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Estimation of Serum Uric Acid, Lipids Profile and HbA1c in Diabetic and Hypertension Patients in River Nile State, Sudan

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Abstract

Diabetes mellitus (DM) is a chronic disease characterized by high blood glucose as a consequence of insulin deficiency and/or insulin resistance. Hyperuricemia has been reported in gout and used as biomarker for renal insufficiency. This study was aim to estimate serum uric acid level among diabetic patients with and without hypertension. Analytical cross sectional hospital based study conducted at diabetes friend's association center, River Nile state, Atbara, Northern Sudan, and carried out from March to October 2020.Hundred subjects were enrolled in the study, 50 diabetic patients without hypertension and other 50 diabetic with hypertension, the age and sex were match. The distribution of study population according to gender was 36% male and 64% was female, the age ranged between (10 - 85) years with their mean (48.83±14.11) years, while, the duration of the disease ranged between (1 – 20) years with their mean (6.650±4.35) years. The serum biochemical parameters were estimated using spectrophotometers, and the data was analyzed using SPSS version (25). All study parameters were insignificance except the blood pressure (Systolic and Diastolic) were a highly significances (p= 0.000).The BM1 and serum Cholesterol were significantly increased in study population among female than male. The serum uric acid was non correlated with age (r= Pearson Correlation – p= p.value) (r= -0.006, p= 0.954), BMI(r= 0.058, p= 0.568), Systolic pressure (r= 0.011, p= 0.910), diastolic (r= 0.081, p= 0.423), fasting blood glucose (r= 0.073, p= 0.423), duration of disease

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(r= 0.018, p= 0.858) and postprandial (r= 0.053, p= 0.604), the serum uric acid was negative correlated with HbA1c (r= -0.241, p= 0.016).

Key words: Serum uric acid, Hypertension, Diabetes mellitus, Sudanese, HbA1c.

المستخلص

داء السكري هو مرض مزمن يتميز بارتفاع نسبة السكر في الدم نتيجة لنقص في إنتاج الأنسولين أو مقاومة لعمل الأنسولين. زيادة نسبة حمض اليوريك في الدم مثل ما في حالة مرض النقرس تعتبر ايضا مؤشر بيولوجي للاصابة بالقصور الكلوي. هدفت هذه الدراسة الى تقيم مستوى حمض اليوريك في الدم لمرضى السكري المصابين وغير المصابين بارتفاع ضغط الدم . أجريت هذه الدراسة التحليلية المقطعية في مركز جمعية أصدقاء مرضى السكري بولاية نهر النيل ، مدينة عطبرة بشمال السودان في الفترة من مارس الى أكتوبر 2020 وتضمنت الدراسة مائة مشارك وكان خمسين منهم مريض بالسكري ولا يعانون من ارتفاع ضغط الدم و خمسين مريض بالسكري ويعانون ايضا من ارتفاع ضغط الدم ، كلا المجموعتين كانتا متماثلتين من حيث العمر والجنس. كان توزيع مجتمع الدراسة حسب الجنس (36٪) ذكور و (64٪) اناث ، وتراوح العمر بين (10 - 85) سنة بمتوسط (48.83 ± 14.11) سنة ، بينما تراوحت مدة المرض بين (1 - 20) سنة بمتوسط (6.650 ± 4.35) سنة. تم قياس مستوى حمض اليوريك في الدم باستخدام جهازالطيف الضوئى وتم أخذ نتائج السكر التراكمي HbA1c والسكر للصائم ومقياس الضغط وكتلة الجسم من الملفات للمرضى وتم تحليل البيانات بواسطة برنامج الحزمة الإحصائية للعلوم الاجتماعية الإصدار 25. أظهرت نتائج الدراسة فروقات غير معنوية في جميع المؤشرات باستثناء ضغط الدم (الانقباضي والانبساطي) فقد اظهر دلالة معنوية عالية. أوضحت نسبة الكوليسترول في الدم فروق معنوية بين الإناث مقارنة بالذكور. نسبة حمض اليوريك في الدم غير مرتبطة بالعمر (r = -0.006، p = 0.954) ، مؤشر كتلة الجسم (r = 0.058، p = 0.568) ، الضغط الانقباضي (r = 0.011، p = 0.910) ، الانبساطي (r = 0.081، p = 0.423) ، نسبة الجلوكوز في الدم عند الصيام (r= 0.073, p= 0.423)، مدة المرض (r= 0.018, p= 0.858) وبعد الأكل (r= 0.053, p= 0.604) ، حمض اليوريك في الدم مرتبط سلبيًا بالسكر التراكمي HbA1c (r= -0.241, p= 0.016) . خلصت الدراسة إلى أن مستوى حمض اليوريك في الدم مرتبط ارتباطا عكسيا مع مستوى السكر التراكمي في الدم HbA1c.

Introduction

Diabetes mellitus is a chronic metabolic disease associated with high glucose level in blood which results from defects in insulin secretion, insulin action, or both (Kitabchi *et al.*, 2009). The patients with diabetes mellitus have a higher incidence of hypertension. This is particularly correct for type 2 diabetes patients. Diabetes characterizes a major risk of cardiovascular disease and nephropathy. This risk is significantly heightened by the co-existence of hypertension. A number of studies in the current years have revealed that tight blood pressure control is indispensable in diabetic patients to have greatest protection

against cardiovascular events and the worsening of renal function (Neupane *et al.*, 2016). Type two diabetes mellitus (T2DM) was increase worldwide, that lead to increased burden on health care systems and individuals (Eggers, 2011). Uric acid (UA) is produced as product of purine oxidation. It is found that it was associated with diabetes mellitus and other clinical conditions as atherosclerotic disease. It is recommended in various studies that UA as significant indicator for kidney diseases, predominantly in hypertensive patients (Momeni, 2012; Tavafi, 2013). Hypertension and raised serum uric acid level confound the debates of uric acid role in progression of cardiovascular disease like atherosclerosis. Many clinical studies have been done to associate between uric acid and hypertension (Feig *et al.*, 2006). Studies have observed that a uric acid elevation predicts the development of metabolic syndrome such as hypertension and diabetes (Feig *et al.*, 2008). Uric acid levels had negative correlation with plasma glucose levels in type two diabetic patients (T2DM) (Nan *et al.*, 2007). Obesity, hypertension, and dyslipidemia are cardiovascular risk factors are more prevalent in patients with T2DM (Wang and Reusch, 2012). The relation between high serum uric acid concentration and development of diabetes mellitus was not clarified, Whereas, some studies suggested that high uricemia was linked with increased risk of diabetes mellitus (Dehghan *et al.*, 2008; Modan *et al.*, 1987).

Materials and Methods

Ethical consideration:

Approval was taken from Omdurman Islamic university review board and verbal constant taken from all participants before collection the data.

Sample size:

An analytical cross sectional study was conducted in Diabetes Friend's Association Center, River Nile state, Atbara, Northern Sudan from March to October 2020.Hundred subjects were enrolled in the study, 50 diabetic patients without hypertension and other 50 diabetic with hypertension.

Inclusion and exclusion criteria:

Patients clinically diagnosed with type 2 diabetes mellitus were included. Patients with renal disease, anti-cholesterol drugs, liver and heart diseases and also Patients having

nephropathy, taking any hypertensive drugs or taking any drug to lower uric acid level were excluded.

Statistical analysis:

The data was entered and analyzed by using SPSS software version (25) for statistical analysis, t-Test was used, and ($p \leq 0.05$) value was considered significant.

Results and discussion

From a total of 100 participants about 36% were male and 64% were female with age ranged between (10 - 85) years with mean (48.83±14.11) years, while, the duration of the disease ranged between (1 – 20) years with mean (6.650±4.35) years. All study parameters were not significance deferent between DM with HT and DM without HT except the blood pressure indices (Systolic and Diastolic) were a highly significances (p= 0.000).The BM1 and serum Cholesterol were significantly differences in study population between female and male. The serum uric acid was non correlated with age(r= -0.006, p= 0.954), BMI(r= 0.058, p= 0.568), Systolic pressure (r= 0.011, p= 0.910), diastolic (r= 0.081, p= 0.423), fasting blood glucose (r= 0.073, p= 0.423), duration of disease (r= 0.018, p= 0.858), and postprandial (r= 0.053, p= 0.604), the serum uric acid was negative correlated with HbA1c (r= -0.241, p= 0.016).

Table (1): The age and duration of disease among the DM patients with and without HT

Variables	Minimum	Maximum	Mean ± SD
Age	10.00	85.00	48.83±14.11
BMI	18.20	37.10	27.56±3.99
Duration	1.00	20.00	6.650±4.35

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Table (2): Demographic and laboratory data on the study population

Parameters	DM with HT (Mean ± SD)	DM without HT (Mean ± SD)	*P-value*
BMI	27.61±3.57[a]	27.52±4.28[a]	0.910
Systolic pressure	132.5±18.36	114.6±12.56	0.000
Diastolic pressure	85.88±8.97	76.50±7.61	0.000
Cholesterol	173.0±30.66	170.8±38.20	0.763
TG	193.4±93.97	178.6±75.64	0.387
LDL	67.44±33.94	59.92±30.90	0.255
HDL	72.08±20.11	78.75±18.94	0.096
HBA1c	6.67±1.05	6.84±1.31	0.474
Uric Acid	5.23±1.47	5.13±1.73	0.768
FBS	122.7±36.29	131.4±47.74	0.329
Postprandial 2hr	210.8±51.81	171.7±45.93	0.242

Table (3): Comparison of study parameters among male versus female

Parameters	**Male (Mean ±S D)**	**Female (Mean ± SD)**	***P-value***
BMI	26.46±3.98	28.18±3.89	0.039
Systolic	123.2±17.93	120.9±17.27	0.538
Diastolic	81.80±9.35	79.38±9.32	0.214
Cholesterol	160.9±41.52	177.7±29.83	0.021
TG	193.7±87.32	179.3±81.22	0.409
LDL	55.99±33.01	66.82±31.32	0.107
HDL	78.33±16.92	74.82±20.97	0.393
HBA1c	6.68±1.17	6.82±1.24	0.575
Uric Acid	4.91±1.51	5.32±1.67	0.241
FBS	134.4±52.50	124.2±37.53	0.260
Postprandial 2hr	176.2±58.16	193.5±66.78	0.613

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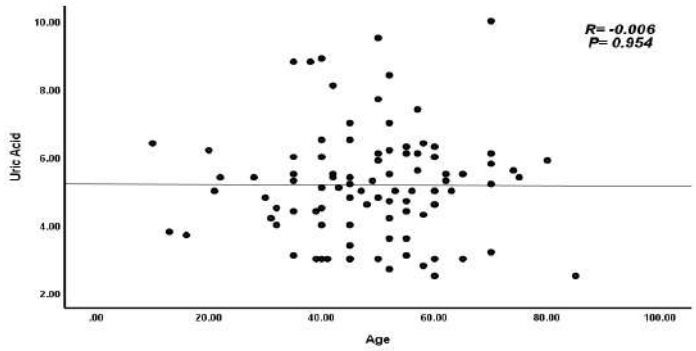

Figure (1): Correlation of serum uric acid and age among study population

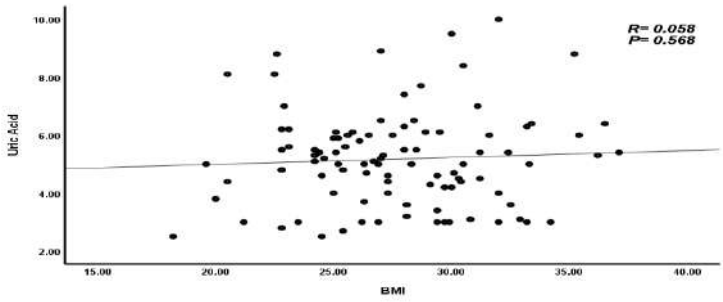

Figure (2): Correlation of serum uric acid and BM1 among study population

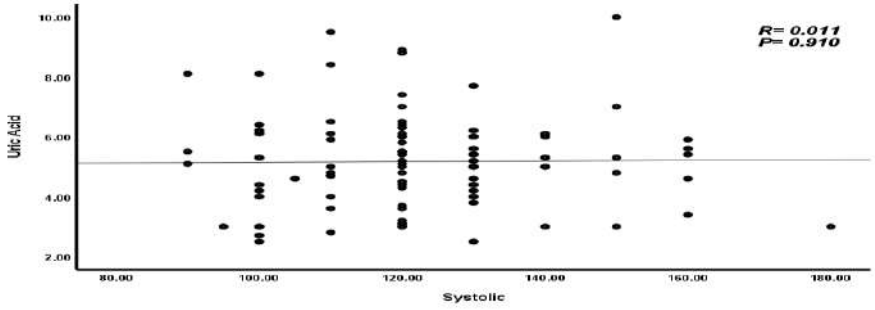

Figure (3): Correlation of serum uric acid and systolic pressure among study population

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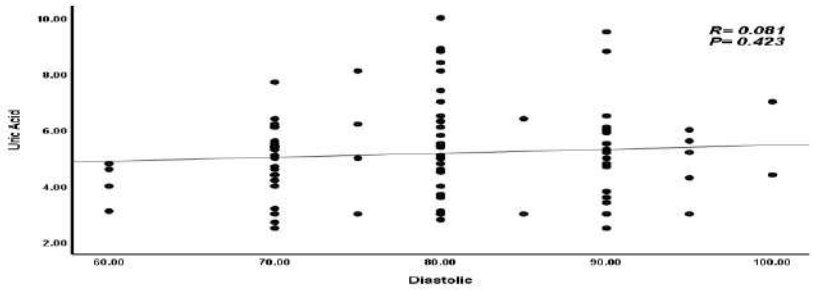

Figure (4): Correlation of serum uric acid and diastolic pressure among study population

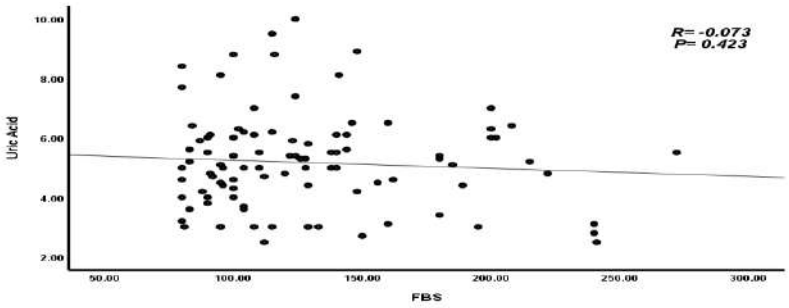

Figure (5): Correlation of serum uric acid and fasting blood glucose among study population

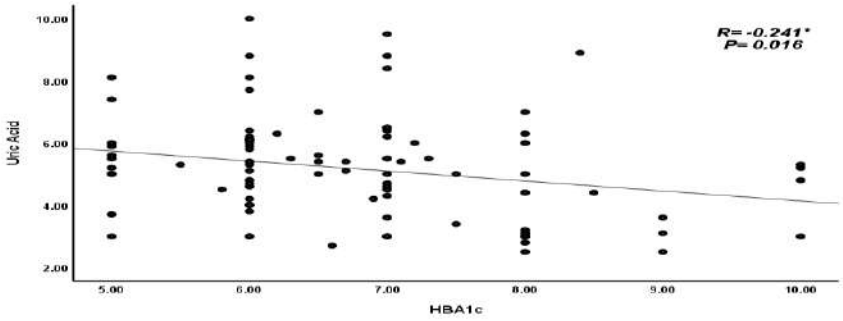

Figure (6): Correlation of serum uric acid and HbA1c among study population

GadAllah Modawe, Abuagla M. Dafalla, Leena A. Dafalla, Rimaz Gurashi, Nadir Abuzeid, Abdelsamee E. M., Elamin, (2023). Estimation of Serum Uric Acid, Lipids Profile and HbA1c in Diabetic and Hypertension Patients in River Nile State, Sudan. *Al-Butana Journal of Applied Science (16):* 1-12

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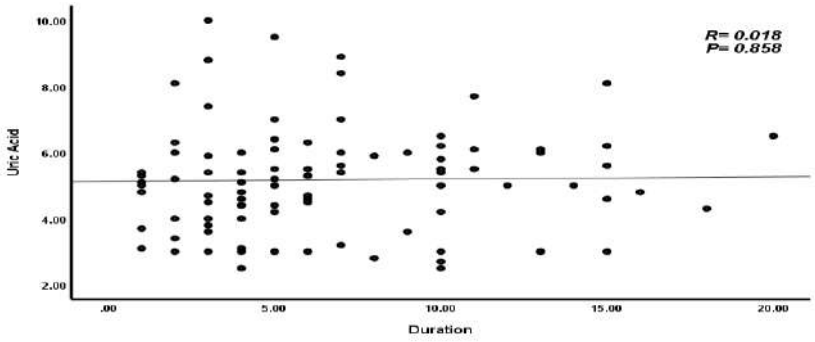

Figure (7): Correlation of serum uric acid and duration of disease among study population

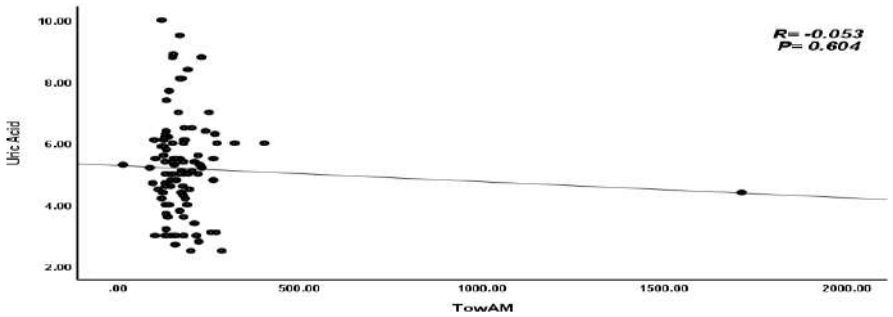

Figure (8): Correlation of serum uric acid and postprandial 2hours among study population

Discussion

Uric acid elevation predicts the development of metabolic syndrome such as hypertension and diabetes mellitus (Feig *et al.*, 2008). In type two diabetic patients the uric acid levels were decline when plasma glucose levels were increased (Nan *et al.*, 2007). In this study it was seen that serum uric acid level is correlated with HbA1c in diabetic patients with and without hypertension, also a significantly differences on blood pressure (systolic and diastolic) in diabetic patients with and without hypertension. This result differs with those done by Rashid *et al* (Rasheed *et al.*, 2016), reported that a strong correlation between serum uric acid and systolic and diastolic blood pressure levels in type 2 diabetic patients, However, agree with study done by Kamran (Aziz, 2014) reported that higher levels of uric acid are associated with lower HbA1c type-2 diabetic patients. The results of this study showed that the increased total cholesterol, TG and LDL, while decreased HDL in diabetic patients with HT when compare with other diabetic patients without HT, increased lipid

obvious marker for atherosclerosis as a result of deposition of lipid in vessels which a near to literature indicated to the obesity, hypertension, and dyslipidaemia as cardiovascular risk factors are more prevalent in patients with T2DM (Wang and Reusch, 2012). Current study concluded to negative relationship between serum uric acid andHbA1c in diabetic patients; it was not agree with expected hypothesis. Hence, in present study uric acid was a potential biomarker of glucose metabolism. Furthermore, uric acid has been also known as antioxidant (Ames *et al.*, 1981; Bowman *et al.*, 2010). Antioxidant delay cell apoptosis that lead to improve the ß-cell function in diabetics especially insulin secretion, this phenomenon has been observed in current study. However, further studies are required to search the uric acid role as antioxidant in diabetes state. Also our study collides with Rafieian-Kopaei*et al* (Rafieian-Kopaei and Nasri, 2014), reported that serum uric acid had a strong association with levels of blood pressure in diabetic type two patients, whereas, it is near to study mentioned that serum uric acid level has contrary effect on controlling of blood sugar level in type two diabetic patients (Babikr *et al.*, 2016). Although other researchers interpret the hyperuricemia in poor controlling of glucose in diabetic patients as a result to inhibition or reduction of uric acid reabsorption in renal tubule especially proximal tubule as a consequence to high glucose levels in diabetic individuals (Tuomilehto *et al.*, 1976; Herman *et al.*, 1976). In this study a negative correlation may be due to increased glucose in blood above the renal threshold (high glycemic control) and then excreted in urine but body need glucose therefore kidney reabsorbed glucose until maximum transport by nephrons which used transporters like GLUT9 in competency with the uric acid reabsorption (John and Guyton, 2011; Martín and Nieto, 2011); as a result of this competition, reabsorption of uric acid has been reduced, thus the negative relationship between uric acid and glucose conflict with hypothesis that assume glycosuria causes uricosuria. This conflict may be due to some study limitations such as some factor that interfere or effect on metabolism of uric acid and carbohydrate like smoking, GFR, diuretic medication and protein intake which were not included in this study (Wild *et al.*, 2004; Ogbera and Azenabor, 2010). Further studies are recommended to study the effect of uric acid lowering drugs on the glycemic control in type two diabetic patients.

