1.1 Motivation

Learning disability or specific learning disability is a lifelong neurodevelopmental disorder which manifest in childhood as persistent difficulties in learning to efficiently read, write or do simple mathematical calculations despite normal intelligence, conventional schooling, intact hearing and vision, adequate motivation and socio-cultural opportunity [1]. It is now known that a learning disability is not connected to mental retardation. The learning disabled frequently have high IQs. It is also not a single disorder, but includes disabilities in any of areas related to reading, language and mathematics.

During the past few decades, the understanding of learning disability has changed. However, it is a tremendous challenge to identify and diagnose and
assist children with learning disability. As the concept is still new, in many developing countries including India, the research conducted in learning disability has been primarily done over the last two decades and is yet in the infancy stage. In India, the research conducted in learning disability has been primarily done over the last two decades and is today comparable with the research carried out in west nearly half a century ago.

Since no national census of the learning disabled has been taken in India, it is difficult to collect their actual number. In India, the learning disabled children are not identified using reliable tests. However, at least 10% of children in India have a learning disability [2]. We do not have a clear idea about incidence and prevalence of learning disability in India. These facts suggest that the early diagnosis of learning disability in children is critically important to identify and suggest remedial solutions to the parents and children to understand about the learning disability as stumbling blocks such as lack of awareness, indifference and apathy and hamper success.

The problems of LD affected children have been a cause of concern to parents and school authorities for some time. With the right help at right time, right assessment and remediation, children with LD can and do learn successfully and become winners in the society later. Since LD has distinctive symptoms in its early stage, diagnosis approaches have been improved noticeably over the past decades in many counties. Research works done in this area using computer based methods is found very little compared to the magnitude of learning disability affected children.

The present method available to determine LD in children is based on check lists containing the symptoms and signs of LD. This traditional method is time consuming, not accurate and obsolete also. Such LD identification facilities are much less at schools or even in cities. Parents are either unaware or
may not willing to take their children to undergo such an evaluation. Even if, teachers are advised, parents may hesitate to such evaluation process because of the unawareness of the society about LD as they might think that the child may be mentally retarded. If the LD determination facility is attached with schools and the check ups are arranged as a routine process, LD can be identified at an early stage.

Under these circumstances, it is felt to design a tool based on machine learning techniques for prediction of learning disability in school-age children. Hence, it is decided to carry out a research work in the topic in a view to increase the diagnostic accuracy of learning disability prediction. Based on the statistical machine learning tool developed, the presence and degree of learning disability in any child can be determined accurately at an early stage.

1.2 Problem Statement

The main problem considered in this work for analyzing and solving is the design of a tool based machine learning technique for prediction of learning disability in school-age children. The problem also involves in identifying the important parameters of LD, identifying the hidden relationship between the symptoms of LD and estimating the relative significance of each symptoms of LD using data mining techniques. The drawbacks in the existing classification algorithms have also to be determined first. Then how these algorithms can be effectively modified and used in the prediction and classifications of learning disabilities are studied. Thus the main task of the study is to find out how effectively the different classification algorithms existing in data mining can perform the prediction of learning disabilities. The problem also involves how these drawbacks in the existing algorithms has determined while performing the prediction of LD and how these are eliminated to maximize the accuracy of the
This research work has faced difficulties in collecting data from clinics and schools. Either the doctors or the school authorities are not like to reveal the data related to LD affected children. As there are no such related works in the field, we felt difficulties in acquiring data as well as normalizing the attribute values. However, we convinced the professionals in the field regarding the necessity and effectiveness to be achieved, they agreed to sit along with them during clinical consultations. Then from the experience gained with them for the long term, we could evaluate the deficiencies in their traditional methods of LD evaluation and thereby formed new informal checklists, which have been approved by them and they are now using it.

1.3 Data Mining

In recent years the sizes of databases has increased rapidly. The amount of data in the world seems to go on increasing and there is no end. In data mining, the data search is automated by computer and stored electronically. This has lead to the development of tools capable in the automatic extraction of knowledge from data. The term Data Mining or Knowledge Discovery in Databases, has been adopted for a field of research dealing with the automatic discovery of implicit information or knowledge within databases [3]. Data mining is defined as the process of discovering patterns in data. It is the non trivial extraction of implicit previously unknown and potentially useful information about data. It is an analytic process designed to explore data in search of consistent patterns and/or systematic relationships between variables, and then to validate the findings by applying the detected patterns to new subsets of data [4]. The data mining process must be automatic or semiautomatic. The patterns discovered must be meaningful in that they lead to
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some advantage, usually an economic advantage [5]. Conventionally the
construction of model of the semantic structure of the dataset is the information
that is mined. The model might be utilized for prediction and categorization of
new data. Diverse fields such as marketing, customer relationship management,
engineering, medicine, crime analysis, expert prediction, web mining and
mobile computing besides others utilize data mining [6]. A majority of areas
related to medical services such as prediction and classification of effectiveness
of surgical procedures, medical tests, medication and discovery of relationship
among clinical and diagnosis data also make use of data mining methodologies
[7]. The kind of learning techniques that do not use the conceptual problems, it
is called machine learning.

