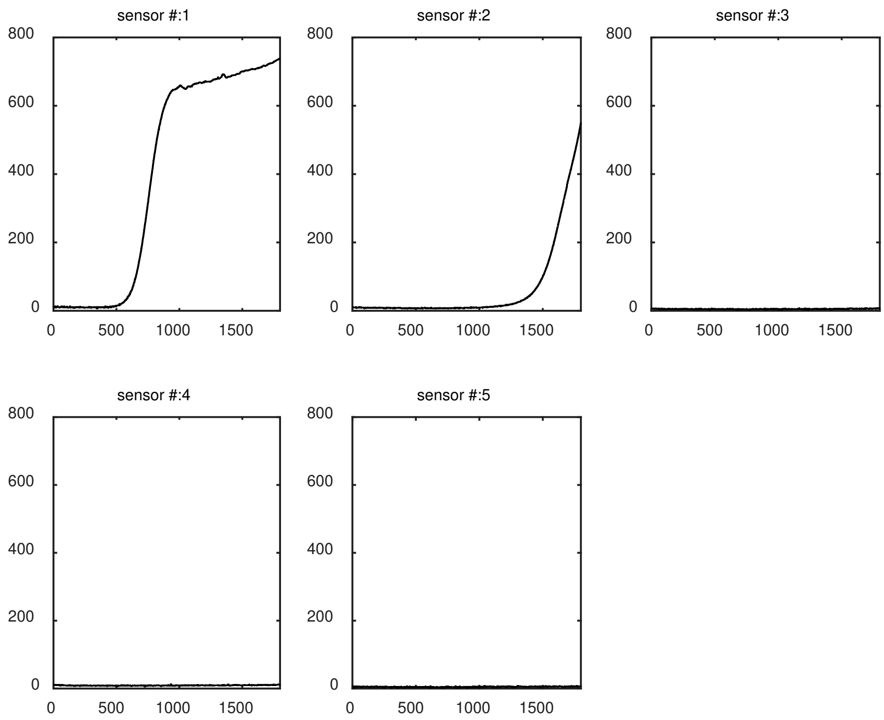


Figure 7.5. 900sec measurements for soil sample #4 with 5 LDR sensors and 5 red laser lights.

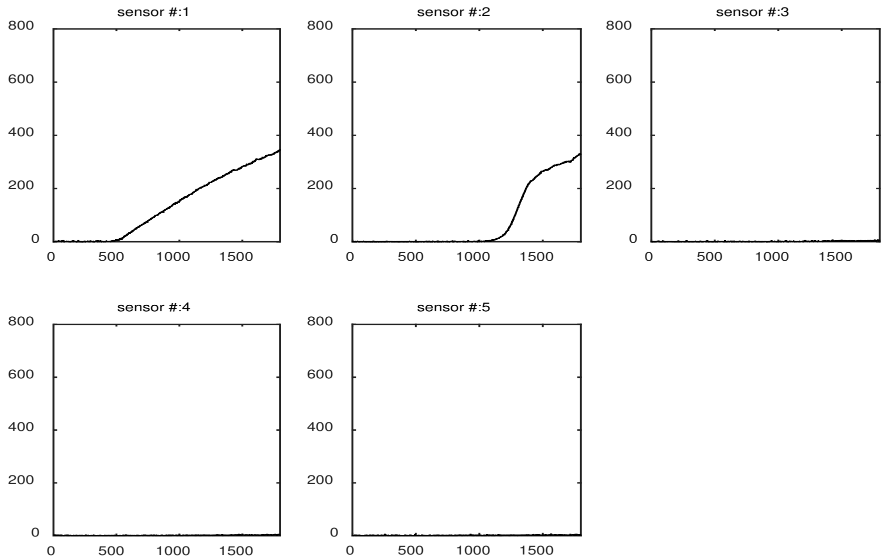


Figure 7.6. 900sec measurements for soil sample #5 with 5 LDR sensors and 5 red laser lights.

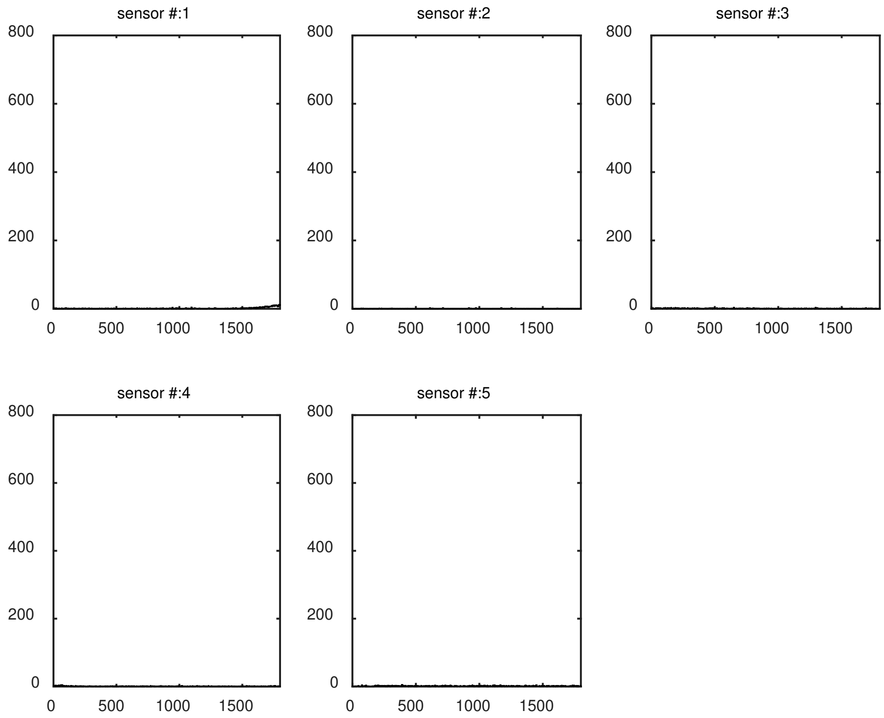


Figure 7.7. 900sec measurements for soil sample #1 with 6 LDR sensors and 5 red laser lights.