Conclusion

Our study revealed, the serum uric acid was not significant different in diabetic patients with and without hypertension with negative correlated with HbA1c, while lipid profiles except HDL were increased in DM with hypertension.

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Survey of Parasitic Nematodes Associated with Cotton (BT) Cultivar Cultivated at Different Localities in Gezira state

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ABSTRACT

This study aimed to **survey** for the plant- parasitic nematodes associated with cotton grown around Gezira, Experimental Farm in Gezira University ,Lotaha fields and Agricultural ,Research Corporation(ARC) farm and Alhalawin farms. to assess their relative occurrence in the soil (rhizosphere) and the roots of cotton plants and identification of extracted nematode from soil and plant parts. 14 samples consisted of uprooted cotton plants and approximately 100 gram rhizosphere soil of each plant were randomly taken . each plant and soil sample was placed in a fully labeled polythene bags. The soil was thoroughly mixed and the number of the nematodes per gram soil was determined using 24 hours movement assay. By this method the number of the nematodes which had passed through the filter was counted. During the survey of plant parasitic nematodes associated with cotton cultivar roots and rhizosphere soil at different mentioned locations , nearly overall these areas cotain the following plant parasitic nematodes , *Pratylenchus sudanensis*., *Ditylenchus sp.* , *Tylenchorhynchus sp.* , *Helicotylenchus sp* and *Hoplolaimus sp.*, Lotaha area was found to be the most contaminated with all plant parasitic nematodes ,followed by Alhlawen and ARC. Experimental farm Geziera University was the least contaminated with these nematodes . It was found that *Pratylenchus sudanensis* and *Ditylenchus sp.*,were the most predominant pathogenic nematode species in these areas .

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Keywords: uprooted cotton, *Pratylenchus, Ditylenchus* , parasitic nematodes

INTRODUCTION

Cotton (*Gossypium hirsutum*) is known globally as a leading fiber and oil cash crop which is commercially grown in many countries in the Tropic and Subtropics regions. Cotton has been growing in sudan since early 19 th century. Until recent time ,sudan is considered the world second largest producer of long-staple cotton. The crop is grown in both irrigated and rain-fed sectors.The irrigated sector is symbolizes 90% of the total cultivated cotton area in sudan (Salim,2007). The main important cotton production areas in Sudan include Gezira, Suki, Rahad, New Halfa, White Nile area and Nuba Mountains. There are many commercial varieties cultivated such as Genetically Modified Cotton (Bt),Barakat 90 and Abdin.The crop participated in financial development of local communities in the region where cotton is cultivated. Cotton crop in the sudan is known to be affected by many pests and diseases, the insect pests are African boll worm (*Heliothis armigera*), white flies *(Bemisia tabaci*) ,Jassids (E*mpoasca lybica*), Thrips (*Caliothrips sudanensis)*,Termites (*Microtermes thoracalis)* , Pink boll worm (*Platyedra gossypiella)* , Sudan boll worm (*Diparopsis watersi*, Aphids *(Aphids gossypii*) (Hargreaves 1948) .Numbers of diseases includes pre-emergent such as damping off , Ryhzocotonia and post-emergent such as root rot (Fusarium),Charcoal rot (Macrophomina), Alternaria leaf spots *(Alternaria spp)* ,leaf curl virus, the most important disease is black arm or Bacterial Blight of cotton (*Xanthomonas axonopodis pv . malvacearum*). In the Sudan ,the association of plant –parasitic nematodes with the cotton crop , as plant parasites or from the soil around the crop system, a preliminary survey conducted by Decker,et al (1981) showed the presence of *Tylenchorhynchus cylindricus* ,

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Ditylenchus myceliopbagas ,Telotylenchus sp ,Tylenchus sp ,Aphelenchoides sp and *Aphelenchus avenae* were found in association with roots of cotton, cv (.Barakat and Acala) .Yassin (1973) reported that at least two species were isolated from within and round the roots of cotton with stunted growth areas , eg., the Gezira, Khashm, Elgirba and Guneid, these are *pratylenchus sudanensis* n.sp. loof and Yassin and *P.delattrei* luc. The commonest is, however , *P. sudanensis.*

Other plant parsitic Nematodes associated with cotton crops in the world .e.g *Meloidogyne incognita ,Rotylenchulus reniformis ,Hoplolaimus spp.Tylenchorhynchus spp ,Helicotylenchus spp ,Aphelenchoides ,Longidorus spp , Xiphinema spp.*Kinloch and Sprenkel (1994) ,Sasser (1972),Smart and Perry (1969).

Materials and Methods

Sampling for the plant-parasitic nematodes associated with cotton *Gossypium hirsutum*(Bt)

The work was undertaken to investigate the presence of the plant parasitic nematodes in the main areas for cultivation of this crop during 2019 - 2021. For this purpose root samples and rhizosphere soil were obtained from Lotaha , Al hlawin, Agricultural Reseurch Corporation (ARC)and Experimental Farm in Gezira University cultivated with cotton Bt cultivar in an attempts to collect , examine and identify the plant parasitic nematodes associated with this plant . Subsequently from each of the surveyed areas 14 samples consisted of uprooted cotton plants and approximately 100 gram rhizosphere soil of each plant were randomly taken . each plant and soil sample was placed in a fully labeled polythene bags. The soil was thoroughly mixed and the number of the nematodes per gram soil was determined using 24 hours movement assay. By this method the number of the nematodes which had passed through the filter was counted.

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Extraction of nematode from plant parts and soil

The technique used in this study was similar to those described by Fallis (1943); Stemerding (1964); Ooestenbrink (1960) and Siddig (1976). Cotton seedlings roots were washed free from soil using tap water, then chopped up into small pieces. For each sample approximately 5 grams roots were randomly taken and macerated in 100 ml water using an electric blender for 10 seconds. Immediately after that the root nematode suspension was placed in a plastic sieve which was over laid with tissue paper and the sieve itself was placed in a tray containing few amount of water, to saturate the tissue. Then the filtrated suspension was left for 24 hours movement assay to allow the nematodes to pass through the filter. The numbers of the nematodes which had passed through were collected and counted. The mean number of the nematodes per 1 ml was determined. The soil samples containing nematodes were extracted and counted in an exact way as mentioned above using 24 hours movement assay.

Nematode preservation and slides preparation

The methods used for preservation, killing , fixation and slide preparation for the nematode were similar to those described by the modified Seinhorst method (De Grisse,1969a), Akaraib (1989), Ibnouf (1992) and Abdalla (2000). 5 ml nematode water suspension was placed in a test tube then 10 ml F.A 4:1 (10ml) formalin 40%.1 ml glacial acetic acid,89 ml distilled water) was heated to 100 c, and added to the suspension . Nematodes selected for examination were transferred into 0-5 ml glycerol rapid method described by Seinhorst (1962). Placed in to small Syracuse dishes then mounted in Hoyer's solution (200g chloral hydrate,30 g gum Arabic,20 ml glycerine and 50 ml distilled water), as described

by (Cobb,1917),using paraffin wax ring for sealing. The prepared slides were subjected to study by the light microscope (L.M).

Nematodes were identified at first to genus level and then to species level using the prescribed characters mentioned by the Ibnouf (2001), Abdalla (2000) and (Zeidan and Geraert, 1991).

RESULT

Surveyfor Parasitic Nematodes Associated with Cotton *Gossypium hirsutum*(Bt) cultivated at DifferentIocalities in Gezira State

The survey results in Table 1 reveal that 2 endo parasitic nematodes *Pratylenchus sudanensis*.and *Ditylenchus* sp, 1 semiendo *Tylenchorhynchus* . sp.2ecto parasitic *Helicotylenchus.* sp and *Hoplolaimus* sp,were found associated parasitic with grown cotton cultivar *Gossypium hirsutum*(Bt) in Lotaha, Alhlawin(Dolga office), Agricultural Research Corporation (ARC)and Experimental Farm in Gezira University. The results indicated that *Prtaylenchus sudanensis*is shown to be the most predominant endo parasitic nematode in these areas followed by *Ditylenchussp.* Their percentage occurrence were 73.2 and 50%, respectively.

In the case of the semi endo parasitic nematode, the percentage occurrence of *Tylenchorhynchussp*. is 26.9%.

The results also showed that *Helicotylenchus* sp. and *Hoplolaimus* sp were ecto parasitic nematodes, their counted percentages occurrence were 48.2 and 35.7%,respectively.That was less than 50% than those of predominant endoparastic nematodes *Pratylenchus sudanensis and Ditylenchus* sp.

The percentages of occurrence in the four cotton cultivated areas as in table 2 ,it can be seen that the endoparasitic nematode *pratylenchus sudanensis* percentages of occurrence at Lotaha, Alhlawen), ARC and Experimental Farm were also, high and were found to be 92.8 ,85.7 and 64.3 respectively, comparable percentage of occurrence at Experimental Farm was 50%,. While the percentage of occurrence of the *Ditylenchus* sp. at Experimental Farm was found to be less and is 7.1 and 71.4 ,64.3 and 57.1 at Lotaha, ARC and Alhlawen.

The semi endoparasitic nematode *Tylenchorhynchus* sp gave noticeably variable percentages of occurrence 42.8,28.6,21.4 And 14.3 % at Lotaha, Experimental Farm, ARC and Alhlawen, respectively.

The results also showed that *Helicotylenchus* spand *Hoplolaimus* sp. were ectoparasitic nematodes, their counted percentages occurrence were71.4, 64.3 , 42.8 and 14.3% compared to 42.8 ,50,28.6 and 21.4% for *Hoplolaimus* spat Lotaha, Alhlawen, ARC and Experimental Farm ,respectively .

The results showed in the Lotaha fields the proportion of both *Ditylenchus* sp.and *Helicotylenchus* sp.were equal to 71.4%. the Experimental Farm area the ratio of *Tylenchorhynchus* sp was 28.6 two times the ratio of *Hilicotylenchus* sp which was 14.3%.For the ARC fields the results showed that the ratio of *Pratylenchus sudanensis* and *Ditylenchus* sp. was equal to 64.3 %.

The comparable percentage of occurrence for Alhlawen fields showed that the highest percentage was 85.7 % in *pratylenchus sudanensis* and the lowest percentage was 14.3% in *Tylenchorhynchus* sp .

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Table (1): Number and Percentage Occurrence of Parasitic Nematodes Species Obtained from Cotton Soil and Plant Parts at Different Localities

Nematodes Species								
Cultivated Areas	**No. of sample**	**Endo parasitic Nematodes**		**Semi endo parasitic**	**Ecto parasitic Nematodes**		**Total number**	**Total percentage**
		Pratylenchs. sudanensis	***Ditylenchus*.sp**	***Tylenchorhynchus.sp***	***Helicotylenchus* sp**	***Hoplalaimus* sp**		
Lotaha	14	13	10	6	10	6	45	321.4 %
Alhlawen	14	12	8	2	9	7	38	271.4 %
ARC	14	9	9	3	6	4	31	221.4 %
Experimental farm	14	7	1	4	2	3	17	121.4 %
Total	56	41	28	15	27	20	131	
Percentage occurrence		73.2	50	26.9	48.2	35.7	233,9	

* Number of selected samples (14) was based on the same size of cotton cultivated area .

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Table (2): Percentage Occurrence of Parasitic Nematode Species Obtained From Cotton Soil and Plant Parts in Each Surveyed Are

		Nematodes Species				
Cultivated Areas	**No. of samples**	***Pratylenchus sudanensis***	***Ditylenchus*.Sp**	***Tylenchorhynchs* sp**	***Helicotylenchus*Sp**	***Hoplalaimus* sp**
Lotaha	14	92.85%	71.4%	42.8%	71.4%	42.8%
Alhlawen	14	85.7%	57.1%	14.3%	64.3%	50%
ARC	14	64.3%	64.3%	21.4%	42.8%	28.6%
Experimental farm	14	50%	7.1%	28.6%	14.3%	21.4%

DISCUSSION

In this study, the survey results revealed that *pratylenchuns sudanesis* was a predominant plant parasitic nematode associated with cotton cultivar , followed by *Ditylenchus* sp, *Helicotylenchus* sp, *Hoplalaimus* sp and *Tylenchorhynchus* sp. similar results were obtained by Yassin (1973), Yassin (1986) and Saeedabe (1985) who stated that *Pratylenchuns sudanesis* was a devastating nematode to cotton, *Ditylenchus* sp, which was found in high population densities ,this finding is supported by Decker *etal.* (1981) in Delta Tokar with (cotton, cv.Barkat). Ibrahim and Sharkawy (2001), Sasser (1969) and Smear (1969) also mentioned that *Hoplalaimus* sp and *Tylenchorhynchus* sp as major species on this crop.

The results has been shown that the percentages occurrence of the various plant parasitic nematodes species obtained from Experimental farm, ARC,

Alhlawen and lotaha were as follows 121.4, 221.4, 271.4 and 321.4 %, respectively. Table(1) these results indicate that Lotha and Alhlawen areas are shown to be highly populated with plant parasitic nematode, while, ARC and Experimental farm were found to be less populated with these nematodes. Differences between the population of the plant parasitic nematodes appear to be correlated with abundance of food organic matters available in the soils, which is considered to directly inhibit the plant parasitic nematodes and increase the free living forms population. The trend expressed above indicated that the food organic matter is shown to be more abundant in Experimental farm and ARC where less plant parasitic nematodes populations were obtained compared with those in the other areas. This view, is also supported by the works of Kampfe (1964) and Hasabo (2006) who pointed that the free living forms are capable to mass reproduce within a short life span. Therefore, it seems reasonable to attribute that less organic food source found in Lotha and Alhlawen, maybe reasonable for the increasing numbers of plant parasitic nematodes and decreasing free living forms. The above findings are supported by several workers. For example Wallace(1963) reported that in the fertile soils few plant parasitic nematode were found. Akaraib (1989) found that the use of cow manure reduces *Radopholus similis* population on banana and Ibnouf(1992) recorded highly significant reduction ($P<0.5$) in *Ditylenchus dipsaci* rate of population growth obtained from soil and root tissue of both test onion cultivars using animal manure. It has been suggested that frequent cotton cultivation in these areas may play an important role increasing plant parasitic nematodes percentage of infestations, therefore the nematodes are likely to find the environment is unfavourable, especially with adoption of proper crop rotation. Hooper (1972) stated that rotation with resistant

crops for 3-4 years is effective in avoiding nematode attack .Koura (1968) reported that proper crop rotation proved to be an efficient practice for the control of *Pratylenchuns zeae* in Egypt.

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Characterization and Iological Effects of 2(1-phenylethylidene) Hydrazine-1-carbothioamide Schiff base and it Complex Nickel (II) and Manganese (II)

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Abstract

Schiff bases play an important role in inorganic chemistry as they easily form stable complexes with the most metal cations**,** Schiff bases bonding ability depends on the nature of atoms that act as a coordination site, such as N, O, and S, the electronegativity and steric factors**.** Schiff bases and their metal complexes show antibacterial, antifungal, antitumor, and antiviral activities and work as therapeutic agents against biological disorders like cancer, inflammation, and allergy. This work dealt with the Synthesis, Characterization, and biological activity of 2-(1-phenylethylidene)hydrazine-1-carbothioamide Schiff Base Ligand and Some of their metal complexes. A Schiff base ligand 2-(1-phenylethylidene)hydrazine-1-carbothioamide has been synthesized by condensation between thiosemicarbaizde and acetophenone in the molar ratio 1:1. This synthesized ligand was used for complexation with different metal ions like Ni (II), and Mn (II), by using a molar ratio of ligand to the metal of 2:1 in ethanol. The ligand and metal complexes have been characterized by melting point, NMR (1H and 13C), UV–vis spectroscopy, FTIR, MS, and molar conductivity studies. The electronic impact mass spectra of the Schiff base ligand showed molecular ion(M^+) peaks at m/z = 193 a.m.u corresponding to the$[C_9H_{11}N_3S]^+$, confirming the empirical formulae of the ligand. In conductivity experiments, all metal chelates were found to be non-electrolytic in nature. IR spectra of the ligand showed the strong band at 1585 cm^{-1} assigned to ν C=N and bands at 763 cm^{-1} corresponding to the C=S, IR spectra showed that the ν C=N and ν C=S of the Schiff base ligand were shifted to lower or higher frequencies in the spectra of all the complexes indicating coordination of the azomethine nitrogen and sulfur. The anti-microbial activities of both the ligand and their complexes were screened

against two Gram-positive bacteria (Staphylococcus aureus and Bacillus subtilis) and two Gram-negative bacteria (Escherichia coli and Proteus vulgaris). The anti-fungal activity was screened against Candida albicans and Aspergillusfumigatu, and the results show that the metal complexes are more biologically active than the ligand.

Keywords: Schiff base, azomethine, acetophenone, anti-microbial.

Introduction

The term Schiff's base derives from the name of the German chemist Hugo Schiff, who was the first to describe the products resulting from the reaction of primary amines with carbonyl compounds(Schiff; 1864).

Schiff bases are a vast group of compounds characterized by the presence of a double bond linking carbon and nitrogen atoms, the versatility of which is generated by the many ways to combine a variety of alkyl or aryl substituents. Compounds of this type are both found in nature and synthesized in the laboratory,Schiff bases have a number of applications as catalysts (Westheimer and Taguchi;1971), and their most important medical applications include antibacterial (Abdel Aziz et al;2012), antifungal (Gungor and Gurkan; 2012), antiviral (Kumar et al; 2010), and anticancer (Bensaber et al; 2014).Thiosemicarbazide has been shown to be a good ligand for a range of metals, including manganes, mercury, cadmium, nickel and others (Dincer et al; 2005).Many Schiff bases have a second functional group, normally OH and SH groups or another N atom, which are near the imine group, these functional groups can allow the formation of five or six member chelate rings when coordinated with different metal ions.A Schiff base acts as an active ligand due to the low electronegativity of nitrogen, N of the azomethine group (>C=N), lone pair of electrons on the nitrogen atom, and electron donating character of the double bond (Kostova and Saso; 2013).

Materials and Methods

Chemicals

Thiosemicarbazide 98% (LOBA CHEMIE/India), absolute ethyl alcohol (DuKSAN/ India), acetophenone (LOBA CHEMIE/India),glacical acetic acid (Sigma/USA), Dimetheylsulfoxide (DMSO) (LOBA CHEMIE/ india), Nickel chloride hexahydrate $NiCl_2.6H_2O$ (CDH/India), and Manganese chloride

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tetrahydrate $MnCl_2.4H_2O$ (CDH/India). Double distilled water was used in all preparations. (All of the chemicals were analytical grade).