The mining software is one of the analytical tools for analyzing data. It
allows users to analyze data from many different dimensions or angles,
categorize it and summarize the relationships identified. Technically, it is the
process of finding correlations or patterns among a lot of fields in large
relational databases. The patterns, associations, or relationships among all this
data can provide information. Data mining provide a link between the
transaction and analytical systems. Any one of the following four types of
relationships is generally mined for determining the existing patterns in the data
base. These relationships are classes, clusters, associations and sequential
patterns. Stored data is used to locate data in predetermined groups known as
Classes. Data items are grouped according to logical relationships are clusters.
Data can be mined to identify associations and sequential patterns are the data
mined to anticipate behavior patterns and trends. The three stages consists in
the process of data mining are initial exploration, model building and
predictions. Different levels of analysis available are artificial neural networks,
genetic algorithms, decision trees, rule induction and data visualization.
Data mining has an inherent connection with statistics. Statistics studies the collection, analysis, interpretation or explanation and presentation of data. A statistical model is a set of mathematical functions that describe the behavior of the objects in a target class in terms of random variables and their associated probability distributions. Statistical models are widely used to model data and data classes. Applying statistical methods in data mining is far from trivial [8]. When applying the high complex algorithm, data mining is required to continuously handle fast, real time data stream. In general the statistical methods are categorized in to two, viz. parametric and nonparametric methods.

Classification and prediction are the ultimate goals of data mining. Classification is the process of finding a model that describes and distinguishes data classes or concepts, for the purpose of being able to use the model to predict the class of objects whose class label is unknown. The derived model is based on the analysis of a set of training data.

In this research work, different classifications methods and models such as neural network, decision tree, support vector machine, rough set, fuzzy set and neuro fuzzy are used. The data sets are undergone to classification through these methods or models. Then these models are used for prediction of learning disabilities.

1.4 Statistical Machine Learning

Learning is an essential human property. It is the process by which observed data is used for constructing models with the intention to use them for prediction. Machine learning, a branch of artificial intelligence, is a scientific discipline concerned with the design and development of algorithms that allow computers to evolve behaviors based on empirical data, such as from sensor data or databases. The general idea behind the statistical method is the detection
of class to learn a generative model fitting the given datasets and then to identify the objects in low probability regions of the model as the class. However in different ways we can learn generative models.

A major area of the machine learning research is to learn automatically in recognizing complex patterns and make intelligent decisions based on data. The difficulty lies in the fact that, the set of all possible behaviors, given all possible inputs is too large, to be covered by the set of observed examples. Hence the learner must generalize from the given datasets, so as to be able to produce a useful output in new cases. Machine learning is concerned with the development of algorithms and technique that allow computers to learn. Machine learning has wide spectrum of applications including natural language processing, search engines, medical diagnosis, detecting credit card fraud, stock market analysis, etc. [6]. Some fundamental types of learning are supervised learning, unsupervised learning, reinforced learning, etc. In the research work different supervised algorithms and unsupervised algorithms are used for predicting the learning disability accurately.

1.5 Learning Disability

The term ‘Learning Disabilities (LD)’ is a relatively new one. It was first used by Dr. Samuel Kirk of Chicago, USA in 1963. The Children with Specific Learning Disabilities Act (USA) was passed in 1969. However, it was not until 1990s that the biological basis for LDs found support. Specific learning disability which includes dyslexia, dysgraphia, dyscalculia is commonly referred to as ‘Learning Disability’ or ‘LD’ in India. Now special educators for remediation are available in India [9].

A learning disability is found across all ages and socio-economic classes. It is not a type of mental retardation as sometimes mistakenly thought,
in fact, IQ scores could fall in the very high range [10]. LD is a hidden handicap that affects academic achievement, vocational career and social life [11]. Every child born in this world gets the care and comfort from the family in which he or she is born. But the children with disability cannot enjoy and get such care and comfort from the family [11]. If a child grows, he develops into a worthy citizen. These children are able to quantify well and prove their worth. Similarly the society expects the same from the disabled students also, here the children failed. Specific learning disabilities have been recognized in some countries for much of the 20th century, in other countries only in the latter half of the century, and yet not at all in other places [12]. These may be detected only after a child begins school and faces difficulties in acquiring basic academic skills.

Learning disability is a general term that describes specific kinds of learning problems. It is a neurological disorder that affects a child's brain and impairs his ability to carry out one or many specific tasks. The LD affected children are neither slow nor mentally retarded [12]. They have either normal or above average intelligence. A child with a learning disability is often wrongly labeled as being smart but lazy. A learning disability can cause a child to have trouble learning and using certain skills. The skills most often affected are: reading, writing, listening, speaking, reasoning and doing math. There is no cure for learning disabilities [13]. There are also certain clues, most relate to elementary school tasks, because learning disabilities tend to be identified in elementary school, which may mean a child has a learning disability. A child probably won't show all of these signs, or even most of them. They are life-long. However, children with LD can be high achievers. They can be taught ways to get around the learning disability. With the right help, children with LD can and do learn successfully.
Learning disability is a disorder in which a child has difficulty in learning in a typical manner, usually caused by an unknown factor or factors. The unknown factor is the disorder that affects the brain's ability to receive and process information [14]. This disorder can make it problematic for a child to learn as quickly or in the same way as some child who isn't affected by a learning disability. Learning disability is not indicative of intelligence level. Rather, children with a learning disability have trouble performing specific types of skills or completing tasks if left to figure things out by themselves or if taught in conventional ways. A learning disability cannot be cured or fixed. There are also certain clues, most relate to elementary school tasks, because learning disabilities tend to be identified in elementary school, which may mean a child has a learning disability. A child probably won't show all of these signs, or even most of them. Even where they have been recognized, the amount of help available varies from no services to their universal provision. This unevenness in intervention services is tragic since most children with learning disabilities who receive sufficient, knowledgeable remediation can proceed through the school system and attain jobs that range from professor to labourer. Conversely, if they are not helped, the possibility of adjustment of problems arising is considerable. As our world becomes more complex, the knowledge base increases and the concepts more abstract, an increasing number of children will experience difficulty and be assumed to have learning to our collective lives is not forfeited.

Learning disabilities are formally defined in many ways in many countries. However, they usually contain three essential elements: a discrepancy clause, an exclusion clause and an etiologic clause. The discrepancy clause states there is a significant disparity between aspects of specific functioning and general ability; the exclusion clause states the disparity is not primarily due to
intellectual, physical, emotional, or environmental problems; and the etiologic clause speaks to causation involving genetic, biochemical, or neurological factors [15].

As many as 1 out of every 10 children in the United States has a learning disability. Almost 3 million children (ages 6 through 21) have some form of a learning disability and receive special education in school [12]. In fact, over half of all children who receive special education have a learning disability [15]. A learning disability often displays a cluster of characteristics over time, in various intensities, which interfere with his/her overall development and achievement. LD affected children can face unique challenges that are often spreading throughout their lifespan. Depending on the type and severity of the disability, interventions may be used to help the individual learn strategies that will foster future success. Some interventions can be quite simplistic, while others are intricate and complex. Teachers as well as parents will be a part of the interventions. They can give aid to the children successfully in completing different tasks. School psychologists quite often help to design the intervention and coordinate the execution of the intervention with teachers and parents. With the right support and intervention, LD affected children can succeed in school and go on to be successful later in life. Social support is also a crucial component for these type children in the school system and should not be overlooked in the intervention plan. Parents of LD affected children often find themselves attempting to cope with a bewildering array of problems. Their children appear to be intelligent but they encounter all kinds of obstacles in school [16].

In India the term disability is used synonymously as impairment, and handicap or disability. These terms are different. The impairment means, the loss of physical or sense organs. The child has not able to see, it is disability.
Handicap is the result of impairment and disability. Learning disability is a broad term that covers a wide range of problems, including dyslexia and behavioral problems and the full range of ability. If a child having learning disability, that child requires special education needs. Learning disabilities vary from child to child. One child with LD may not have the same kind of learning problems as another child with LD [13].

This lifelong disability can interfere with the students’ acquisition of academic and other basic skills necessary for survival as an independent adult. Some of the common signs of learning disabilities and learning disorders in children will be able to catch the problem early and take steps to get help to child. It is very important in paying attention to normal developmental milestones for toddlers and preschoolers. As early detection of developmental differences is an early signal of a learning disability and thus the problems that are spotted early can be easier to correct.

LD is real and a stumbling block for a nation’s development process. The problems of children with specific learning disabilities have been a cause of concern to parents and teachers for some time. When a LD is suspected based on parent and/or teacher observations, a formal evaluation of the child is necessary. A parent can request this evaluation, or the school might advise it. Parental consent is needed before a child can be tested. Many types of assessment tests are available. Child's age and the type of problem determines the tests that child needs. A complete evaluation often begins with a physical examination and testing to rule out any visual or hearing impairment [15]. Pediatricians are often called on to diagnose specific learning disabilities in school- age children. Many other professionals can be involved in the testing process.

The purpose of any evaluation for LDs is to determine child's strengths
and weaknesses and to understand how he or she best learns and where they have difficulty. The information gained from an evaluation is crucial for finding out how the parents and the school authorities can provide the best possible learning environment for the child.

Depending on the type and severity of the disability, interventions may be used to help the individual learn strategies that will foster future success. Some interventions can be quite simplistic, while others are intricate and complex. Teachers and parents will be a part of the intervention in terms of how they aid the individual in successfully completing different tasks. School psychologists quite often help to design the intervention and coordinate the execution of the intervention with teachers and parents. Social support can be a crucial component for students with learning disabilities in the school system and should not be overlooked in the intervention plan. With the right support and intervention, children with learning disabilities can become great success in school as well as later in the society.

1.5.1 Concept of Learning Disabilities

Learning Disability is a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities. These disorders are intrinsic to the individual presumed to be due to central nervous dysfunction, and may occur across the life span [10] irrespective of regionwise.

Based on the frequency of occurrence, the important characteristics of learning disability are

(i) Disorders of attention
(ii) Perceptual impairments
(iii) General coordination deficits
(iv) Disorders of memory and thinking
(v) Specific difficulties in the areas of reading, arithmetic, writing and spelling and
(vi) Disorders of speech and hearing

Attention is the ability to concentrate on a task long enough to grasp its essential features [11]. Learning disabled children are having short attention span and lacking in concentration, but this does not mean that all inattentive children are learning disabled. A child may have an attention disorder for many reasons. A significant characteristic frequently associated with learning disability in a child is hyperactivity, although the relationship between the two is still not clearly substantiated. Some expert refers to hyperactivity as an attention deflects hyperactivity disorder. Hyperactivity is a much misunderstood term and widely misused.

Children with learning disability are generally characterized by inefficient memory systems. There is little doubt that in the area of academic learning, children with learning disability are low achievers. They may have problem in the specific areas of reading, writing and mathematics, although it is not necessary that a child poor in spelling will also be poor in mathematics. Listening is a complex process that requires good attention, discrimination and memory systems. The child may use a lot of fillers such as articulation difficulties. Learning disabled individual could make grammatical errors while talking and use words incorrectly. Research in the area of learning disability has primarily focused on assessment and diagnosis.