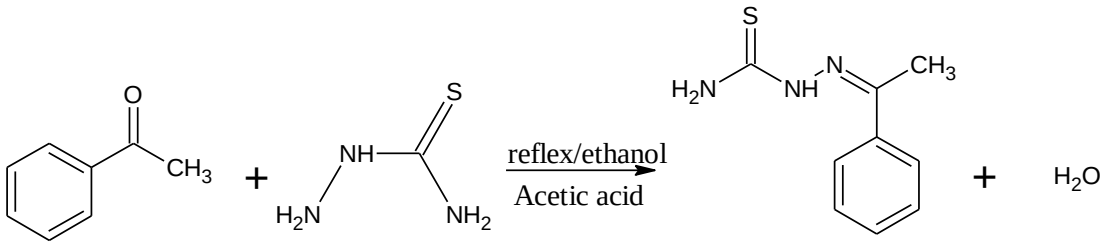
Instruments

Infrared spectra were recorded on a FTIR-8400S SHIMADZU spectrophotometer using KBr pellets in the mid-infrared region 4000-400 Cm^{-1}, UV/Vis spectra in DMSO (c =1.0×10^{-3}mol dm^{-3}) at room temperature were recorded on theUV-1800 model, Shimadzu Japan, ^{1}H -^{13}C NMR spectra were recorded on a Bruker High Performance Digital NMR Spectrometer Avance III (400 MHz) in deuterated dimethyl sulfoxide, Carbon, hydrogen, and nitrogen contents were determined on an Elemental analysis using the FLASH 2000 CHN analyzer (USA),and mass spectra were carried out on the direct in-it part of the mass analyzer in the Thermo Scientific GCMS model ISQ.

Method

Synthesis of the ligand 2-(1-phenylethylidene) hydrazincarbothioamide(L1)

1.82 g (0.02mol) of thiosemicarbaizde was dissolved in 25 ml of absolute ethanol. To this solution, 2.4 ml (0.02mol) of acetophenone dissolved in 25 ml of hot absolute ethanol was added, followed by the addition of a few drops of glacial acetic acid. The mixture was refluxed for 4 h at 70◦ C with constant stirring.On cooling in ice, pale yellow crystals were precipitated. The precipitate was filtered, washed with ethanol, and left to dry in the air. The product was recrystallized from ethanol.



Synthesis of Schiff base ligand (L1)

Synthesis of Complexes of Nickel (II)

The complexes were prepared by the addition of a solution of the salt $NiCl_3.6H_2O$ (0.71g,0.003 mol) in 25 ml of ethanol into solutions of the ligand [L1] (1.15g ,0.006 mol) dissolved in 25 ml of hot ethanol. The resulting

mixtures were then refluxed for 3h with constant stirring and allowed to cool at room temperature. The precipitated solids of the complexes formed were filtered off, washed with ethanol, and left to dry in the air.

Synthesis of Complexes of Manganese (II)

The complexes were prepared by the addition of a solution of the salt $MnCl_2.4H_2O$ (0.59g, 0.003 mol) in 25 ml of ethanol and solutions of the ligand [L1](1.15g ,0.006mol) dissolved in 25 ml of hot ethanol. The resulting mixtures were then refluxed for 3h with constant stirring and allowed to cool at room temperature. The precipitated solids of the complexes formed were filtered off, washed with ethanol, and left to dry in the air.

Antimicrobial Study

The ligand 2-(1-phenylethylamine) hydrazincarbothioamide and their metal complexes were tested for their antimicrobial (antibacterial and antifungal) activities. The antimicrobial profile was tested against Gram-positive bacteria species (Staphylococcus aureus and Bacillus subtilis), Gram-negative species (Escherichia coli, and Proteus vulgaris), as well as fungi including one filamentous fungus (Aspergillusfumigatus) and one yeast species (Candida albicans) using a modified well diffusion method. Briefly,100 ml of the test bacteria/fungi were grown in 10 ml of fresh media until they reached a count of approximately 10 8 cells/ml for bacteria or 10 5 cells/ml for fungi. One hundred ml of the microbial suspension was spread onto agar plates corresponding to the broth in which they were maintained and tested for susceptibility by the good diffusion method. One hundred ml of each sample (at 10 mg/ml) was added to each well (6 mm diameter holes cut in the agar gel). The plates were incubated for 24-48 h at 37 °C (for bacteria and yeast) and for 48 h at 28 °C (for filamentous fungi). After incubationthe growth of the microorganisms was observed. The resulting inhibition zone diameters were measured in millimeters and used as the criterion for antimicrobial activity.

Results and Discussion

Characterization of Schiff base ligand

Physiochemical data

The analytical data along with some physical properties of the ligand are summarized in Table-1. The complexes prepared were stable at room

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temperature and non-hygroscopic. The results of the C, H and N percentages are in accordance with the composition suggested for the ligand.

Table-1: Physical properties of synthesized Schiff base ligand (L1)

Compound	Molecular formula	Color	M.P. (°C)	Elemental analysis Found (Calculated) (%)			Molecular weight	
				H	C	N	Found	Calculate
L1	$C_9H_{11}N_3S$	Pale Yellow	110	5.74 (5.58)	55.93 (55.84)	21.74 (21.67)	193	193

Mass Spectra

The electronic impact mass spectra of the ligand(Table-1) show molecular ion (M+) peaks at m/z = 193 a.m.u, corresponding to $[C_9H_{11}N_3S]^+$, confirming the empirical formulae of the ligand. The spectra also show a series of peaks corresponding to various fragments of the compound (Figure-1).

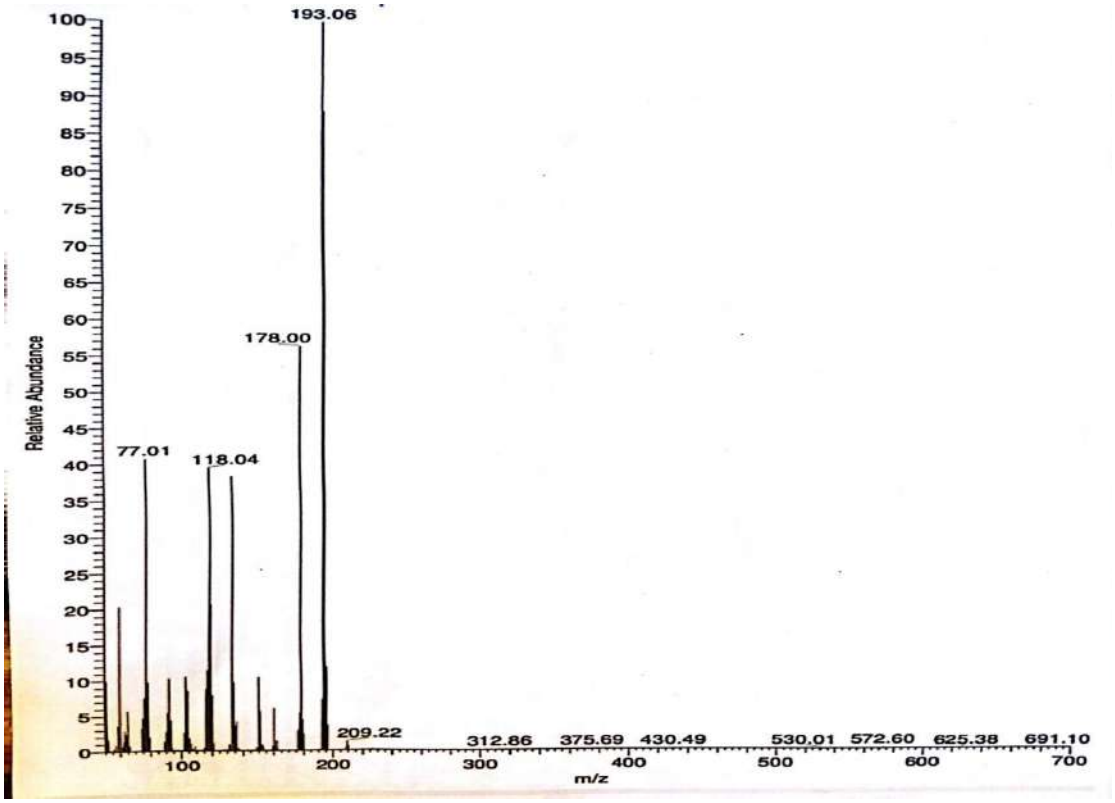

Figure (1): mass spectrum of the ligand (L1)

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Infrared Spectra

The infrared spectra of Acetophenonethiosemicarbazaide [L1], Schiff base ligand (Table-3) showed a strong bandat 1585 cm^{-1} which was assigned to ν C=N stretching mode of the azomethine function of the ligand , whereas the IR stretching vibration bands appear at 3413 cm^{-1} corresponding to the NH2 group, the band at 763cm^{-1} which is assigned to ν (C=S) , and the band observed in the range 1577 cm^{-1} due to the stretching vibrations of the aromatic ring (Figure-2).

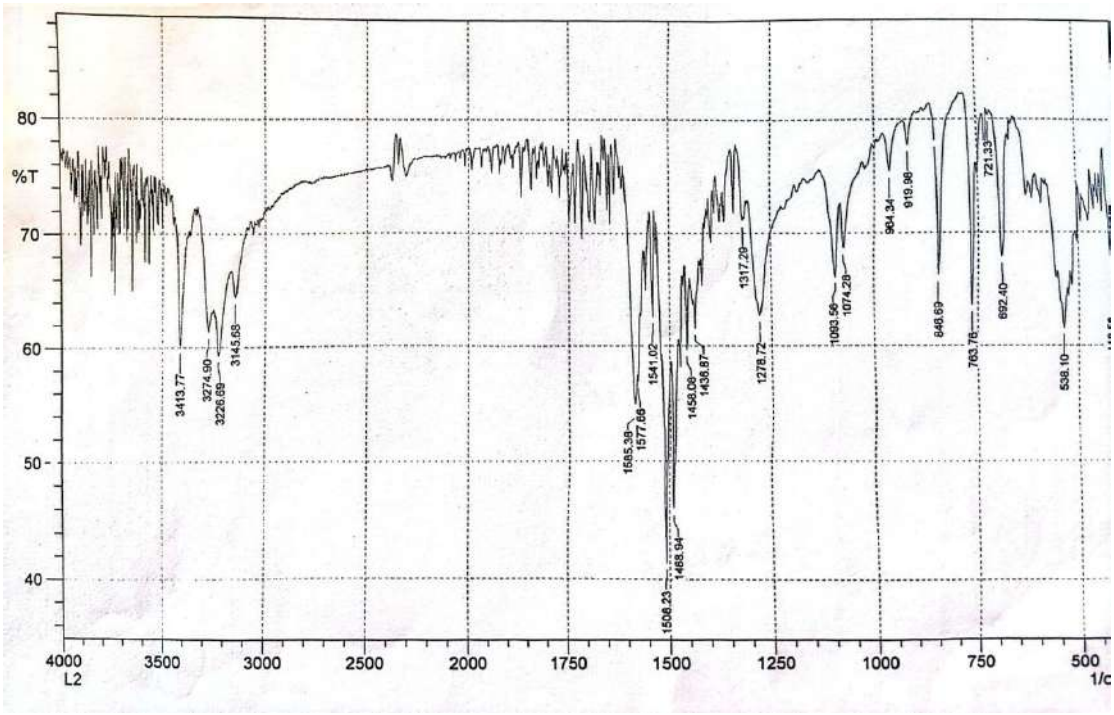

Figure (2): Infrared Spectrum bands of the ligand [L1]

Electronic Spectra

The electronic spectrum of the ligand (Figure-3) shows a band at 304 nm, which is attributed to the n → π* transition of conjugation between the lone pair of electrons ofthe p orbital ofthe N atom intheazomethine group and the conjugated π bond of the benzenering. The bands appearing at 245 nm are attributed to π → π* of the benzene ring.

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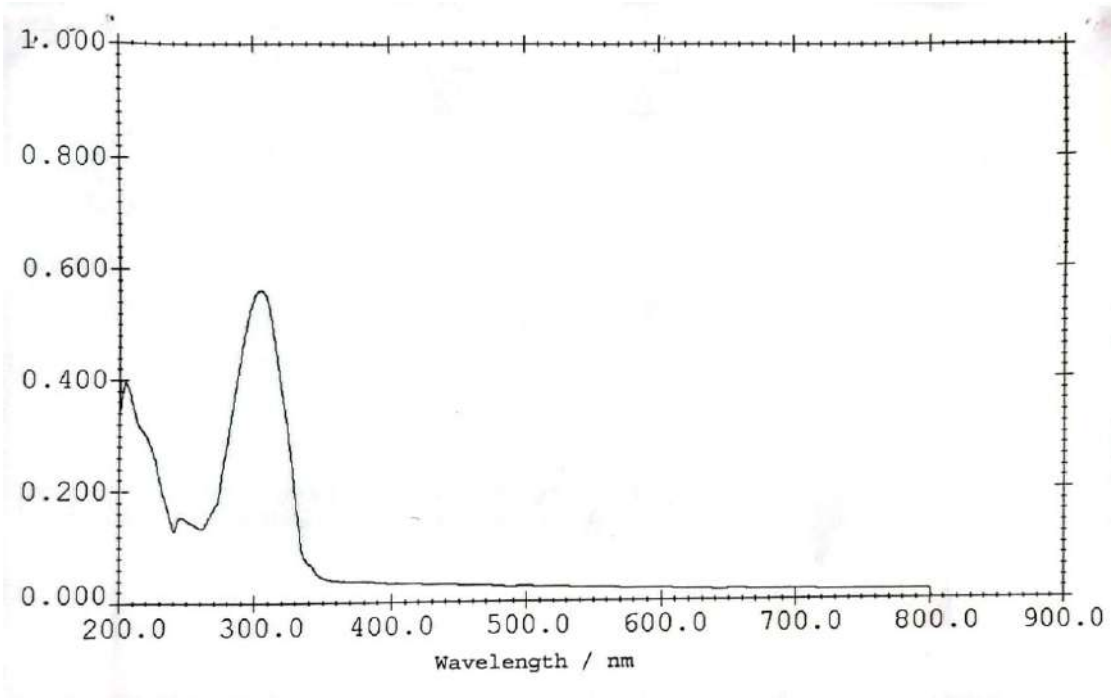

Figure (3): UV-visible spectrum of the ligand [L1]

NMR spectra

The ^{1}H NMR spectrum of the ligandL1 in DMSO (Figure-4), exhibited proton signals at 10.2 ppm, which are assigned to (1H, NHCS), while the singlet signal at 8.2 ppm correspond to the azomithine (1H, CH=N) proton, signals at 7.8 ppm corresponds to (2H, NH2) proton, signals at 3.3ppmcorresponds to the (3H, CH3), and triplet signals were observedat 7.3 ppm due to the aromatic protons of the Schiff base. The^{13}C NMR spectraof L1 in DMSO (Figure-5),showed signals at 14 ppm, which were assigned for the three methyl groups, signals at 147 ppm, which were assigned for imine group carbon, and aromatic carbon exhibited signals at 142 ppm.

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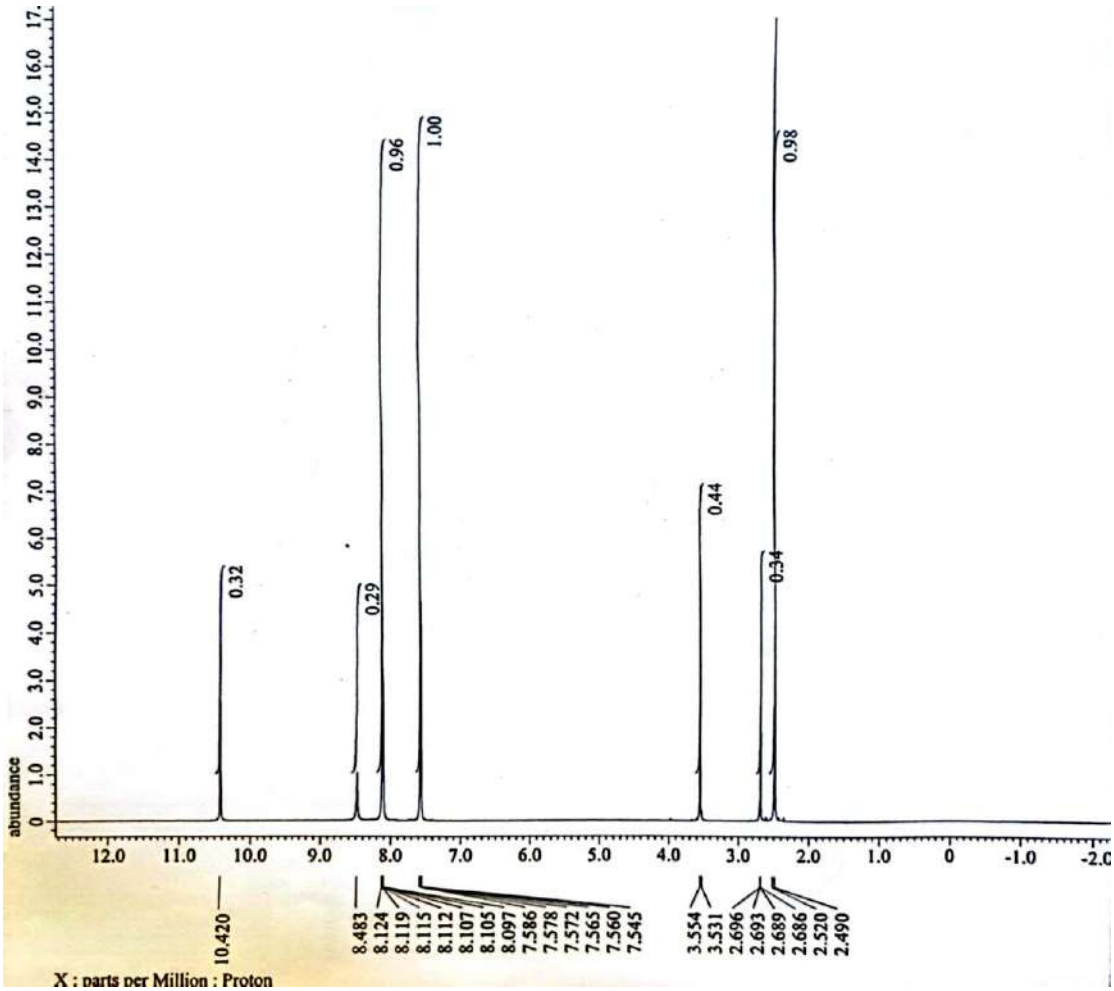

Figure (4):^{1}H NMR spectrum of the ligand (L1)