There is no one sign that shows a child has a learning disability. Experts look for a noticeable difference between how well a child does in school and how well the child could do, given his or her intelligence or ability. There are certain general symptoms that may mean a child has a learning disability. A child
probably won't show all of these signs, or even most of them. However, if a child shows a number of these problems, then parents and the teacher should consider the possibility that the child has a learning disability. Parents need to be especially alert to developmental delays as a child approaches school age [16].

When a child has a learning disability, he or she may show some symptoms. Some of these common symptoms are listed below [17];

(i) may have trouble learning the alphabet, rhyming words or connecting letters to their sounds;
(ii) may make many mistakes when reading aloud and repeat and pause often;
(iii) may not understand what he or she reads;
(iv) may have real trouble with spelling;
(v) may have very messy handwriting or hold a pencil awkwardly;
(vi) may struggle to express ideas in writing;
(vii) may learn language late and have a limited vocabulary;
(viii) may have trouble remembering the sounds that letters make or hearing slight differences between words;
(ix) may have trouble understanding jokes, comic strips and sarcasm;
(x) may have trouble following directions;
(xi) may mispronounce words or use a wrong word that sounds similar;
(xii) may have trouble organizing what he or she wants to say or not be able to think of the word he or she needs for writing or conversation;
(xiii) may not follow the social rules of conversation, such as taking turns, and may stand too close to the listener;
(xiv) may confuse math symbols and misread numbers;
(xv) may not be able to retell a story in order (what happened first, second, third); or
(xvi) may not know where to begin a task or how to go on from there.
1.5.2 Basic Types of Learning Disabilities

As pointed out earlier, learning disability is a lifelong disorder that affects the manner in which, individuals with average or above average, intelligence select, retain and express information. It reflects a difficulty in encoding and decoding information as it travels between the senses and the brain. Learning disabilities are also termed as ‘learning differences’, based on the fact that certain individuals learn differently - they are not unable to learn, but respond best to ways of learning that are different from traditional teaching methods.

Many gifted and talented children are often misdiagnosed as having learning disabilities or behavior disorders. This occurs because there are many characteristics of gifted children, both social and emotional, that are mistaken as symptoms of specific learning disorders. It is not uncommon for some gifted children, with IQ scores over 140 to display a significant discrepancy between Verbal IQ and Performance IQ and possess characteristics of a learning disability. Often gifted children have unusual learning styles, and even though they are very intelligent, they may also have learning disorders.

Learning disabilities tend to be diagnosed only when a child reach school age. This is because school focuses on the very things that may be difficult for the child — reading, writing and math, listening, speaking and reasoning. Teachers and parents notice that the child is not learning as expected. The school may ask to evaluate the child to see what is causing the problem. Parents can also ask for their child to be evaluated. With hard work and the proper help, children with LD can learn more easily and successfully. It's important to remember that a child may need help at home as well as in school.
A developmental lag might not be considered as a symptom of a LD until the child is older, but we can intervene early if we recognize it when the child is young. The activity of diagnosing the type of learning disability can be overwhelming and time consuming. Try not to get caught up in trying to determine the label or type of disorder and focus instead on figuring out how best to support the child. The checklist, organized by skill set and age group, can help in evaluating the child’s signs and symptoms and indicate whether seek further assistance from a teacher or professional skilled in diagnosing learning disabilities. Types of learning disabilities are often grouped by school area skill set or cognitive weakness. If the child is in school, it will probably be apparent if he or she is struggling with reading, writing, or math, and narrowing down the type will be easier.

The common types of Learning Disabilities are explained below;

i. **Dyslexia** - Difficulty processing language- Problems in reading, writing, speaking.

   It is the most common type of LD affecting in children. It refers to a specific difficulty in the area of reading. The terms generally used instead of dyslexia are severe reading disability, primary reading disability, specific reading disabilities and word blindness. It has been estimated that of the children who attend school, approximately 10% to 15% have some difficulty in reading and 85% to 90% percentage of all learning disabled children have reading problems. Boys with reading problem outnumber girls at the surprising rate of 4 to 1. In fact dyslexia has becomes synonymous with learning disability to such an extent that it has been suggested that dyslexia should be used as an umbrella term for all learning disability in general. All learning disabilities are not dyslexia and the same time dyslexia does not exemplify all learning disabilities. Dyslexia is a
broad term describing a reading disability. The word dyslexia implies the meaning **difficulty with words**. It affects a child’s ability to read. It is neurological in origin, likely to be present at birth and its effects are lifelong. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction [10].

Learning disabilities in writing can involve the physical act of writing or the mental activity of comprehending and synthesizing information. Expressive writing disability indicates a struggle to organize thoughts on paper. Symptoms of a written language learning disability revolve around the act of writing and include. They include problems with neatness and consistency of writing, accurately copying letters and words, spelling consistency, writing organization and coherence. Signs of a language based learning disorder involve problems with verbal language skills, such as the ability to retell a story and the fluency of speech, as well as the ability to understand the meaning of words, parts of speech and directions.

ii. **Dyscalculia** - Difficulty with math- Problems doing math problems, understanding time, using money.

In 1919, Henschen reported that number blindness could occur independently of specific reading disability [10]. Some persons observed that memory and order disorders frequently occurred along with numerical problems. Dyscalculia may result from lesions in widely disparate regions of the brain. Dysfunctions associated within left temporal lobe were characterized by difficulties with complex operations involving a sequence
of steps or mental or oral calculation or reasoning. These disorders are termed as secondary arithmetic disturbance. Children with learning disabilities exhibit a variety of deficits in the area of mathematics. Shape discrimination, size discrimination, sets and numbers and counting are the different areas of dyscalculia.

Learning disabilities in math vary greatly depending on the child’s other strengths and weaknesses. A child with a math based learning disorder may struggle with memorization and organization of numbers, operation signs, counting principles or have difficulty telling time.

**iii. Dysgraphia** - Difficulty with writing- Problems with handwriting, spelling, organizing ideas.

Disorders of written language are referred to as dysgraphia and this include difficulties in three areas of handwriting, spelling, content [10]. Many learning disabilities authorities have expounded why writing is so important and how it can be taught to learning disabled students [18]. The key characteristics associated with dysgraphia includes the main areas of written language –handwriting, spellings and the content. Usually these are interlinked problems and it is expected that a child having difficulties in any one of these areas may experience a spill over in the others too. Most disabled children hate to write and avoid it wherever it possible. Lack of motivation becomes a real obstacle and a teacher needs to be at her creative best when encouraging learning disabled child to write.


Motor difficulty means problems with movement and coordination whether it is with fine motor skills like cutting, writing, etc. or gross motor
skills like running, jumping etc. A motor disability relates to the output of information from the brain. In order to run, jump, write or cut something, the brain must be able to communicate with the necessary limbs to complete the action. Signs that the child might have a motor coordination disability include problems with physical abilities that require hand–eye coordination, like holding a pencil or buttoning a shirt.

v. **Auditory Processing Disorder** - Difficulty hearing differences between sounds- Problems with reading, comprehension, language.

   The ability to hear things are greatly impacts the ability to read, write and spell, but an inability to distinguish slight differences in sound or hearing sounds at the wrong speed make it hard to explore words and understand the basic concepts of reading and writing. Problems in visual perception include missing slight differences in shapes, skipping lines, skipping words, reversing letters or numbers, misperceiving depth or distance or having problems with eye–hand coordination. In addition to the above, the other disorders that make learning difficulty are anxiety, stressful events, emotion, depression and other conditions affecting concentration make learning more of a challenge.

vi. **Visual Processing Disorder** - Difficulty interpreting visual information- Problems with reading, math, maps, charts, symbols, pictures.

vii. **Attention Deficit Hyperactivity Disorder (ADHD)**

   It is a neurobiological disorder that starts early in childhood and can continue into adulthood. The disorder is characterized by a delay or permanent inability to self-regulate behavior or to control behavioral responses.
viii. Social And Emotional Difficulties

Sometimes kids have trouble expressing their feelings, calming themselves down and reading nonverbal cues, which can lead to difficulty in the classroom and with their peers. Social and emotional skills are an area where the parent can have a huge impact. For all children, but especially those with learning disabilities, social and emotional skills are the most consistent indicators of success, outweighing everything else, including academic factors. Certain personal qualities and social relationships are very much needed by the learning disabled children to make a satisfactory adjustment to post school life [18].

1.5.3 Assessment and Remediation

LD can be a lifetime condition. There may be several apparent overlapping learning disabilities in some children while others may have a single, isolated learning problem that has little impact on their lives. LD is diagnosed by a qualified child psychologist in association with a pediatrician. The process of diagnosing a learning disability can be confusing. It shall be started with the child's school. It involves testing, history taking and observation by a trained specialist. A series of tests may be required to be done to identify the affected areas. Special education brings some solution to the problems the children affected with LD. Finding a reputable referral is important. Since the educational needs of such children are different they will be given special academic sessions in an integrated set up. Other professionals such as speech therapist for children with speech disorder and physiotherapists to those with motor deficits may be required. In some case psychotherapist may also be involved in the treatment process.
When a LD is suspected based on parent and/or teacher observations, a formal evaluation of the child is necessary. A parent can request this evaluation, or the school might advise it. Parental consent is needed before a child can be tested. Periodic evaluation of such children done to check for improvement will help so that they can be integrated into the mainstream society as soon as possible.

1.5.3.1 Assessment of LD

Assessment is the systematic process of collecting information about a child, his past and current levels of performance his strength and weakness, in order to help make better education decisions [10]. Assessment needs to be relevant to the teaching goals and interventions that the child will receive. Assessment is directly linked with how one will go about helping the child. It is linked with intervention methods. The information collected through the assessment must be relevant and of practical help in the class room. Assessment helps parents to better understand their child’s problems and adjust their expectations on the basis of the assessment data. It is pertinent to note that, in India the history of LD assessment is still in its infancy.

Many types of assessment tests are available. Child's age and the type of problem determine tests that child needs. Before any formal testing, a conference is usually arranged between the child's parents and representatives from the special education department. A factor that prevents accurate diagnosis of twice exceptional is the prevalent practice of comparing gifted children with the norms for average children. In psychology, as well as in other therapeutic fields, such as audiology, speech pathology, occupational therapy and optometry, the diagnostic question that is usually asked is how this child’s performance compares with the norm. If the child scores within the normal range, no disabilities are detected.
The purpose of any evaluation or assessment for LDs is to determine child's strengths and weaknesses and to understand how he or she best learns and where they have difficulty. A major factor that makes it difficult to assess a learning disabled child is the confusing nature of the disability itself. The absence of testing instrument relevant to Indian students is another major drawback. Most tests are designed for native English speakers and have items which lie outside the cultural experience of the average Indian student. Assessment can be expensive too.

Just as there are many different types of LDs, there are a variety of tests that may be done to pinpoint the problem. Examples of the types of testing and evaluations include:

(i) Interviews and direct observation of the child.

(ii) Review of the child's educational and medical history.

(iii) Parent conferences (a parent's input is of great importance because the parent have observed the child since birth and can provide important details about his or her growth and development).