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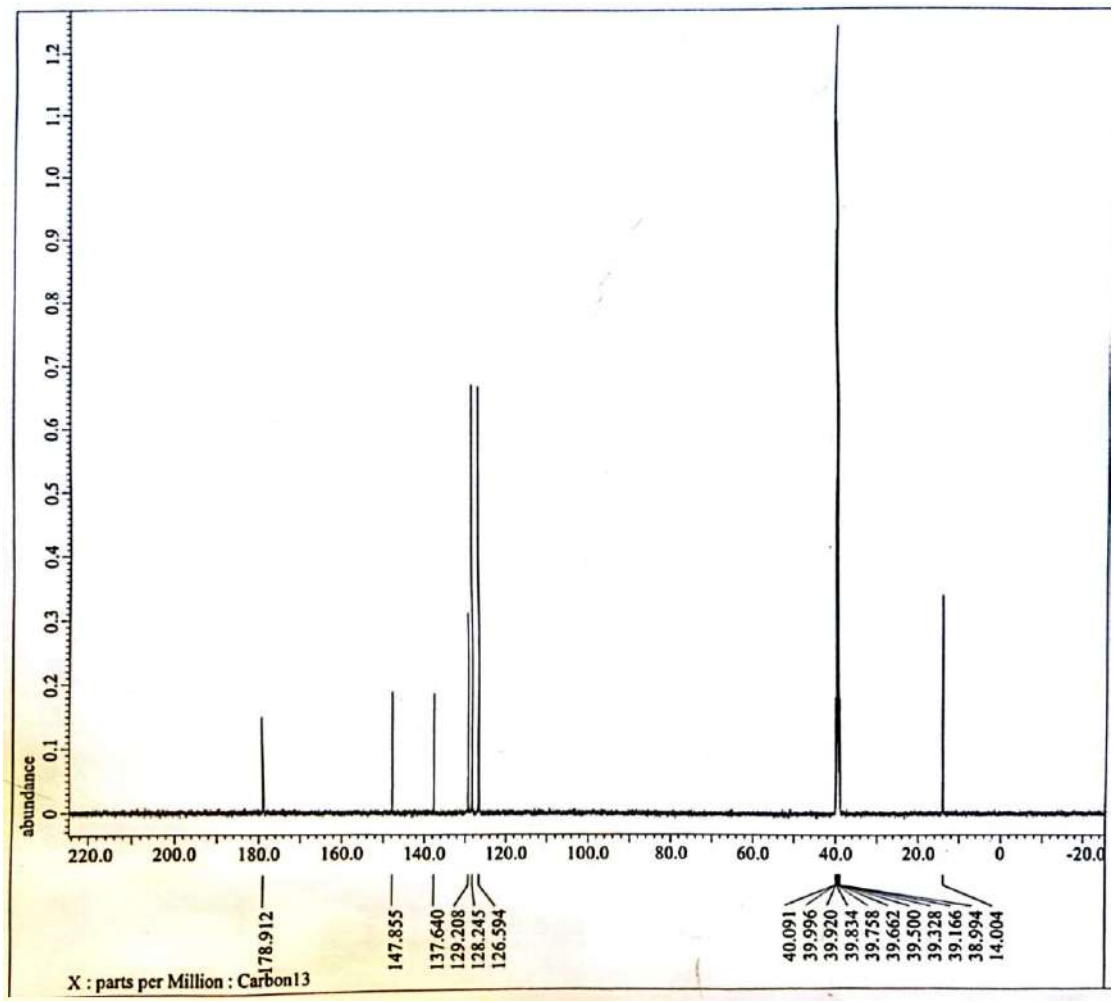

Figure (5):^{13}CNMR of the ligand [L1]

Characterization of Metal Schiff base Complexes:

Physiochemical data:

The complexes were found to be stable in air and completely soluble in ethanol and DMSO. The physical properties of the metal Schiff base complexes and molar conductance data are listed in Table -2. It was found that all the metal complexes have comparatively higher melting points than the Schiff base. This indicated the higher stability of the compound after binding with metal. The low conductivity values of the metal complexes suggest the non-electrolytic nature of the metal complexes**.**

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Table -2: Physical properties of synthesized Compounds

Compound	Solubility	Color	M.P.(C)	Conductivity (μscm^{-1})
L1	Ethanol DMSO	Pale Yellow	110	-
$[Ni(C_9H_{11}N_3S)_2]$	Ethanol DMSO	Green	241	3.5
$[Mn(C_9H_{11}N_3S)_2]$	Ethanol DMSO	Pale Yellow	178	1.7

Infrared Spectra

In the complex of Ni (II) with the ligand (L1), the band at 1585 cm^{-1} which is assigned to the v (C=N) in the free ligand, is shifted to 1595 cm^{-1} in the spectrum of the complex, this indicates the complexation of the ligand through the azomethine nitrogen to the Ni (II) ion. The band at 763 cm^{-1} assigned to *v* (C=S) is slightly shifted to 765 cm^{-1}, which suggests coordination of the ligand through the (C=S) sulfur (Figure-6). In the complex of Mn (II) with the ligand (L1), the band at 1585 cm^{-1} which is assigned to the *v* (C=N) in the free ligand, is shifted to 1587 cm^{-1} in the spectrum of the complex, this indicates the complexation of the ligand through the azomethine nitrogen to the Mn (II) ion. The band at 763 cm^{-1} assigned to *v* (C=S) is slightly shifted to 757 cm^{-1}, which suggests coordination of the ligand through the (C=S) sulfur (Figure-7).

Table (3): Main IR band (40-400) cm^{-1} for the ligand (L1) and their metal complexes

No	Compound	C=N	C=S	C=C	NH_2
1	L1	1585	763	1577	3413
2	$[Ni(C_9H_{11}N_3S)_2]$	1595	765	1508	3195
3	$[Mn(C_9H_{11}N_3S)_2]$	1587	757	1573	3421

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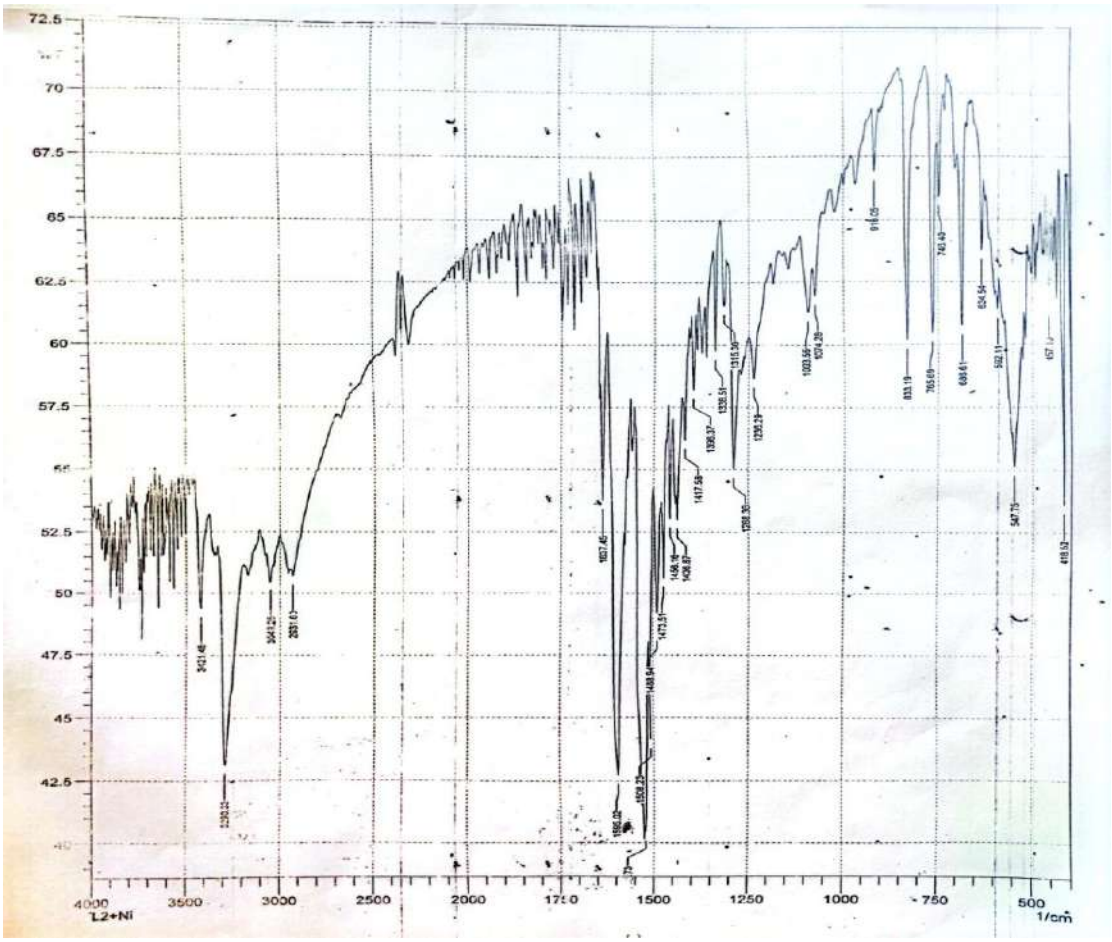

Figure (6): Infrared spectrum bands of Ni^{2+} with [L1]

Wafa AbdAlabage, Musa Abdelrahman, Amna Alameldeen H,(2023), Characterization and biological effects of 2(1-phenylethylidene) hydrazine-1-carbothioamide Schiff base and it complex Nickel (II) and Manganese (II) , Al-Butana Journal of Applied Science (16): 25-40.

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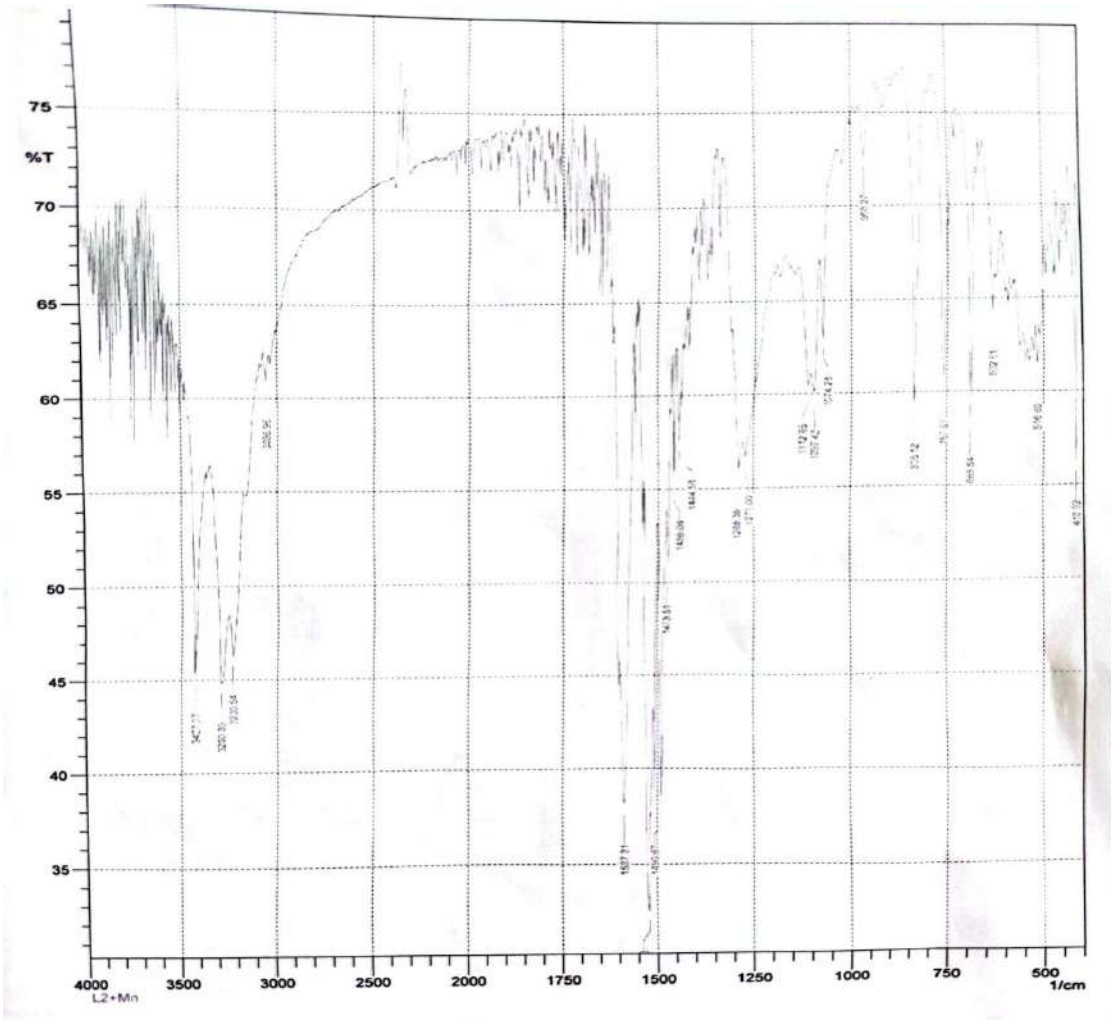

Figure (7): Infrared spectrum bands of Mn^{2+} with [L1]

Electronic spectra

In the spectrum analysis of Schiff base (2Z)-2-(1-phenylethylidene)hydrazine-1-carbothioamide optimum absorption was measured at 304 nm. In the case of metal complexes, a red shift in the spectra was observed. Ni has optimum absorption at 306 nm and Mn at 304 nm (Figure 8, 9).

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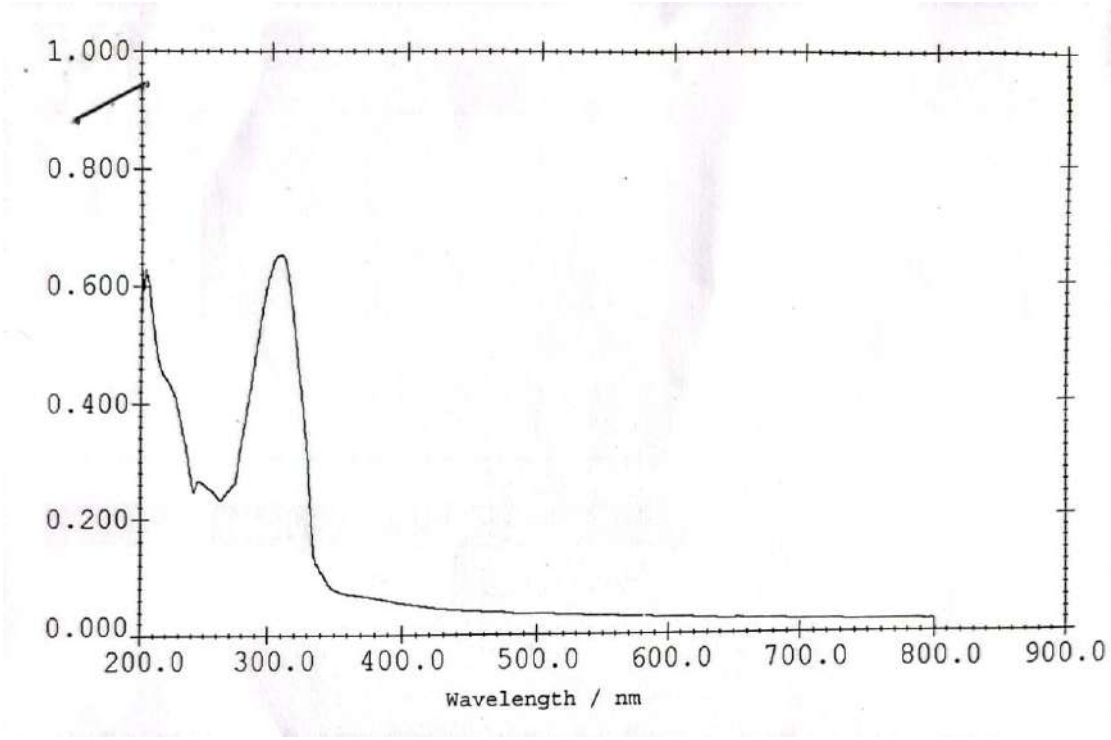

Figure (8) UV-visible spectrum of complex Ni^{2+} with [L1]

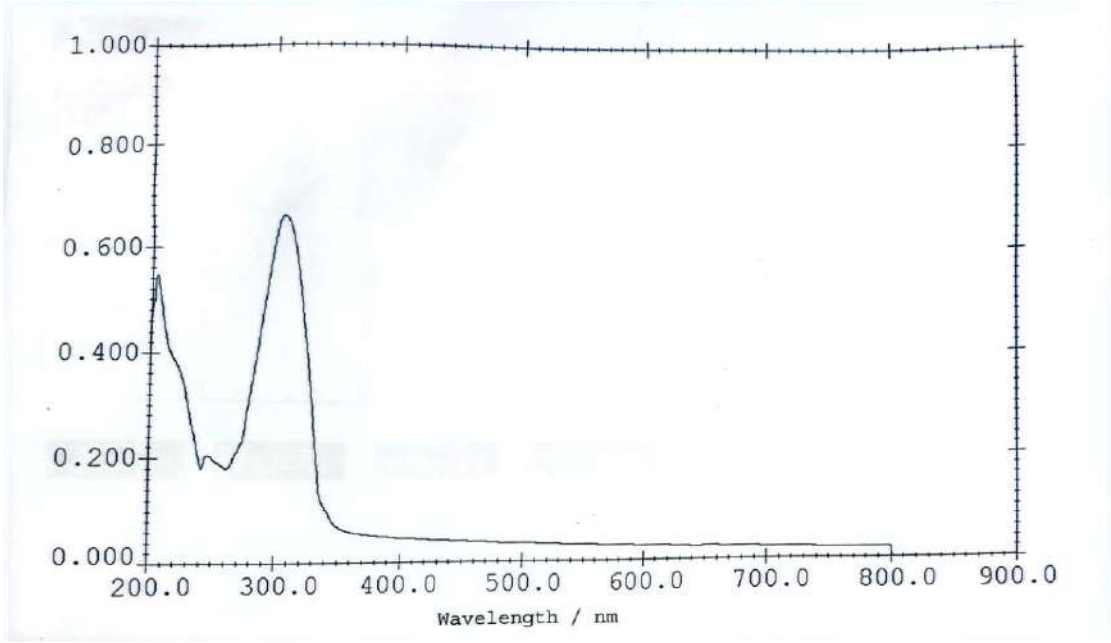

Figure (9) UV-visible Spectrum of Complex Mn^{2+} with [L1]

Wafa AbdAlabage, Musa Abdelrahman, Amna Alameldeen H,(2023), Characterization and biological effects of 2(1-phenylethylidene) hydrazine-1-carbothioamide Schiff base and it complex Nickel (II) and Manganese (II) , Al-Butana Journal of Applied Science (16): 25-40.

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Antimicrobial Activity

The test was done using the diffusion agar technique. Gentamycin (100 mg/ml) was used as the standard drug, and DMSO was used as a negative control. The susceptibility of the bacteria in the test samples was determined by the formation of a zone of inhibition (mm) produced on a range of environmental and clinically pathogenic bacteria using (10 mg/ml-1) concentration of the tested samples. Table -4 shows the inhibition zones (mm) of each compound. Ligand (L1) is active against all the gram-positive and gram-negative bacteria but less than the standard drug. After complexing, the complexes of Ni(II) and Mn(II) showed significant activity against all the gram-positive and gram-negative bacteria but less than the standard drug**.** The Ni(II) results show that the metal complexes are more active than the ligand.

Table (4): Antibacterial activity of the ligand L1 and its complexes

	Zone of inhibition in diameter using (1mg/ml) of sample			
	Gram positive bacteria		**Gram negative bacteria**	
Sample	**Staphylococcus aureus**	**Bacillus subtillus**	**Escherichia coil**	**proteus vulgaris**
Control DMSO	0.0	0.0	0.0	0.0
St. Gentamycin (+)	24	26	-	-
St. Gentamycin (-)	-	-	30	25
L1	12	13	12	15
$[Ni(C_9H_{11}N_3S)_2]$	18	19	18	20
$[Mn(C_9H_{11}N_3S)_2]$	12	14	11	15

The ligands and their complexes were tested for in vitro antifungal activity against Aspergillusfumigatus and Candida albicans fungi. Ketocoazola was used as a standard fungicide. The results of the antifungal activity of free ligands and their complexes are summarized in table -5. The free ligand (L2) is not active against Aspergillusfumigatus, it was active against Candida albicans fungi, but less than the standard drug. The complexes with Ni(II) show the

highest activity due to the complexation process. The results show that the Ni(II) metal complexes are more biologically active than the ligand.

Table (5): Antifungal activity of the ligand L1 and their complexes

	Fungal inhibition zone % (conc.10 mg/ml)	
Sample	**Aspergillusfumigatus**	**Candida albicans**
Control DMSO	0.0	0.0
Ketocoazole	17	20
L1	-	15
$[Ni(C_9H_{11}N_3S)_2]$	20	19
$[Mn(C_9H_{11}N_3S)_2]$	-	-

Conclusion

Ni (II) and Mn (II) complexes with the Schiff base ligand derived from thiosemicarbaizde and Acetophenone were synthesized and characterized by various physico-chemical methods. The bonding of ligand to metal ion is confirmed by spectral studies like UV–Visible, FT-IR, and conductance measurements. The lower molar conductance values suggested the non-electrolytic nature of the complexes. The coordination of the Schiff base to the metal atom was found to be through the azomethine nitrogen, and the sulfur atoms. Antibacterial and antifungal studies of the ligand and complexes have also been studied which indicate that activity increases on chelation in Ni (II) complexes.

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Nurses` Knowledge Regarding Prevention and Control of Diabetic Septic Foot at *King Fahad* General Hospital in Jeddah, Kingdom of Saudi Arabia (2016)

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Abstract

Foot infection is an open sore infection or wound that most commonly occurs on planter aspect of the foot in about 15% of patient with diabetes. Nurses are the largest health workforce group and they play with important role in the care and education of diabetic patient. This descriptive hospital based study was conducted at King *Fahad* General Hospital in Jeddah. Kingdom of Saudi Arabia in 2016. This study aimed to assess nurses` knowledge, and attitudes regarding prevention and control of diabetic septic foot. The sample size consisted of (94) nurses working at each of surgical, medical, orthopedic wards at king *Fahad* General Hospital during the study period. The data were collected by using structured questionnaire designed by the researcher for the purposes of the study. The results showed that (18.2%, 12.8, and 22.3%) of study sample responded with correct complete answers regarding definition, causes of diabetic foot ulcer and signs and symptoms respectively. The study concluded that most of nurses` knowledge regarding prevention and control Diabetic Septic Foot at king *Fahad* General Hospital was inadequate.

***Key wards**: Nurses,* knowledge, diabetic, prevention. Diabetic foot ulcer.

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Introduction

It is estimated that on an average 7% of the world population are diabetics now and this number is estimated to increase to 8.3% by 2030. It is also estimated that 80% of the diabetic's patients live in developing countries (IDF, 2001). On an average every 30 s an extremity is amputated due to complications of diabetes mellitus (DM) and the majority of these amputations are secondary to Diabetic foot ulcer (Boullon *et al.*, 2005). Diabetic foot ulcer (DFU) is not only a patient problem but also a major health care concern throughout the world. Diabetic foot ulcer is one of the common and serious complications in diabetic patients. Treatment of infection in diabetic ulcer is difficult and expensive. Patients usually need to take long-term medications or become hospitalized for an extended period of time. It is estimated that usually 15-25% of diabetic patients develop DFU during their life-time (Singh and Armstrong 2005). On the other hand, more than 70% of patients who have developed DFU, experience an exacerbation of the disease in the next 5 years If an ulcer develops unfortunately, the treatment is challenging and need long duration. Team work consists of orthopedic surgeon, endocrinologist, infectious disease physician and a trained nurse in dressing is necessary to care for the wound. It is also advisable to add a podiatrist to the team if one is available. DFU treatment is expensive. On an average, the treatment cost for wounds with Wagner grade I in five industrialized countries was $3096 in 2010. However, if the wound becomes complicated and amputated, the cost will rise to almost $107900 (Apelgvist *et al.*, 2012) Therefore, based on the noble quote in health care profession "prevention is better than the treatment of the disease," Diabetic patients and health care providers to diabetic patients should familiarize themselves with the principals of diabetic foot ulcer prevention. The

training methods should be designed in a manner that diabetic patients understand and perform the foot care as it is intended. With a total of 344 million patients around the world, it seems that diabetes reached the extent of the epidemic in the world as well as in some Arab societies, such as Saudi Arabia, where the infection rate reached about 25% of the population, the center of a potential estimates, up ratio. Up as diabetes rate (type I) between Saudi children 4% of the total proportion of patients with diabetes. Knowing that children Kingdom 35.5% of them suffer from obesity, where the growing diabetes rate National Center for Diabetes in Saudi Arabia confirms that many individuals develop diabetes without their knowledge, which threatened thereby obtaining life-threatening complication (Bakker, 2012).

Materials and Methods

Ethical Consideration

Permission was taken from the Hospital Manager, Assistance and general director for Nursing affairs in King *Fahad* General Hospital in Jeddah.

Study Design

This study is a descriptive cross-sectional hospital-based study.

Study Period

The study was conducted during the period from March to June 2016.

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Study Area

The study carried out in King *Fahad* General Hospital which is a large hospital located in Jeddah It receives patients from the whole provinces and study provinces: *Rabbig*, *Aleeth* and *Addamprovince*.

Inclusion Criteria: -

Nurses working at surgical, medical and orthopedic rewards for more than one year. Nurses who accept to participate in the study.

Exclusion Criteria

Nurses who do not accept to participate in the study.

Sample Size

The total number of nurses working at surgical, medical and orthopedic was 120. The sample size of the nurses who participated in this study was 94 nurses.

Data Analysis

The Statistical Packages for Social Science (SPSS) software version 19 was used. The descriptive analysis was adopted including frequency distribution and percentages presented in tables and figures.

Result and Discursion

The study revealed that the majority (60.6%) of the study sample acquired knowledge regarding prevention and control of diabetic septic foot from medical staff while only 33.00% acquired it from mass media results regarding nurses' knowledge revealed that (18.2%.12.8% and 223%) of the study sample responded with complete correct answers regarding definition and causes of diabetic foot

ulcers and signs and symptoms, respectively. Also (23.4%, 20.2% and 27%) of a study sample responded with complete correct answers regarding diabetic foot complications, factors of avoiding infections and management of diabetic foot infection, respectively. It was also found hat (53.2% and 26.5%) of study sample responded with correct complete answers regarding the types of diabetes and control of high blood-sugar, while (40.4% and 41.5%) of them responded with correct incomplete answers. The study showed good knowledge of diabetes prevention as 72.3% of the studied nurses know correct hygiene, among 87.2% for observation foot. This is not similar to what was conducted by (Prospers, 2007) , who stated that almost half of nurses (49.4%) had no knowledge of hygiene or what to be observe in their feet, and 53.6% did not know the correct way to cut toe nail However, it is similar to the study that showed (68.1%) of the sample study trimotor nails straight with care, 32.2% showed nail cutting, 43.6% knew ideal foot wear and about more than three quarters of nurse has adequate knowledge towards feet care regarding ideal drying. Also (60.6%) of the study sample stated that it is important for a diabetic patient to use warm water for washing/bathing and (73.4%) of study sample stated that it is important for a diabetic patient to keep skin moist feet to prevent dryness while (85.1%) of study sample responded with correct complete answers regarding to wear any design of shoes. The current study reveals that the mean score±SD of total knowledge of the nurses participated in the study regarding prevention and control of diabetic septic foot were (1.76 and 19) respectively. That means the total knowledge of nurses regarding diabetic septic foot is 1,67 + 19 Total attitude of nurses in King *Fahad* General Hospital regarding prevention and control of Diabetic Septic Foot (81.3%). From the discussion, the researcher concluded that there are some studies with similar results shown above agreed with the present study results.

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Table (1) Showed the percentage of educational level and experience

Educational level	No	%
Diploma	38	40.0%
Bachelor	54	57.5%
Master	2	2.1%
Less than 1 years	8	8.5%
1-5 years	47	50%
6-10 years	27	28.7%
More than 10 years	12	12%

Table (2) showed the percentage of knowledge regarding Definition, Causes, signs and symptoms of Diabetes Septic foot

Knowledge Items	Correct complete answers		Correct incomplete answers		Wrong answers		Total	
Definition	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
	17	18.2	52	55.3	25	26.5	94	100.0
Causes of Diabetics septic foot	12	12.8	47	50	35	37.2	94	100.0
Sign and symptoms	21	22.3	43	45.7	30	32.0	94	100.0

Table (3) showed the percentage of knowledge regarding the types of diabetes and control of high blood sugar

Conclusion

Total knowledge of nurses regarding prevention and control of diabetic septic foot is good. Total attitude of nurses regarding prevention and control of diabetic septic foot is adequate.

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Performance Analysis of High Voltage DC (HVDC) Transmission Systems

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Abstract

The rapid increase in electrical power demand causes a need for the interconnection of power networks in different areas to increase supply reliability, and to facilitate power exchange between areas. The interconnection of separated networks results in a large power system expanding hundreds and even thousands of kilometers. Electrical power can either be transmitted using high voltage alternating current (HVAC) or high voltage direct current (HVDC) transmission systems. HVDC technology is preferred, because it is better when considering many factors such as cost, reliability and stability. Simply HVDC is conversion of alternating current into direct current using a phase-controlled converter with thyristors and then transfer the power as direct current into other side which again converts the direct current into alternating current using inverter HVDC transmission depends mainly on the progress of power electronics devices. This paper discusses line commutated converter high voltage direct current (LCC)-HVDC transmission technology application in power system interconnections. Natural commutated converters are most used in the HVDC systems. These convertors use a thyristor, which is a controllable semiconductor that can carry very high currents and able to block

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very high voltages. Sudanese – Ethiopian tie line is taken as case study. The study is done using MALAB \ simulink, under steady state and fault conditions. The used method provides efficient and stable operation of the power system and maximizes flexibility of power control without compromising the safety of equipment. Moreover various levels of control can be used. The results show the control of transmission and the ability of the system to recover quickly after fault clearance when HVDC transmission is used, and the recover time is 0.4 sec only.

Key words: High dc voltage, Converter, Steady state, high ac voltage.

Introduction

HVDC power transmission is a significant technology used successfully to transmit power in more economical way over a long distance to connect two synchronous networks. The idea and relevant technology were under development for many years and started as early as in the late 1920. Development of the thyristor and other power electronic devices drive the changes and the improvements in the HVDC technology. In simple terms HVDC is conversion of AC into DC using a phase-controlled converter with thyristors and then transfer the power as DC into other side which again converts the DC into AC using inverter (Achae, 2002). Due to the rapid increase in electricity demand, the need arises for the interconnection of power networks distributed in different areas to increase supply reliability, and to facilitate power exchange between areas. The interconnection of separated networks results in a large power system expanding hundreds and even thousands of kilometers. In this large power system, HVAC systems are used to accommodate the power over long distances between the different networks. HVAC lines have proven to be effective in transmission and distribution of electrical power but this creates challenges for power system operators such as:

1-The transmission losses are so high in HVAC system

2-The AC transmission system requires expensive reactive power compensation at both ends of the line to avoid voltage problems.

3- Non-synchronized grids operation is not possible.

4- In synchronous connections as in AC systems, the operation of the tie-line may cause power oscillations; moreover the fault in part of the network will propagate and affect the whole system.

HVDC transmission has been extensively researched the cost of a transmission over the last seven decades as an alternative to conventional HVAC transmission systems. A tie line using HVAC transmission technology is used between Ethiopia and Sudan for economic and security purpose. Tie – Line Power Flow Control Method for Grid- Connected Micro grids with SMES based on Optimization and Fuzzy Logic is presented in (Said, Ali, and Hartmann, 2020). In this work HVDC transmission is proposed for Ethiopian – Sudanese link.

Optimal location of HVDC transmission line using genetic algorithm is discussed in (Abbas and Tuaimah, 2020). Overview, introduction and technical review about HVDC are discussed in details in (Watson and Watson, 2020) (Kumar and Hussain, 2018) (Meah, and Blanding, 2009) (Samira and Huq, 2018).

Comparison between AC and DC Transmission:

Making a plan to select between AC and DC transmission is based on an evaluation of transmission costs, technical considerations, and the reliability offered by the two transmission alternatives (Rashid, 2001).

Evaluation of Transmission Costs:

Line comprises of the capital investment required for the actual infrastructure (i.e. right-of-way (ROW) towers, conductors, insulators, and terminal equipment) and costs incurred for operational requirements (i.e. losses). Assuming similar insulation requirements for peak voltage levels for both AC and DC lines, a DC line can carry as much power, with two conductors (having positive/negative polarities with respect to ground), as an AC line with three conductors of the same size. Therefore, for a given power level, a DC line requires a smaller ROW, simpler and cheaper towers and reduced conductor and insulator costs.

With the DC option, since there are only two conductors (with the same current capacity of three AC conductors), the power transmission losses are also reduced to about two-thirds of the comparable AC system. The absence of skin

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effect with dc is also beneficial in reducing power losses Figure 1 shows the variation of infrastructure costs with distance for ac and dc transmission.

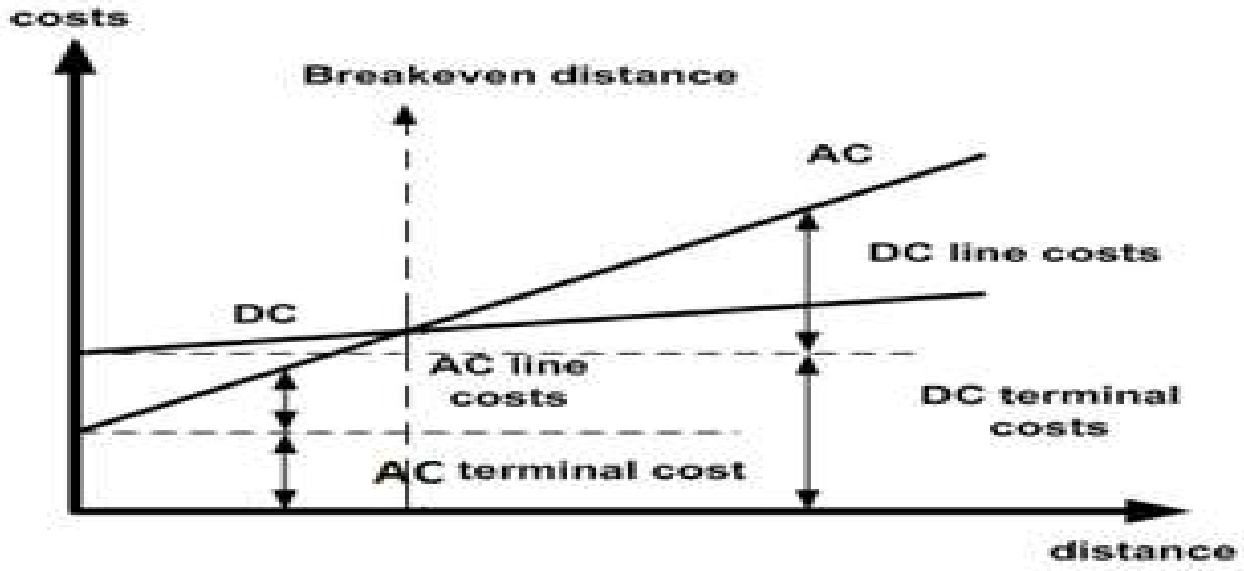

Figure (1): Comparison of AC and DC transmission system costs (Rashid, 2001).

Evaluation of Technical Considerations:

Due to its fast controllability, a DC transmission system has full control over transmitted power, an ability to enhance transient and dynamic stability in associated AC networks and can limit fault currents in the DC lines. Furthermore, DC transmission overcomes many problems associated with AC transmission such as stability limit, voltage control, line compensation and ground impedance.

Evaluation of Reliability and Availability Costs:

Statistics on the reliability of HVDC links are maintained by IEEE working Groups. The reliability of DC links has been very good and is comparable with that of AC systems. The availability of DC links is quoted in the upper 90% (Rashid, 2001) (Padiyar, 1999).

Applications of DC Transmission:-

The detailed comparison of AC and DC transmission in terms of economic and technical performance lead of the following areas application for DC transmission:

1- Underground or underwater cables.
2- Long distance bulk power transmission.
3- Asynchronous interconnection of AC systems operating at different frequencies or where independent control of system is desired.
4- Stabilization of power flows in integrated power system (Rashid, 2001) (Padiyar, 1999).

3-1 Underground or underwater cables:

In the case of long-cable connections over the breakeven distance of about 40–50 km, the DC cable transmission system has a marked advantage over the AC cable connections.

Long distance bulk power transmission:

Bulk power transmission over long distances is an application ideally suited for DC transmission and is more economical than AC transmission whenever the breakeven distance is exceeded.

The breakeven distance is being effectively decreased with the reduced costs of new compact converter stations possible due to the recent advances in power electronics.

Asynchronous interconnection of AC systems operating at different frequencies or where independent control of system is desired:

In terms of an asynchronous interconnection between two AC systems, the DC option is preferred. There are many instances of "back to back" connections where two AC networks have been tied together for the overall advantage to both AC systems. With recent advances in control techniques, these interconnections are being increasingly made at weak AC systems.

Stabilization of power flows in integrated power system:

In large interconnected systems, power flow in AC ties (particularly under disturbance conditions) can be uncontrolled and lead to overloading and stability problems, thus endangering system security. Strategically placed DC lines can overcome this problem due to the fast controllability of DC power and provide much needed damping and timely overload capability (Rashid, 2001).

The HVDC Technology:

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The fundamental process that occurs in a HVDC system is the conversion of electrical current from AC to DC (rectifier) at the transmitting end, and from DC to AC (inverter) at the receiving end. There are three ways of achieving conversion:

1- Line Commutated Converters (LCC).
2- Capacitor Commutated Converters (CCC)
3- Voltage Source Converters (VSC).

Line Commutated Converters (LCC):

Natural commutated converters are most used in the HVDC systems as of today. The component that enables this conversion process is the thyristor, which is a controllable semiconductor that can carry very high currents and is able to block very high voltages. By means of connecting the thyristors in series it is possible to build up a thyristor valve, which is able to operate at very high voltages. The thyristor valve is operated at net frequency (50 Hz or 60 Hz) and by means of a control angle it is possible to change the DC voltage level of the bridge. This ability is the way by which the transmitted power is controlled rapidly and efficiently..

Capacitor Commutated Converters (CCC):

Improvement in the thyristor-based commutation, the CCC concept is characterized by the use of commutation capacitors inserted in series between the converter transformers and the thyristor valves. The commutation capacitors improve the commutation failure performance of the converters when connected to weak networks.

Voltage Source Converters (VSC):

This type of converters introduces a spectrum of advantages, e.g. feed of passive networks (without generation), independent control of active and reactive power, power quality. The valves of these converters are built up with semiconductors with the ability not only to turn-on but also to turn-off. They are known as (Forced Commutated Converters). Two types of semiconductors are normally used in the voltage source converters.

They are gate turn-off (GTO) thyristor and insulated gate bipolar transistor (IGBT). Both of them have been in frequent use in industrial applications since early eighties. The VSC commutates with high frequency (not with the net

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frequency). The operation of the converter is achieved by Pulse Width Modulation (PWM). With PWM it is possible to create any phase angle and amplitude (up to a certain limit) by changing the PWM pattern, which can be done almost instantaneously. Thus, PWM offers the possibility to control both active and reactive power independently. This makes the PWM Voltage Source Converter a close to ideal component in the transmission network. From a transmission network viewpoint, it acts as a motor or generator without mass that can control active and reactive power almost instantaneously (Johansson,2004)

LCC – HVDC Transmission System:-

A HVDC transmission system is highly controllable. Its effective use depends on appropriate utilization of this controllability to ensure desired performance of the power system. With the objectives of providing efficient and stable operation and maximizing flexibility of power control without compromising the safety of equipment, various levels of control are used in a hierarchical manner.