(iv) IQ testing and psychological evaluation usually performed by a psychologist or psychiatrist.

(v) Developmental history or social assessment.

(vi) Speech and language evaluation usually performed by a speech therapist.

(vii) Evaluation of fine motor skills, visual-motor integration and sensory integration usually performed by an occupational therapist.

(viii) Evaluation of gross motor skills, muscle tone and balance usually performed by a physical therapist.
Two approaches are generally used to describe testing or the assessment. They are formal and informal testing. The former uses standardized testing while the latter uses non-standardized testing [10]. The standardized test demands a high degree of uniformity in administration and interpretation. They allow comparison of students of the same age or grade and can be used individually or in groups. Informal tests or assessment are non-standardized procedure used by teachers and other professionals to collect information. The advantage of informal test is that they are simple to construct, administer and score. They targeted at a specific objective and are of greater value for making instructional decisions. The most frequently used informal procedures are observations, interviews, questionnaires and tests. Check lists and rating scales are another way of collecting behavioral data.

Generally, there are about 40 characteristics of LD, any one or more is found in LD affected children. These characteristics in the form of a check lists are used in the traditional methods of assessment of LD. These assessment questions are formed based on discussions made with professionals/doctors engaged in LD assessment fields. These 40 characteristics of LD, expressed in the form of a questionnaire are listed below [17];

1. Do you find words difficult to spell?
2. Are you unsure about the use of full stops capital letters etc.?
3. Do you feel unsure about how to tackle reading unknown words?
4. Do you get very frustrated with your own performance?
5. Do you find it difficult to understand what you have read the first time?
6. Are you unsure how to organize writing a letter, a report or an essay?
7. Do you limit your writing to words you know you can spell?
8. Do you feel you have to read every word on the page?
9. Can you spell a word one day and forget it the next?
10. Do you miss deadlines because you didn’t start early enough?
11. Do you find it difficult to listen and write at the same time?
12. Do you find it difficult to take message on the telephone?
13. Do you have difficulty in telling the difference between sounds?
14. Do you read slowly?
15. Do you have to ‘see’ and ‘feel’ if a word looks right?
16. Do you mix up dates and appointments so that you miss them or are double booked?
17. Do you get numbers mixed up? e.g. roll numbers, telephone numbers?
18. Do you panic when you get to unknown words?
19. Do you confuse the order of the months of the year?
20. Do you remember words one day and forget them the next?
21. Do you find it difficult to follow written instructions?
22. Do you have days when things go dramatically wrong and equally days when things go really well?
23. Do you find organizing your thoughts difficult?
24. When writing do you think that you end up with really what you wanted to say?
25. Is map reading difficult?
26. Do you find it difficult to remember what you have read?
27. Do you find you have too many ideas to maintain focus?
28. Do you say the wrong word in the wrong place or at the wrong time?
29. Do you get the order of the letters wrong when writing?
30. Do you think your spelling weak?
31. Do you find organizing your life difficult?
32. Do you have difficulty telling left from right?
33. Does the print blur or move around as you are reading?
34. Do you find it difficult to skim and scan for information?
35. Is it difficult to see the detailed steps needed to complete a task?
36. Do you forget things quickly?
37. Do you have problems saying long words?
38. Do you lack confidence in yourself and think others are better than you?
39. Do you find it confusing putting sounds together to pronounce words?
40. Do you dislike reading aloud?

In the present research work, the method of informal assessment is adopted for designing the tool for predicting the learning disabilities in children. Even though different types of checklists are generally available for assessing LD characteristics, a checklist containing the 16 most frequent and important characteristics (signs & symptoms) of LD collected from the above 40 general characteristics, after eliminating the unwanted and redundant ones, is prepared suiting to the LD conditions generally prevailing in Kerala. This general check list adopted in this research work is shown in Table 1.1 below. As this check list is prepared based on the experience of professionals including outside India, the same is not region wise [24]. This check list is used as first phase of LD assessment. Based on which, new check list is developed incorporating
additional symptoms, viz. sub attributes, with different scores for each, as discussed in Chapter 3. The new check list developed given at Table 3.3 is used in the study of determination of LD, which can be used irrespective of region. The increase in number of characteristics, if any, will merely increase the prediction time.

**Table 1.1 General check list**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Indicators of LD</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Difficulty with Reading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Difficulty with Spelling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Difficulty with Handwriting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Difficulty with Written Expression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Difficulty with Basic Arithmetic skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Difficulty with Higher Arithmetic skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Difficulty with Attention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Easily Distracted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Difficulty with Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Lack of Motivation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Difficulty with Study Skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Does Not like School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Difficulty in Learning a Language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Difficulty in Learning a Subject</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Slow To Learn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Repeated a Grade</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The general check list can be easily used by the parents and teachers. It is used to investigate the presence of learning disability. It includes the general indicators of learning disability and focuses on understanding of the learning disability. The goal is to provide concise and accurate set of diagnostic
attributes which can be implemented in a user friendly and automated fashion. If a child has unexpected problems learning to read, write, listen, speak, or do math, then teachers and parents may want to investigate more. The same is true if the child is struggling to do any one of these skills. The child may need to be evaluated to see if he or she has a learning disability.

The expert trained to do psychological testing and result interpretation are clinical psychologists, school psychologists, educational psychologists, developmental psychologists, neuropsychologists, occupational therapists, speech and language therapists. Several professionals coordinate services as a team to obtain an accurate diagnosis, including input from the child’s teachers. Recommendations can then be made for special education services or speech language therapy within the public school system. If the public school is not working out, then a nonpublic school provide specializes in treating learning disabilities might be a good alternative. A professional learning disorders specialist might refer to the importance of integration to learning.