Basic Principle of Control:-

Consider the HVDC link in figure 2, and the equivalent circuit in figure 3.

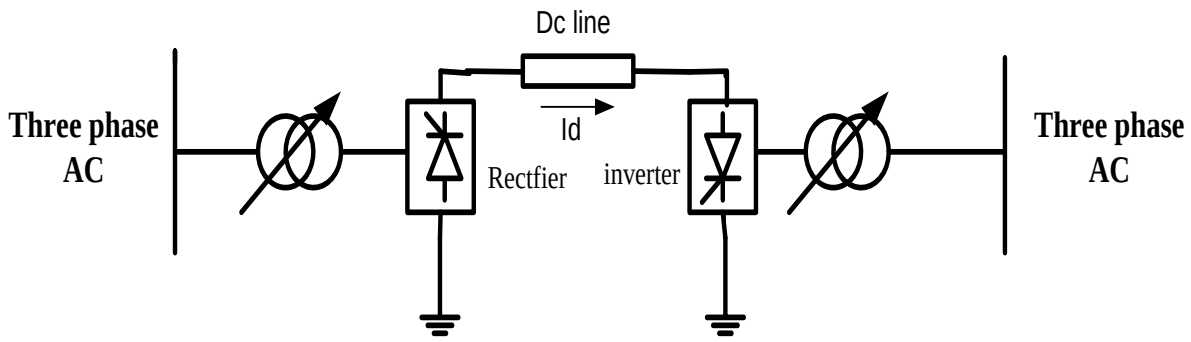

Figure (2): Schematic diagram of HVDC System. (Kundur, 1994)

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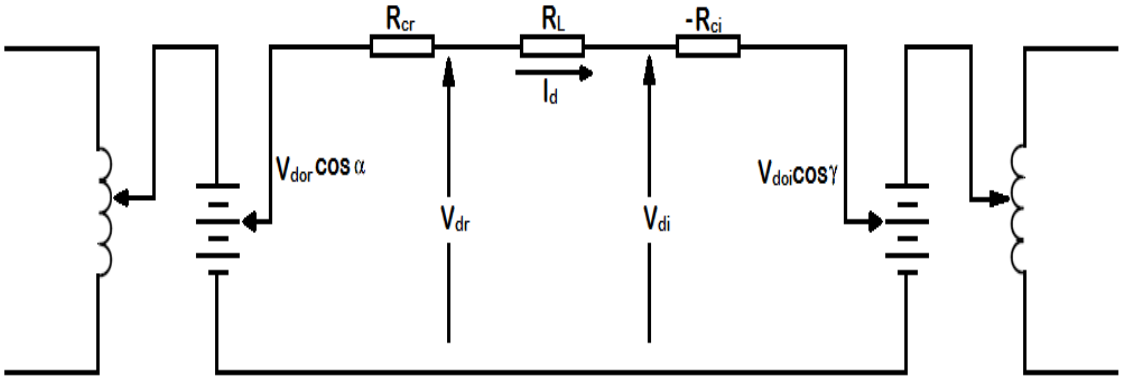

Figure (3): Equivalent circuit of HVDC System. (Kundur, 1994)

The direct current flowing from the rectifier to the inverter is

$$I_d = \frac{V_{dor}\cos\alpha - V_{doi}\cos\gamma}{R_{cr}+R_L-R_{ci}} \quad (1)$$

The power at the rectifier terminals is

$$P_{dr} = V_{dr}I_d \quad (2)$$

The inverter terminal is

$$P_{di} = V_{di}I_d = P_{dr} - R_L I_d^2 \quad (3)$$

The direct voltage at any point on the line and the current (or power) can be controlled by controlling the internal voltages (Vdor $\cos\alpha$) and (Vdi $\cos\gamma$). This is accomplished by grid/gate control of the valve ignition angle or control of the AC voltage through tap changing of converter transformer.
Grid/gate control, which is rapid (1 to 10 ms) and tap changing which is slow (5 to 6 s per step) are used in complementary manner. Grid/gate control is used initially for rapid action, followed by tap changing to restore the converter quantities (α for rectifier and γ for inverter) to their normal range.

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Power reversal is obtained by reversal of polarity of direct voltage at both ends (Kundur, 1994).

Control Characteristics:

The rectifier maintains constant current by changingα. However, α cannot be less than its minimum value (α_{min}). Once α_{min} is reached, no further voltage increase is possible, and the rectifier will operate at constant ignition angle (CIA).

Therefore, the rectifier characteristic has really two segments (AB and FA) as shown in Figure 4. The segment FA corresponds to minimum ignition angle and represents the CIA control mode. The segment AB represents the normal constant current (CC) control mode.

In practice, the constant current characteristic may not be truly vertical, depending on the current regulator. With a proportional controller, it has a high negative finite gain of the current regulator, as shown below (Kundur, 1994).

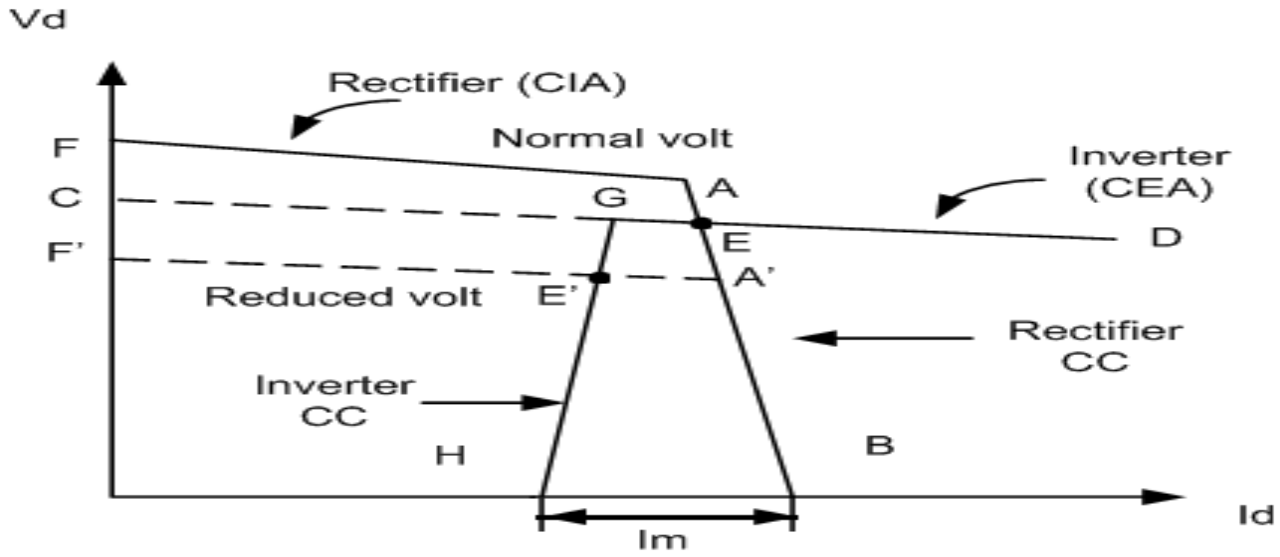

Figure (4): Actual converter control characteristics.(Kundur, 1994)

Case Study:-

The case study is the tie line between Sudan and Ethiopia.

The system can be divided into three main parts as follows:-

1- AC system 1.

2- AC system 2.

3- DC link

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6-1 AC system1 Parameters:
1- Three- phase voltage source:
500KV, 50Hz, L=98.03$\mathbf{e^{-3}H}$
2-Transformer:
1200MVA, 500/110KV, K=0.9 'tap ratio', Rt1=0.0025p.u, Rt2=0.00125p.u, Lt2=0.24p.u, Rt3=0.00125p.u, Lt3=0.24p.u, Rm=500p.u, Lm= 500p.u
AC system 2 Parameters:
1-Three-phase voltage source:
500Kv, 50Hz, L=28.$\mathbf{e^{-3}H}$
2-Transformer: 1200 MVA, 500/110Kv, K=0.96 tap ratio, Rt1=0.0025p.u, Rt2=0.00125p.u, Lt2=0.24p.u, Rt3=0.00125p.u, Lt3=0.24p.u, Rm=500p.u Lm=500p.u,
S (base) = 100MVA, V (base) = 500 KV
DC Link Parameters:
R=0.067$\mathbf{\Omega/km}$, C=0.01306$\mathbf{e^{-6}F/km}$, L=0.961$\mathbf{e^{-3}\ H/km}$, Length=194km,
DC smoothing reactor = 0.5H.

Simulation Results:-
The results are obtained during steady state operation and during fault at DC line.
System Behavior during Steady State Operation Condition:
The results for the HVDC tie line at the rectifier side under steady state for the voltage, current and rectifier and inverter delay angles, are shown in figures (5), (6), (7) respectively. The rectifier and inverter delay angles are 16.5°,150.9°. Where the dc voltage is 0.63pu (approx) and the dc current is 1pu.

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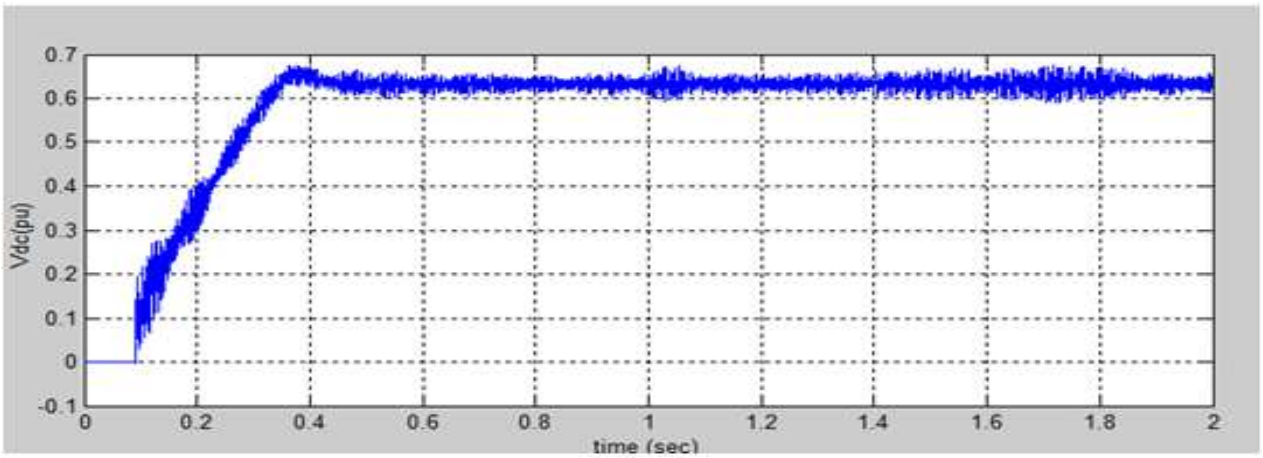

Figure (5): HVDC Tie Line Voltage waveform under Steady State.

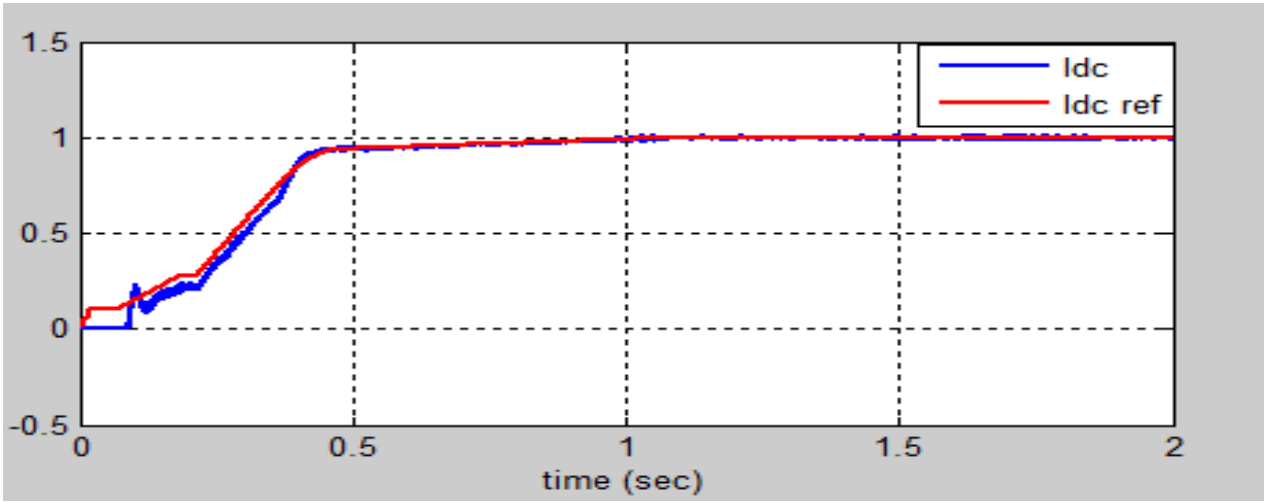

Figure (6): HVDC Tie Line Current waveform under Steady State.

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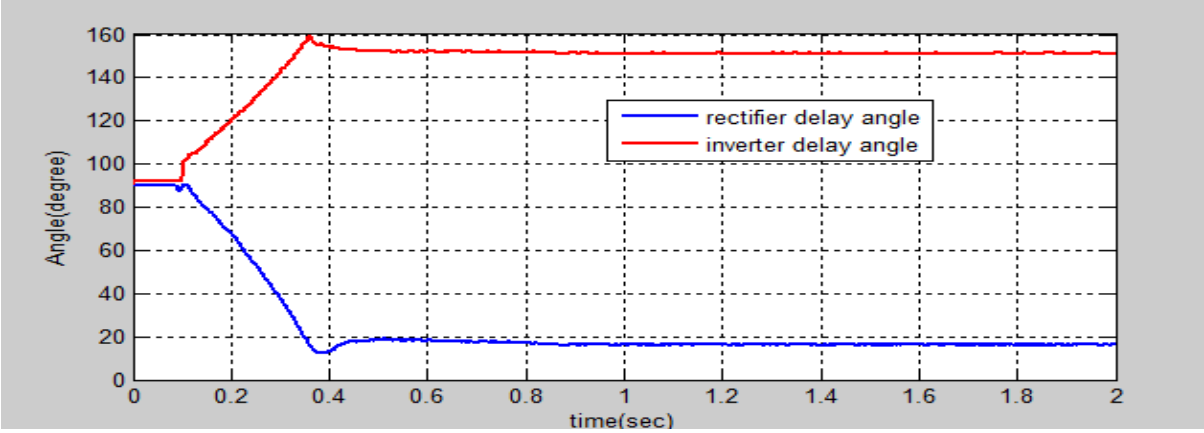

Figure (7): HVDC Tie Line Rectifier and Inverter delay angle under Steady State.

System Behavior during Fault at DC Side:

Figure (8) shows the HVDC tie line voltage, current and rectifier time delay waveform during Fault.

The DC fault was applied at t = 0.7 sec, and the DC Fault protection in the rectifier is activated as default. During the fault, the DC current increases quickly to 2.3 pu and the DC voltage falls to zero at the rectifier. This DC voltages drop is seen by the voltage dependent current order limiter which reduces the reference current to 0.3 pu at the rectifier. The DC current continues to circulate in the faulty value. Then, at t = 0.77 sec, the rectifier firing angle is forced to 166 degrees by the DC protection.

The rectifier now operates in inverter mode. The DC line voltage becomes negative and the energy stored in the line is returned to the AC network, causing rapid extinction of the fault current at its next zero-crossing. Then, firing angle is released at t = 0.87 sec and the normal DC voltage and current recover in approximately 0.4 sec.

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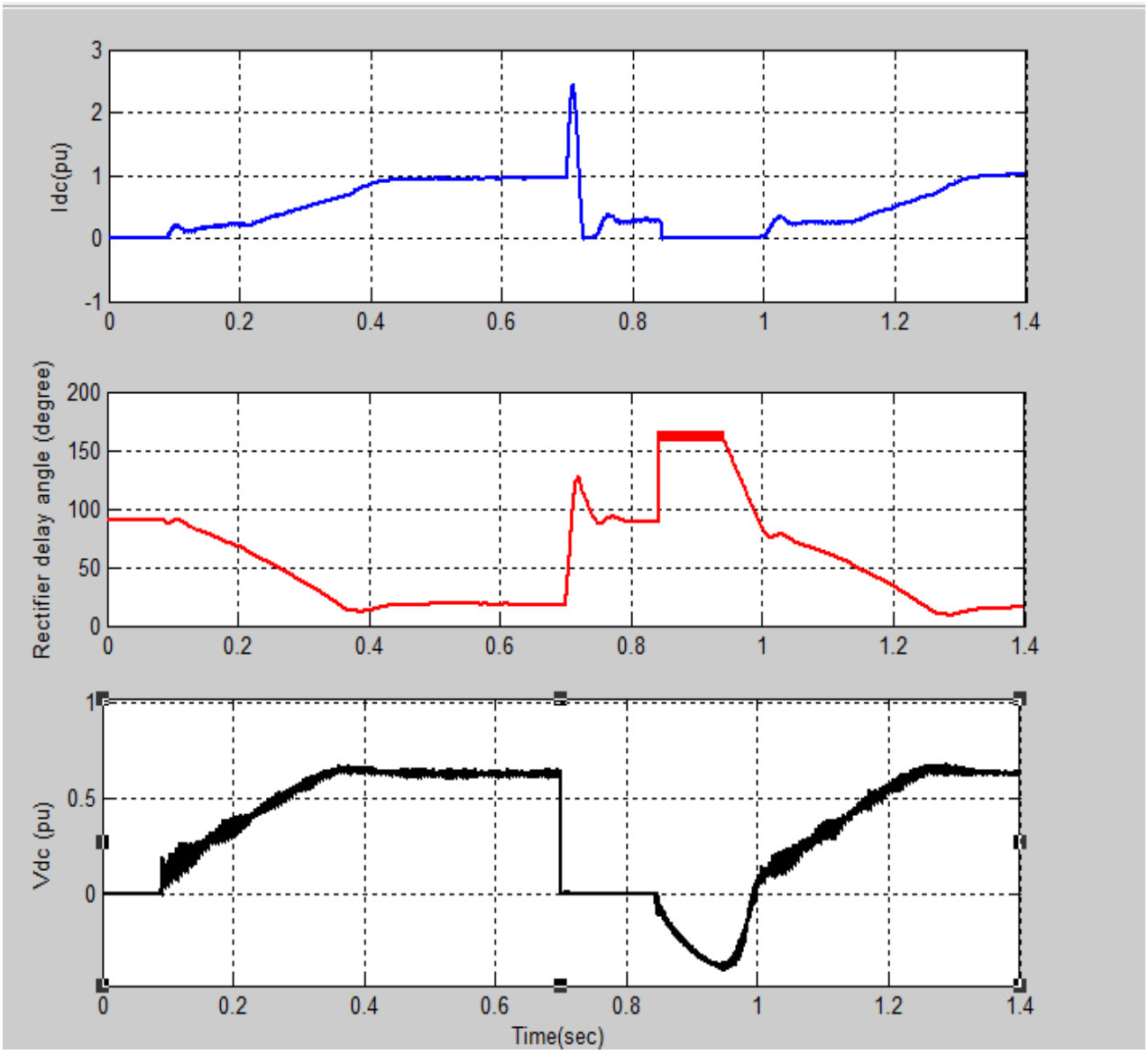

Figure (8): HVDC Tie Line Voltage, Current and Rectifier time delay waveform during Fault.

Conclusion

At normal operation use of fast controllability HVDC transmission solves many of HVAC transmission problems for tie lines such as; the presence of large power oscillations which can lead to frequent tripping increase in fault level, transmission of disturbances from one system to the other, and requirement of reactive power compensation due to line parameters.

LCC-HVDC transmission is preferred for long distances, over land or submarine for economic and environmental considerations. Controlling the power flow and avoiding overloading to prevent cascading trips, thus limiting system breakup under severe contingencies are one of the technical advantages for LCC-HVDC transmission.

The effect of fault is less when using HVDC. Moreover the recover time after fault clearance is relatively small, and it is just 0.4 sec for the case study.

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A computational Study Uses LDL ^{T} A computational Study Uses LDL ^{T}on QP Problems with General Linear Constraints

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Abstract

Quadratic programming (QP) solves the problem of a quadratic objective function. The objective function may contain quadratic up to the second degree. Constrained optimization is optimizing an objective function concerning a certain variable but taking constraints on those variables into effect. LDL^{T} Method to solve for Quadratic Programming problem (QPP) is proposed. In addition, an alternative approach is presented. This method is simple when dealing with non-linear programming problems (NLPP) such as quadratic programming problems (QPP). Based on the procedure, we developed a new strategy for solving a Quadratic Programming Problem using the LDL^{T} method. When the new strategy is compared to Wolfe's method in the sense of the computational process for solving NLPP, we found that the new method requires less or at most the same amount of iterations as Wolfe's method. The technique yielded the best result. The method produces efficient results. We also spend less time simplifying numerical Problems and CPU time.

Keywords:A computational, **LDL ^{T}**, QP problems, general linear ,Constraints.

INTRODUCTION

Quadratic programming (QP), it minimizes quadratic objectives based on equality and inequality constraints, is basis of all scientific algorithms. Applications include basic functions in simulation, engineering, animation, and finance where the correct, reliable, effective, and scalable solution of QP problems is significant. But the QP algorithms that are currently on the market

are usually either accuracy or scalability, not both. Because they require dense matrix techniques, certain algorithms only successfully solve QP problems of the scale being smaller (Philip, 1966) .

A matrix of rank one is added to a positive definite matrix A, and many modifications to the LDL^T factorization of matrix A are compared. The presentation gives a worked example that also shows how errors grow. The method extensions that make it possible to represent and update positive semi-definite matrices efficiently is discussed. (Fletcher and Powell, 1974).

For updating a matrix's factors with a rank-one change, several approaches have surfaced. This has probably limited their use in a wider field because these methods have always been presented in the context of particular applications. This study describes a number of ways to change Cholesky factors. While some of these have been published before, some are being presented here for the first time. Additionally, a new approach is described changing the general matrix's complete orthogonal factorization, from which the typical QR factors are derived as a specific case. (Gill *et al.*, 1974) .

Consider nonlinear optimization problems with nonlinear equality constraints, changing bounds, and nonlinear optimization. For the resolution of these problems, different augmented Lagrangian methods have been defined in the literature. This paper suggests modifying one of these algorithms, notably Andreani et al.'s ALGENCAN, to include second-order data into the augmented Lagrangian framework using the active-set method. Demonstrate that all of it has the same convergence properties as ALGENCAN and asymptotic quadratic convergence rates under likely assumptions. The numerical results show that the solution suggested can be used to create a more reliable ALGENCAN solution. (Cristofari *et al.*, 2022) .

Using low-rank factorization, provide an entropy regularized splitting model to solve binary quadratic programming with linear inequality constraints (Liu *et al.*, 2022).

Consider of a quadratic programming problem with additional geometric constraints to the quadratic cone constraints. Define necessary and sufficient conditions for a KKT point's optimality under reasonable assumptions, and we describe optimality in particular by employing strong duality as a regularity

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criterion. We then analyse simultaneous diagonalizable quadratic problems in which the Hessian matrices of the associated quadratic functions are all diagonalizable using the same ortho-normal matrix, where two quadratic equality requirements determine the feasible set (Flores-Bazán and Mastroeni, 2022).

There are several methods to implement methods for solving linear inequality and equality requirements in nonlinear optimization problems using numerically stable matrix factorizations (Goldfarb, 1976).

Design NASOQ, a new full-space QP algorithm providing a selected useful, and scalable solution to QP problems. Design a new row modification method and quickly implement LDL^T factorization for infinite systems to enable NASOQ. Together, they make it possible for the iteratively improved KKT systems needed for correct QP solutions to be updated and solved accurately. Fact that QP methods have already undergone important artificial evaluation, a new benchmark set that consists of a variety of graphics-related QPs across physical simulation, animation, and geometry processing tasks has been built in order to test and compare NASOQ's for applicability in real-world applications (Cheshmi, 2020) .

Fletcher and Powell proposed a numerically reliable method for updating the matrix's LDLT factorization when a symmetric low-rank part was added to a symmetric positive-definite matrix (Heights, 2008) .

We supplied a new LDL-T factorization of a symmetric positive-definite matrix in the addition of a symmetric low-rank term, which is numerically efficient. a diagonal matrix and a low rank matrix combined. The LDLT factorizations' display of the elements of the unit lower triangular matrix is the foundation for our new results.

LDL^T Factorizations

Definition

The factorization of LDL-T follows a form of an equation.

$$S = L\ D\ L^T$$

$$s^T = (LDL)^T = (L^T)^T D^T L^T = LDL^T = S$$

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Properties

Theorem

The quadratic form defined by $S = LDL^T$ is

$$q(x) =< x\ ,\ LDL^T x >$$
$$=< L^T x, > DL^T x >$$
$$=< y, Dy >$$
$$= d_1 y_1^2 + d_2 y_2^2 + \cdots + d_n y_n^2$$

The diagonal entries of D control the definiteness of q(x)

LDL^T method

$$[A][x] = [b] \quad (1)$$

$$[A] = [L][D][L]T \quad (2)$$

For example step (1) metric positive definite

Phase 1 Step functiontion
$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ l_{21} & 1 & 0 \\ l_{31} & l_{32} & 1 \end{bmatrix} \begin{bmatrix} d_{11} & 0 & 0 \\ 0 & d_{22} & 0 \\ 0 & 0 & d_{33} \end{bmatrix} \begin{bmatrix} I & l_{21} & l_{31} \\ 0 & 1 & l_{32} \\ 0 & 0 & 1 \end{bmatrix} \quad (3)$$

$$d_{jj} = a_{jj} - \sum_{k=1}^{j-1} l_{jk}^2\, d_{kk} \quad (4)$$

$$l_{ij} = \left[a_{ij} - \sum_{k=1}^{j-1} l_{ik}\, d_{kk} l_{jk} \right] * \left[\frac{1}{d_{jj}} \right] \quad (5)$$

Thus, the following step-by-step methods can be applied to explain the LDL^T algorithms.

Cholesky and LDL^T Decomposition

Step 1: The factorization step

$[A] = [L]\,[D]\,[L]^T$ (2, repeated)

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Step 2: Steps of diagonal scaling and a forward solution

Equation (2) can be substituted into Equation (1) to obtain:

$$[L] = [D]\,[L]^{T}\,[x] = [b] \qquad (6)$$

Let us define

$$[L]^{T}\,[x] = [y]$$

$$\begin{bmatrix} 1 & l_{21} & l_{31} \\ 0 & 1 & l_{32} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} \qquad (7)$$

$$x_i = y_i - \sum_{k=i+1}^{n} l_{ki}\, x_k \; ; \text{for i}$$

$$= n\,, n-1, n-2, \ldots, 2, 1 \qquad (8)$$

Also, define

$$[D]\,[y] = [Z]$$

$$\begin{bmatrix} d_{11} & 0 & 0 \\ 0 & d_{22} & 0 \\ 0 & 0 & d_{33} \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} \qquad (9)$$

$$y_i = \frac{z_i}{d_{ii}}\,, for\ i = 1,2, \ldots, n \qquad (10)$$

Then Equation (6) becomes

$$[L][Z] = [b]$$

$$\begin{bmatrix} 1 & 0 & 0 \\ l_{21} & 1 & 0 \\ l_{31} & l_{32} & 1 \end{bmatrix} \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix} \qquad (11)$$

Or

$$z_i = b_i - \sum_{k=1}^{i-1} l_{ik}\, z_k \; ; for\ i = 1,2, \ldots . n \qquad (12)$$

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Equation (9) can be easily solved for the vector [y] after equation (11) can be solved efficiently for the vector [z].

Step 3: Backward solution step

Equation (7) can be successfully solved for the first unknown vector [x] in this step.

Numerical Example (LDL^T algorithms)

Example

Solve the following system for the unknown vector [x]

$$[A][x] = [b]$$

$$\text{where } [A] = \begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix}, \text{and } [b] = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

Solution

The factorized matrix [D] and [L] can be computed from Equation (3), and Equation (4), respectively

$$D = d_{11} = a_{11} - \sum_{k=1}^{j-1=0} L^2{}_{jk}\, d_{kk}$$

$$= a_{11} \qquad = 2$$

$$L_{11} = (always)$$

$$l_{21} = \frac{a_{21} - \sum_{k=1}^{j-1=0} L_{ik} d_{Kk}\, l_{jk}}{d_{jj}} = \frac{a_{21}}{d_{11}} = \frac{-1}{2} = -0.5$$

$$L_{31} = \frac{a_{31}}{d_{11}} = \frac{0}{2} = 0$$

Column 1 of matrices [D] and [L]

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$$d_{22} = a_{22} - \sum_{k=1}^{j-1=1} L^2{}_{jk}\, d_{kk}$$

$$= 2 - l^2{}_{21} d_{11}$$

$$= 2 - (-0.5)^2(2) \qquad = 1.5$$

$$L_{32} = \frac{\left[a_{32} - \sum_{k=1}^{j-1=1} l_{31} d_{11}\, l_{21}\right]}{d_{22}} = \frac{-1 - (0)(2)(-0.5)}{1.5} = -0.6667$$

Column 2 of matrices [D] and [L]

$$\mathrm{d}_{33} = \mathrm{a}_{33} - \sum_{\mathrm{k=1}}^{\mathrm{j-1=2}} \mathrm{L}^2{}_{\mathrm{jk}}\, \mathrm{d}_{\mathrm{kk}}$$

$$= 1 - \mathrm{l}^2{}_{31}\mathrm{d}_{11} - \mathrm{l}^2{}_{32}\mathrm{d}_{22}$$

$$= 1 - (0)^2(2) - (0.6667)^2(1.5) \quad = 0.3333$$

Column 3 of matrices [D] and [L]

Hence

$$[\mathrm{D}] = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 1.5 & 0 \\ 0 & 0 & 0.3333 \end{bmatrix}$$

And

$$[\mathrm{L}] = \begin{bmatrix} 1 & 0 & 0 \\ -0.5 & 1 & 0 \\ 0 & -0.6667 & 1 \end{bmatrix}$$

The forward solution in Equation (12) becomes:

$$[\mathrm{L}][\mathrm{Z}] = [\mathrm{b}]$$

$$\begin{bmatrix} 1 & 0 & 0 \\ -0.5 & 1 & 0 \\ 0 & -0.6667 & 1 \end{bmatrix} \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

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Or

$$z_i = b_i - \sum_{k=1}^{i-1} l_{ik}\, z_k \; ; for\; i = 1,2,3$$

Hence

$$z_1 = b_1 = 1$$

$$z_2 = b_2 - l_{21}z_1$$

$$= 0 - (-0.5)(1) \qquad = 0.5$$

$$z_3 = b_3 - l_{31}z_1 - l_{32}z_2$$

$$= 0 - (0)(1) - (-0.6667)(0.5) \quad = 0.3333$$

The diagonal scaling phase, shown in equation (9) becomes

$$[D]\,[y] = [Z]$$

$$\begin{bmatrix} 2 & 0 & 0 \\ 0 & 1.5 & 0 \\ 0 & 0 & 0.3333 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 0.5 \\ 0.3333 \end{bmatrix}$$

Or

$$y_i = \frac{z_i}{d_{ii}} \text{ , for i} = 1,2,3$$

Hence

$$y_1 = \frac{z_1}{d_{11}} = \frac{1}{2}$$

$$= 0.5$$

$$y_2 = \frac{z_2}{d_{22}} = \frac{0.5}{1.5}$$

$$= 0.3333$$

$$y_3 = \frac{z_3}{d_{33}} = \frac{0.3333}{0.3333}$$

$$= 1$$

The backward solution phase can be found by referring to equation (7)

$[L]^T\,[x] = [y]$

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$$\begin{bmatrix}1 & 0.5 & 0\\ 0 & 1 & -0.667\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}=\begin{bmatrix}0.5\\ 0.333\\ 1\end{bmatrix}$$

$$x_i = y_i - \sum_{k=i+1}^{n} l_{ki}\, x_k \text{ ; for } i = 3,2,1$$

Hence

$$\begin{gathered}x_3 = y_3\\ = 1\\ x_2 = y_2 - l_{32}x_3\\ = 0.3333 - (-0.6667)(1)\\ = 1\\ x_1 = y_1 - l_{21}x_2\\ = 0.5 - (-0.5)(1) - (0)(1)\\ = 1\end{gathered}$$

Hence

$$\begin{gathered}[x] = \begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}\\ = \begin{bmatrix}1\\ 1\\ 1\end{bmatrix}\end{gathered}$$

Example

Consider the factorizations

$$\begin{bmatrix}3 & -9 & 6\\ -9 & 26 & -23\\ 6 & -23 & -8\end{bmatrix} = \underset{L}{\begin{bmatrix}1 & 0 & 0\\ -3 & 1 & 0\\ 2 & 5 & 1\end{bmatrix}}\underset{D}{\begin{bmatrix}3 & 0 & 0\\ 0 & -1 & 0\\ 0 & 0 & 5\end{bmatrix}}\underset{L^T}{\begin{bmatrix}1 & -3 & 2\\ 0 & 1 & 5\\ 0 & 0 & 1\end{bmatrix}}$$

The quadrate from $q(x) = < x, sx >$ is given by

$$q(x) = 3(x_1 - 3x_2 + 2x_3)^2 - 7(x_2 + x_3)^2 + 5(x_3)^2$$

This quadratic form is indefinite $(d_1, d_3 > 0 \;\&\; d_2 < 0)$ LDL^T Algorithm Statement.

Example

Consider the following S = Lu factorizations

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$$\underset{}{} \qquad L \qquad\qquad u$$

$$\begin{bmatrix} 4 & -12 & 16 \\ -12 & 31 & -83 \\ 16 & -83 & -175 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 3 & 1 & 0 \\ 4 & 7 & 1 \end{bmatrix} \begin{bmatrix} 4 & -12 & 16 \\ 0 & -5 & -35 \\ 0 & 0 & 6 \end{bmatrix}$$

Then $U = DL^T$ Where D = diag (4,-5, 6) which gives

$$\underset{}{} \qquad L \qquad\qquad D \qquad\qquad L^T$$

$$\begin{bmatrix} 4 & -12 & 16 \\ -12 & 31 & -83 \\ 16 & -83 & -175 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -3 & 1 & 0 \\ 4 & 7 & 1 \end{bmatrix} \begin{bmatrix} 4 & 0 & 0 \\ 0 & -5 & 0 \\ 0 & 0 & 6 \end{bmatrix} \begin{bmatrix} 1 & -3 & 4 \\ 0 & 1 & 7 \\ 0 & 0 & 1 \end{bmatrix}$$

Note that S is indefinite $(d_1, d_3 > 0 \ \& \ d_2 < 0)$

Example

Suppose a ≠ 0 and consider the real – symmetric S below

$$S = \begin{bmatrix} 0 & a \\ a & b \end{bmatrix} \quad \lambda_1.\lambda_2 = \det(s) = -a^2 < 0$$
$$one\, is < 0 \ and \ one \ is > 0$$

S is indefinite

Note that the first step to row- reduce S is a row – swap

Algorithm

The following procedure calculates $S = LDL^T$ if the factorization exists

Step 1: start applying the PS = Lu procedure

Step 2: Necessary row –swaps imply is indefinite and

$$S \neq LDL^T$$

Step 3: with S = LU, define D = Diag (U) to obtain

$$S = LDL^T$$

We can identify the definiteness of S without calculating eigenvalues

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Example

Consider the following row- reductions

$$\begin{bmatrix} -2 & 4 & -10 \\ 4 & -11 & 8 \\ -10 & 8 & -102 \end{bmatrix} \longrightarrow \begin{bmatrix} -2 & 4 & -10 \\ 0 & -3 & -12 \\ 0 & -12 & -52 \end{bmatrix} \longrightarrow \begin{bmatrix} -2 & 4 & -10 \\ 0 & -3 & -12 \\ 0 & 0 & -4 \end{bmatrix}$$

(-2, -3, -4)

Negative definite

This gives the $S = LDL^T$ factorization

$$\begin{matrix} S & & & L & & & D & & & L^T \end{matrix}$$

$$\begin{bmatrix} -2 & 4 & -10 \\ 4 & -11 & 8 \\ -10 & 8 & -102 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -2 & 1 & 0 \\ 5 & 4 & 1 \end{bmatrix} \begin{bmatrix} -2 & 0 & 0 \\ 0 & -3 & 0 \\ 0 & 0 & -4 \end{bmatrix} \begin{bmatrix} 1 & -2 & 5 \\ 0 & 1 & 4 \\ 0 & 0 & 1 \end{bmatrix}$$

Definition

A cholesky factorization is an equation of the form

$$S = R^T R$$

S nxn positive semi definite, R nxn upper – triangular (nonnegative diagonal)

The quadratic form defined by S is

$$q(x) = < X, SX >$$

$$= < X, R^T RX >$$

$$= < Rx, Rx >$$

$$= || Rx ||^2$$

The matrix S is positive definite if and only if R is non-singular.

Example

Consider the following Cholesky factorization

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$$\begin{bmatrix} 9 & -6 & 15 \\ -6 & 5 & -2 \\ 15 & -2 & 125 \end{bmatrix} = \begin{bmatrix} 3 & 0 & 0 \\ -2 & 1 & 0 \\ 5 & 8 & 6 \end{bmatrix} \quad \begin{bmatrix} 3 & -2 & 5 \\ 0 & 1 & 8 \\ 0 & 0 & 6 \end{bmatrix}$$

The quadratic form defined by S is

$$q(x) = (3x_1 - 2x_2 + 5x_3) + (x_2 + 8x_3)^2 + (6x_3)^2$$

Note that S is positive definite because R is non-singular.

Cholesky Algorithm

Algorithm

Suppose that S is real – symmetric

Step 1: Apply the PS = LU Procedure

Not positive Semi-definite if a row – swap is required.

Not positive semi-definite if U has a negative pivot

Step 2: factor S as S = LDL^T

Step 3: define $R = \sqrt{DL^T}$

This gives a cholesky factorization S = R^TR

Example:-

Consider the following row – reductions

$$\begin{bmatrix} 9 & 3 & 20 \\ 3 & 2 & 3 \\ 20 & 3 & 58 \end{bmatrix} \xrightarrow{r_2 - \left(\frac{1}{3}\right) r_1 \to r_2} \begin{bmatrix} 9 & 3 & 20 \\ 0 & 1 & \frac{-11}{3} \\ 0 & \frac{-11}{3} & \frac{122}{9} \end{bmatrix} \xrightarrow{r_3 + \left(\frac{11}{3}\right) r_2 \to r_3} \begin{bmatrix} 9 & 3 & 20 \\ 0 & 1 & \frac{-11}{3} \\ 0 & 0 & \frac{1}{9} \end{bmatrix}$$

Positive – definite

This gives the cholesky factorization R^TR where

$$\underset{R}{\begin{bmatrix} 3 & 1 & \frac{20}{3} \\ 0 & 1 & \frac{-11}{3} \\ 0 & 0 & \frac{1}{3} \end{bmatrix}} = \underset{\sqrt{D}}{\begin{bmatrix} 3 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \frac{1}{3} \end{bmatrix}} \quad \underset{L^T}{\begin{bmatrix} 1 & \frac{1}{3} & \frac{20}{9} \\ 0 & 1 & \frac{-11}{3} \\ 0 & 0 & 1 \end{bmatrix}}$$

STATEMENT OF THE PROBLEM

In the following we are going to illustrate the problem of the number of iterations in solving QPP being less (by method) than the solution obtained by the existing method.