1.5.3.2 Remedial solutions

Although several products are available for the identification and remediation of learning disabilities, most of these are either unable to sustain the progress of a disabled child or not aligned to government standards [19]. Pre-assessment helps separate the regular performers from the children who have special needs. Parents and teachers can and should take an active role in the child’s education.

All children can be both exhilarating and exhausting, but it may seem that the child with a learning disability is especially so. Parents and teachers may experience some frustration trying to work with the child, and it can seem like an uphill battle. After the parents learn what their specific learning
disability is and how it is affecting their behavior, they will be able to start addressing the challenges in school and at home. A child with a learning disability cannot try harder, pay closer attention, or improve motivation on their own; they need help to learn how to do those things [20].

As a parent, discovering that something may stand in the way of the child’s success can be unsettling and difficult. Whether or not the child has a learning disability, remember that the way the parents and teachers behave and what they do has the most impact on the child’s chances of success. Everyone faces obstacles and the most important thing the parents and teachers can show the child, apart from the consistent love and support and is how to deal with obstacles. A good attitude won’t solve the problem, but it can give the child hope and confidence that things can improve. The first task as the parent of a child with a learning disability is to recognize that there are many things the parents can do to help the child.

Parents often teach children to compensate for weaknesses, and gifted children learn compensation strategies more quickly than their less capable peers. What they neglect to tell the children is that compensation can break down under various conditions. It takes more energy to compensate and when one is fatigued, ill, stressed, dieting too strenuously, or adjusting to a new situation, there may not be sufficient energy to support the compensation strategy. So the individual is likely to experience good days when the compensations work well, and bad days when they fail. They need to understand that their high intelligence is revealed on their good days and that there will be bad days, when their compensations, like bad brakes, fail to support them.

Special education brings some solution to the problems of children affected with LD [10]. They have to be given special academic sessions in an
integrated set up as their educational needs are different. Periodic evaluations of such individual children have to be done, to check for improvement, which will help them to integrate them into the mainstream society as soon as possible. Nowadays, meeting the challenges in schools, most of the school authorities are compelled to appoint resource persons/counselors in LD to diagnose the same and attain early detection and remedies to improve the school atmosphere and results.

1.6 Objectives of the Present Study

The following are the objectives of the research work:

i. Identifying the important parameters of LD using data mining techniques,

ii. Identifying the hidden relationship between the symptoms of LD,

iii. Estimating the relative significance of each symptoms of LD,

iv. Developing a new method for improving the accuracy of classifiers,

v. Developing fuzzy and rough set models in LD prediction; and

vi. Design a tool based on machine learning techniques for prediction of LD.

1.7 Scope of Work

The scope of research work includes the following;

i. Collection and preparation of real world data set,

ii. Knowledge extraction from domain experts,

iii. Prediction of LD with the help of machine learning algorithms,

iv. Identifying the frequent symptoms of LD,

v. Development of new approaches for LD prediction,

vi. Identification of the problems related to the classification accuracy,
vii. Development of new algorithms for overcoming the identified problems,
viii. Application of new algorithms developed on existing classifiers,
ix. Developing new models in LD prediction with fuzzy and rough set approaches
x. Development of an integrated knowledge based tool for the prediction of learning disability,
xi. Determination of the performance of the developed tool; and
xii. Applicability and use of the developed tool in LD prediction.

1.8 System Framework

The main aim of the proposed research work is to design a tool based on machine learning techniques for accurate prediction of learning disability in school-age children and to effectively measure the percentage of LD present in the child, according to the knowledge obtained from the clinical information. The basic idea of the proposed knowledge based system is to detect the LD at an early stage and to increase the accuracy of the learning disability assessment and reduce the time consumed for the same. For achieving these goals, different statistical machine learning technique are used. Towards the achievement of the full objectives, a learning disability tool is constructed. The proposed tool has many advantages compared to the traditional methods of learning disability determination using check lists. These advantages include; consumption of less manpower and time, the accuracy and efficiency underlying and handling of missing values and redundant data. For the assessment of LD, check lists containing the signs and symptoms of LD (attributes) are used. Obtaining a full fledged information table by interviewing a child will not be a success in all time as the same depends on the mood of the child at the moment of interview. In such occasions, the data may contain missing values. To overcome such a
problem, missing value imputing by applying closest fit algorithm and correlation based new methods developed are adopted in this research. Also there are cases of most of the attributes in the data are unwanted and/or redundant. To overcome this problem, dimensionality reduction method using Principal Component Analysis (PCA) is applied.

The learning disability prediction tool is designed using the five classification methods viz. modified neural network, modified decision tree, fuzzy, fuzzy with reduced attributes and ANFIS. After applying the data preprocessing on the data set, using closest fit algorithm or correlation based method, as the case is, and PCA, the classification methods viz. decision tree, fuzzy and ANFIS are applied.

In the developed tool, the knowledge obtained from the training is used to predict the new data along with the presence of LD and its percentage. In order to make the data appropriate for the mining process, it needs to be preprocessed. In data preprocessing, the redundant data is removed, the number of attributes is reduced and the missing values are imputed. The designed tool is very user friendly. It provides student information record which stores the details of the children in the student database, which can be retrieved as and when required.

1.9 Thesis Contributions

This thesis makes several major contributions. Based on the statistical machine learning tool developed, the presence of learning disability in any child with its percentage can be determined. The class of LD like low, minor and major and the percentage of LD in each class can also determined by this tool. The research work provides the new insights into the interrelationships between symptoms of LD, their relative importance and estimating the significance of
each symptoms of LD. It contributes in developing new models of LD prediction using fuzzy and rough sets and it succeeds in modifying the data preprocessing with J48 decision tree and neural network for LD prediction. The developed tool classifies LD as well as imputes the missing values in the data set accurately. The work developed new algorithm based on correlation for imputing missing values. The missing value imputing, done by the developed tool contributes strong classification results. The number of attributes is reduced by eliminating the unwanted ones by using PCA, helps in reducing the time. The tool developed gives accurate results in lesser time compared to the traditional assessment methods using check lists. The developed tool is very effective for finding the LD affected child from the large database. This research work has also considered an approach to handle learning disability database to predict frequent symptoms of the learning disabilities in school aged children. Early identification of LD will help the parents and school authorities to recommend the child for early remediation, which will ultimately help them to provide the child with best environment for his success. The study will certainly contribute in the development of the nation as LD is a real stumbling block for a nation’s development process.

Parts of this thesis work have been previously published as peer reviewed journal papers and conference papers as shown in the list of publications below.

1.9.1 List of publications


1.10 Road Map

The rest of this thesis is organized as follows;

A detailed literature survey is given in Chapter 2. Apart from the introduction, the chapter contains detailed literature review on learning disability as well as soft computing methods. The chapter ends with summary and conclusion.

Chapter 3 is detailing about the data collection and implementation of various soft computing methods. It begins with an introduction. The chapter explains about technical background, data collection, data sets, data distribution, knowledge extraction process, data normalization, attributes normalization and entropy of LD attributes. The various implementation methods adopted in this study such as neural network with back propagation algorithm, decision tree with J48 algorithm, support vector machine with sequential minimal optimization algorithm, bagging and fuzzy model are explained well with comparison and results and pointed out about the insights of LD. The chapter ends with summary and conclusion, and contributions.

Chapter 4 deals with improving performance by new pre-processing methods. After the introduction, imputing missing values with closest fit algorithm and with correlation based new algorithm developed, dimensionality reduction with PCA, and modified data pre-processing and performance
evaluation with MLP, decision tree, fuzzy model and neuro fuzzy model with reduced attribute are dealt with in detail. The chapter also contains details of study conducted on rough set model, apriori algorithm and clustering with k-means algorithm. This chapter ends with comparisons and results, summary and conclusions, and contributions.

Chapter 5 is development of an integrated knowledge based tool for LD prediction. After the introduction part, the chapter contains system flowchart, architecture of the tool and design of the tool. Tool testing, various screen shots and performance evaluation of the designed tool are also covered in this chapter. The chapter ends with summary and conclusions, and contributions.

The thesis concludes with Chapter 6, containing the summary of the work and contributions of the overall study. This chapter also discusses the future works and final conclusions.

1.11 Contemporary Works

There are only little studies available in the area of LD prediction with knowledge based theories, as mentioned below.

Tung-Kuang Wu, et. al. in 2008, studied two well-known artificial intelligence techniques, artificial neural network and support vector machine, to the LD diagnosis problem [24]. This study is based on the formal assessment of LD whereas the present research work relates to informal assessment of LD. Maitrei Kohli and Prasad T.V., in 2010, proposed an approach for identification of dyslexia and to classify potential cases accurately and easily by ANN [25]. As dyslexia is only a type of LD, the present research on general assessment of LD is entirely different from their study.
1.12 Summary and Conclusion

Learning disability is a classification including several disorders in which a child has difficulty learning in a typical manner, usually caused by an unknown factor or factors. The unknown factor is the disorder that affects the brain's ability to receive and process information. However, children with LD can be high achievers and can be taught ways to get around the learning disability.

Individuals with learning disabilities can face unique challenges that are often persistent throughout the lifespan. Depending on the type and severity of the disability, interventions may be used to help the individual learn strategies that will foster future success. Some interventions can be quite simplistic, while others are intricate and complex. Teachers and parents will be a part of the intervention in terms of how they aid the individual in successfully completing different tasks. School psychologists quite often help to design the intervention and coordinate the execution of the intervention with teachers and parents. Social support can be a crucial component for students with learning disabilities in the school system and should not be overlooked in the intervention plan. With the right support and intervention, children with learning disabilities can succeed in school and go on to be successful later in life.

When a LD is suspected based on parent/teacher observations, a formal evaluation of the child is necessary. Parental consent is needed before a child can be tested. Many types of assessment tests are available. Child's age and the type of problem determines the tests that child needs. A complete evaluation often begins with a physical examination and testing to rule out any visual or hearing impairment. Many professionals can be involved in the testing process. The purpose of any evaluation for LDs is to determine child's strengths and
weaknesses and to understand how he or she best learns and where they have difficulty. The information gained from an evaluation is crucial for finding out how the parents and the school authorities can provide the best possible learning environment for the child.

At present, the methods available for LD prediction and determination are quite less and not accurate. The identification of such problems are really challenging. In this research work, data mining using machine learning techniques are used to analyze the symptoms of LD, establish interrelationships between them and evaluate the relative importance of these symptoms. The diagnostic accuracy of learning disability prediction is increased by way of a knowledge based tool based on statistical machine learning. Identifying the important parameters of LD prediction using the data mining techniques, identifying the hidden relationship between the symptoms of LD and estimating the relative significance of each symptoms of LD are also covered. The developed tool has many advantages compared to the traditional methods of using check lists in determination of learning disabilities.