PROBLEM (Ghadle and Pawar, 2015)

Solve the following **Quadratic programming problem** using **LDL^T method**.

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$$\text{Maximize } z = 2x_1 + x_2 - x_1^2$$
$$\text{Subject to: } 2x_1 + 3x_2 \leq 6$$
$$2x_1 + x_2 \leq 4$$
$$x_1, x_2 \geq 0$$

SOLUTION OF THE PROBLEM

$$A = \begin{bmatrix} 2 & 3 \\ 2 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 6 \\ 4 \end{bmatrix}$$

$$L = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$$
$$L^T = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$
$$D = \begin{bmatrix} 2 & 0 \\ 0 & -1 \end{bmatrix}$$
$x_1 = 1$
$x_2 = 2$
Z=3

Example (Rao, no date)

$$\text{Minimize } f = -4x_1 + x_1^2 - 2x_1x_2 + 2x_2^2$$
$$\text{Subject to } 2x_1 + x_2 \leq 6$$
$$x_1 - 4x_2 \leq 0$$
$$x_1 \geq 0 \ , x_2 \geq 0$$

SOLUTION OF THE PROBLEM

A= [2 1; 1 -4]
b= [6; 0]
L =

1.0000	0
0.5000	1.0000

D =

2.0000	0
0	-4.5000

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X =

2.6667

0.6667

z = -6.2222

Example (Rao, no date)

Minimize $f = (x_1 - 1)^2 + x_2 - 2$
Subject to $-x_1 + x_2 - 1 = 0\,, x_1 + x_2 - 2 \leq 0$

$x_1 \geq 0, x_2 \geq 0$

SOLUTION OF THE PROBLEM

A= [-1 1; 1 1];
b= [1; 2];
L =
1 0
-1 1
D =
-1 0
0 2
X =
0.5000
1.5000
z =
-0.2500

Example(Rao, no date)

Minimize $f = x_1^2 + x_2^2 - 3x_1x_2 - 6x_1 + 5x_2$
Subject to $x_1 + x_2 \leq 4$

$3x_1 + 6x_2 \leq 20$

$x_1 \geq 0, x_2 \geq 0$

SOLUTION OF THE PROBLEM

A= [1 1; 3 6];

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b= [4; 20];
L =
1 0
3 1
D =
1 0
0 -3
X =
12.0000
-2.6667
z =
161.7778

Example (Rao, no date)

Minimize $f = -8x_1 - 16x_2 + x_1^2 + 4x_2^2$
Subject to $x_1 + x_2 \leq 5$
$x_1 \leq 3$
$x_1 \geq 0, x_2 \geq 0$

SOLUTION OF THE PROBLEM

A= [1 1; 1 0]
b= [5; 3]
L =
1 0
1 1
D =
1 0
0 -1
X =
3
2
z =
-31

Example (LBurden and Faires, no date)

Minimize $f = 2x_1 + x_2 - x_1^2$
Subject to

$$2x_1 - x_2 = 1$$
$$-x_1 + 2x_2 - x_3 = 0$$

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$$-x_2 + 2x_3 - x_4 = 0$$
$$-2x_3 + 2x_4 = 1$$

SOLUTION OF THE PROBLEM

```
A=[2 -1 0 0;-1 2 -1 0;0 -1 2 -1;0 0 -1 2];
b=[1 0 0 1]'
L =
    1.0000         0         0         0
   -0.5000    1.0000         0         0
         0   -0.6667    1.0000         0
         0         0   -0.7500    1.0000
D =
    2.0000         0         0         0
         0    1.5000         0         0
         0         0    1.3333         0
         0         0         0    1.2500
X =
    1.0000
    1.0000
    1.0000
    1.0000
z =
    2.0000
```

Example (LBurden and Faires, no date)

```
A= [6 2 1 -1; 2 4 1 0; 1 1 4 -1;-1 0 -1 3]
b= [0 7 -1 -2]'
```

SOLUTION OF THE PROBLEM

```
L =
    1.0000         0         0         0
    0.3333    1.0000         0         0
    0.1667    0.2000    1.0000         0
   -0.1667    0.1000   -0.2432    1.0000
D =
    6.0000         0         0         0
         0    3.3333         0         0
         0         0    3.7000         0
         0         0         0    2.5811
```

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X =
-0.8586
2.4188
-0.9581
-1.2723
z =
-2.1354

Example (LBurden and Faires, no date)

A= [112 7 0 0 0 2; 7 110 5 4 3 0; 0 5 88 0 0 1; 0 4 0 66 0 0; 0 3 0 0 44 0; 2 0 1 0 0 11]

b= [121; 129; 94; 70; 47; 14]

SOLUTION OF THE PROBLEM

L =

1.0000	0	0	0	0	0
0.0625	1.0000	0	0	0	0
0	0.0456	1.0000	0	0	0
0	0.0365	-0.0021	1.0000	0	0
0	0.0274	-0.0016	-0.0017	1.0000	0
0.0179	-0.0011	0.0115	0.0001	0.0001	1.0000

D =

112.0000	0	0	0	0	0
0	109.5625	0	0	0	0
0	0	87.7718	0	0	0
0	0	0	65.8536	0	0
0	0	0	0	43.9175	0
0	0	0	0	0	10.9526

X =
1.0000
1.0000
1.0000
1.0000
1.0000
1.0000

z =
15

Nafisa Abdalmaged Ali Elmahdi , Mohsin Hassan Abdallah Hashim, . Osman Omer Osman yousif and Amna Weis Mohammed Ahmad Idress. (2023). A computational study uses LDL ^{T} on QP problems with general linear Constraints , *Al-Butana Journal of Applied Science* (16): 70-89.

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RESULTS AND DISCUSSION

LDLT factorization and the Cholesky algorithm were used in this paper to solve quadratic programming problems. The excellent results we obtained were compared with the Wolfe method, as demonstrated in the previous example (**PROBLEM** (Ghadle and Pawar, 2015)).

Show the CPU time in in the numerical results in Table 1.

Table 1. Numerical results and CPU time

Problem	**LDLT Numerical solution**	**CPU**
PROBLEM (Ghadle and Pawar, 2015)	$x_1 = 1$ $x_2 = 2$ Z=3	0.0089
Example (Rao, no date)	$x_1 = 2.6667$ $x_2 = 0.6667$ z = -6.2222	0.0788
Example (Rao, no date)	$x_1 = 0.5000$ $x_2 = 1.5000$ z = -0.2500	0.0747
Example(Rao, no date)	$x_1 = 12.0000$ $x_2 = -2.6667$ z = 161.7778	0.0049
Example (Rao, no date)	$x_1 = 3$ $x_2 = 2$ z = -31	0.0040
Example (LBurden and Faires, no date)	$x_1 = 1$ $x_2 = 1$ $x_3 = 1$ $x_4 = 1$ z = 2	0.0044
Example (LBurden and Faires, no date)	$x_1 = -0.8586$ $x_2 = 2.4188$ $x_3 = -0.9581$ $x_4 = -1.2723$	0.0033
Example (LBurden and Faires, no date)	$x_1 = 1$ $x_2 = 1$ $x_3 = 1$ $x_4 = 1$ $x_5 = 1$ $x_6 = 1$	0.0023

CONCLUSION

we provide a new method to solving nonlinear optimization problems to subject and equality constraints. General linear constraints on quadratic

programming (QP) problems are considered. We propose use LDLT factorization to solve quadratic programming in this work. When compared to methods based on the Wolfe method, the suggested algorithm has better computational complexity and performance.

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Compare the Solution between the improved Euler Method and the Runge-Kutta Method in Solving Differential Equations using MATLAB

Mohammed moge Mohammed

Abstract

The MATLAB method in differential equations is one of the important and very useful mathematical tools that help us solve and draw differential equations. The MATLAB solution is considered one of the most famous mathematical programs for solving mathematical problems. The aim of this study is to compare the solution between the improved Euler method and the fourth-order Runge-Kutta method in solving first-order differential equations and to compare the MATLAB solution and the manual solution. We followed the applied mathematical method using Matlab. In this research, we discuss the method of solving the initial value problem of the first-order differential equation, the improved Euler method and the fourth-order Runge-Kutta method, using the manual and MATLAB solution methods, and comparing them to find out. There is an error in each method and which is more accurate. We found that the fourth-order Runge-Kutta method is more accurate than the improved Euler method. Using the MATLAB method, the MATLAB solution is faster and more accurate than the manual solution, and the error rate decreases as the value of h decreases. We recommend solving differential equations using an advanced mathematical method to contribute to reducing the error rate

Keywords: the improved Euler method, Runge-Kutta method, MATLAB

Interdiction:

Differential equations are mathematical descriptions of how the variables and their derivatives (rates of change) with respect to one or more independent variable affect each other in a dynamical way. Their solutions show us how the dependent variable(s) will change with the independent variable(s). Many problems in natural sciences and engineering fields are formulated into a scalar differential equation or a vector differential equation—that is, a system of differential equations. (*Won Young Yang, Wenwu Cao, 2004*) Differential equations are commonly used for mathematical modeling in since and engineering often there is no known analytic solution and numerical approximation are required. **(**john H. Mathews, kurtis D. Fink, 1999). The core

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of the MATLAB system implements a set of functions to cope with some classical numerical problems. Although there is no need for a really deep knowledge of numerical analysis in order to use MATLAB, a grasp of the basics is useful in order to choose among competing methods and to understand what may go wrong with them. In fact, numerical computation is affected by machine precision and error propagation, in ways that may result in quite unreasonable outcomes. Hence, we begin by considering the effect of finite precision arithmetic and the issues of numerical instability and problem conditioning, (John Wiley & Sons, 2006). Numerical differentiation is not a particularly accurate process. It suffers from a conflict between roundoff errors (due to limited machine precision) and errors inherent in interpolation. For this reason, a derivative of a function can never be computed with the same precision as the function itself. (Jaan Kiusalaas, 2005**).** On reaching t_n the basic methods are distinguished by whether or not they use previously computed quantities such as $y_{n-1}, y_{n-2}, \ldots$ If they do, they are called methods with memory and otherwise, one–step methods. IVPs are categorized as non–stiff and stiff. It is hard to define stiffness, but its symptoms are easy to recognize. **(** L.F. Shampine 2003 **)**

Initial value problem:

The general form of a first-order differential equation is

$$y' = f(x, y) \qquad y(x_0) = y_0$$

Where $y' = \frac{dy}{dx}$ and $f(x, y)$ is a given function. The solution of this equation contains an arbitrary constant (the constant of integration). To find this constant, we must know a point on the solution curve; that is, y must be specified at some value of x, say at $x = x_0$.We write this auxiliary condition as

$$y(x_0) = y_0$$

An ordinary differential equation of order n

$$y^{(n)} = f(x, y, y', \ldots, y^{(n-1)})$$

can always be transformed in to n first-order equations. Using the notation

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$$y_1 = y, \quad y' = y_2, \quad y_3 = y'', \quad \dots, \quad y_n = y^{(n-1)}$$

the equivalent first- order equations are

$$y_1' = y_2 \quad y_2' = y_3 \quad y_3' = y_4 \quad \dots \quad y_n' = f(x, y, y_1, y_2, y_3, .. y_n)$$

The solution now requires the knowledge n auxiliary conditions. If these conditions are specified at the same value of x, the problem is said to be an initial value problem. Then the auxiliary conditions, called initial conditions, have the form

$$y_1(x) = x_1 \quad y_2(x) = x_2 \quad y_3(x) = x_3 \quad .... \quad y_n(x) = x_n$$

If y_i are specified at different values of x, the problem is called aboundary value problem. **(**Jaan Kiusalaas, 2005 **)**

On some interval I containing x_0 the problem of solving an n th -order differential equation subject to n side conditions specified at x_0

$$\frac{d^n y}{dx^n} = f(x, y, y', \dots, y^{(n-1)})$$

$$y(x_0) = y_0, \quad y'(x_0) = y_1, \quad \dots, \quad y^{(n-1)}(x_0) = y_{n-1}$$

where $y_0, y_1, \dots, y_{n-1}$ are arbitrary real constants, is called an $n\,th$-order initial-value problem (IVP**). (** DENNIS G. ZILL, 2013**)**

Numerical Method

Numerical method forms an important part of solving initial value problems in ordinary differential equations, most especially in cases where there is no closed form solution. We present here the derivation of Euler's method for generating, numerically, approximate solutions to the initial value problem

$$y'(x) = f(x, y), \quad y(x_0) = y_0.$$

(Ogunrinde R. Bosede, Fadugba S. Emmanuel, 2012**)**

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The improved Euler method

The improved Euler method for solving the initial value problem $y' = f(x,y), \quad y(x_0) = y_0$ is based on approximating the integral curve of $y(x_0) = y_0$ at $(x_i, y(x_i))$ by the line through $(x_i, y(x_i))$ with slope

$$m_i = \frac{f\big(x_i, y(x_i)\big) + f(x_{i+1}, y(x_{i+1}))}{2};$$

that is, m_i is the average of the slopes of the tangents to the integral curve at the endpoints of $[x_i, x_{i+1}]$ The equation of the approximating line is therefore

$$y = y(x_i) + \frac{f\big(x_i, y(x_i)\big) + f\big(x_{i+1}, y(x_{i+1})\big)}{2}(x - x_i)$$

Setting $x = x_{i+1} = x_i + h$ in (5) yields

$$y_{i+1} = y(x_i) + \frac{h}{2}\Big(f\big(x_i, y(x_i)\big) + f\big(x_{i+1}, y(x_{i+1})\big)\Big)$$

as an approximation to $y(x_{i+1})$. As in our derivation of Euler's method, we replace $y(x_i)$ (unknown if $i > 0$) by its approximate value y_i; then $y_{i+1} = y(x_i) + hf\big(x_i, y(x_i)\big)$becomes

$$y_{i+1} = y_i + \frac{h}{2}(f(x_i, y_i) + f\big(x_{i+1}, y(x_{i+1})\big))$$

However, this still won't work, because we don't know $y(x_{i+1})$ which appears on the right. We overcome this by replacing $y(x_{i+1})$ by $y_i + h\, f(x_i, y_i)$, the value that the Euler method would assign to y_{i+1}. Thus, the improved Euler method starts with the known value $y(x_0) = y_0$ and computes $y_1, y_2, \dots, y_n$ successively with the formula

$$y_{i+1} = y_i + \frac{h}{2}\Big(y_i + f\big(x_{i+1}, y_i + hf(x_i, y_i)\big)\Big)$$

The computation indicated here can be conveniently organized as follows: given y_i, compute

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$$k_{1i} = f(x_i, y_i)$$

$$k_{2i} = f(x_i + h, y_i + hk_{1i})$$

$$y_{i+1} = y_i + \frac{h}{2}(k_{1i} + k_{2i})$$

The improved Euler method requires two evaluations of $f(x, y)$ per step, while Euler's method requires only one. However, we'll see at the end of this section that if f satisfies appropriate assumptions, the local truncation error with the improved Euler method is $O(h^3)$, rather than $O(h^2)$ as with Euler's method. Therefore the global truncation error with the improved Euler method is $O(h^2)$; however, we won't prove this.

We note that the magnitude of the local truncation error in the improved Euler method and other methods discussed in this section is determined by the third derivative y''' of the solution of the initial value problem. Therefore the local truncation error will be larger where $|y'''|$ is large, or smaller where $|y'''|$ is small.

Example

Use the improved Euler method with $h = 0.1$ to find approximate values of the solution of the initial value problem

$$y' + 2y = x^3 e^{-2x} \qquad y(0) = 1$$

at $x = 0.1, 0.2, 0.3$.

Solution:

we rewrite as

$$y' = -2y + x^3 e^{-2x} \qquad y(0) = 1$$

$$f(x, y) = -2y + x^3 e^{-2x}, \quad x_0 = 0 \ \ and \ \ y_0 = 1$$

The improved Euler method yields

$$k_{10} = f(x_0, y_0) = f(0,1) = -2$$

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$$k_{20} = f(x_1, y_0 + hk_{10}) = f(0.1,1 + (0.1)(-2))$$

$$= f\ (0.1, 0.8) = -2(0.8) + (0.1)^3 e^{-0.2}$$

$$= -1.599181269$$

$$y_1 = y_0 + \frac{h}{2}(k_{10} + k_{20})$$

$$= 1 + (0.05)(-2 - 1.599181269)$$

$$= 0.820040937$$

$$k_{11} = f(x_1, y_1) = f(0.1,0.820040937)$$

$$= -2(0.820040937) + (0.1)^3 e^{-0.2}$$

$$= -1.639263142$$

$$k_{21} = f(x_2, y_1 + hk_{11})$$

$$= f\ (0.2, 0.820040937 + 0.1(-1.639263142))$$

$$= f\ (0.2,0\ .656114622) = -2(0.656114622) + (0.2)^3 e^{-0.4}$$

$$= -1.306866684$$

$$y_2 = y_1 + \frac{h}{2}(k_{11} + k_{21})$$

$$= 0.820040937 + (0.05)(-1.639263142 - 1.306866684)$$

$$= 0.672734445,$$

$$k_{12} = f(x_2, y_2) = f\ (0.2, 0.672734445)$$

$$= -2(0.672734445) + (0.2)^3 e^{-0.4}$$

$$= -1.340106330,$$

$$k_{22} = f(x_3, y_2 + hk_{12}) = f\ (0.3,0\ .672734445 + .1(-1.340106330)),$$

$$= f\ (0.3,0\ .538723812) = -2(0.538723812) + (0.3)^3 e^{-0.6}$$

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$$= -1.062629710,$$

$$y_3 = y_2 + \frac{h}{2}(k_{12} + k_{22})$$

$$= 0.672734445 + (0.05)(-1.340106330 - 1.062629710)$$

$$= 0.552597643.$$

Matlaby solution

Problem

using the improved Euler method with step size $h = 0.1$ to find approximate values of the solution of the initial value problem

$$y' + 2y = x^3 e^{-2x} \qquad y(0) = 1$$

At x $0, 0.1, 0.2, 0.3, \ldots, 1.0$.and the values of the exact solution

$$y = \frac{e^{-2x}}{4}(x^4 + 4)$$

Solution

Table 1.Numerical solution of $y' + 2y = x^3 e^{-2x}$ $y(0) = 1$ by the improved Euler method.

i	x_i	y_i	$Exact$ (i)	Error (i)
0	0	1	1	0
1.000000000	0.10000000	0.820040937	0.818751221	0.0012897151
2.000000000	0.20000000	0.672734445	0.670588174	0.0021462711
3.000000000	0.30000000	0.552597643	0.549922980	0.0026746635
4.000000000	0.40000000	0.455160637	0.452204669	0.0029559671
5.000000000	0.50000000	0.376681251	0.373627557	0.0030536938
6.000000000	0.60000000	0.313970920	0.310952904	0.0030180159
7.000000000	0.70000000	0.264287611	0.261398947	0.0028886638
8.000000000	0.80000000	0.2252677018	0.222570721	0.0026969804
9.000000000	0.90000000	0.1948795006	0.192412038	0.0024674623
10.00000000	1.00000000	0.1713880703	0.169169104	0.0022189662

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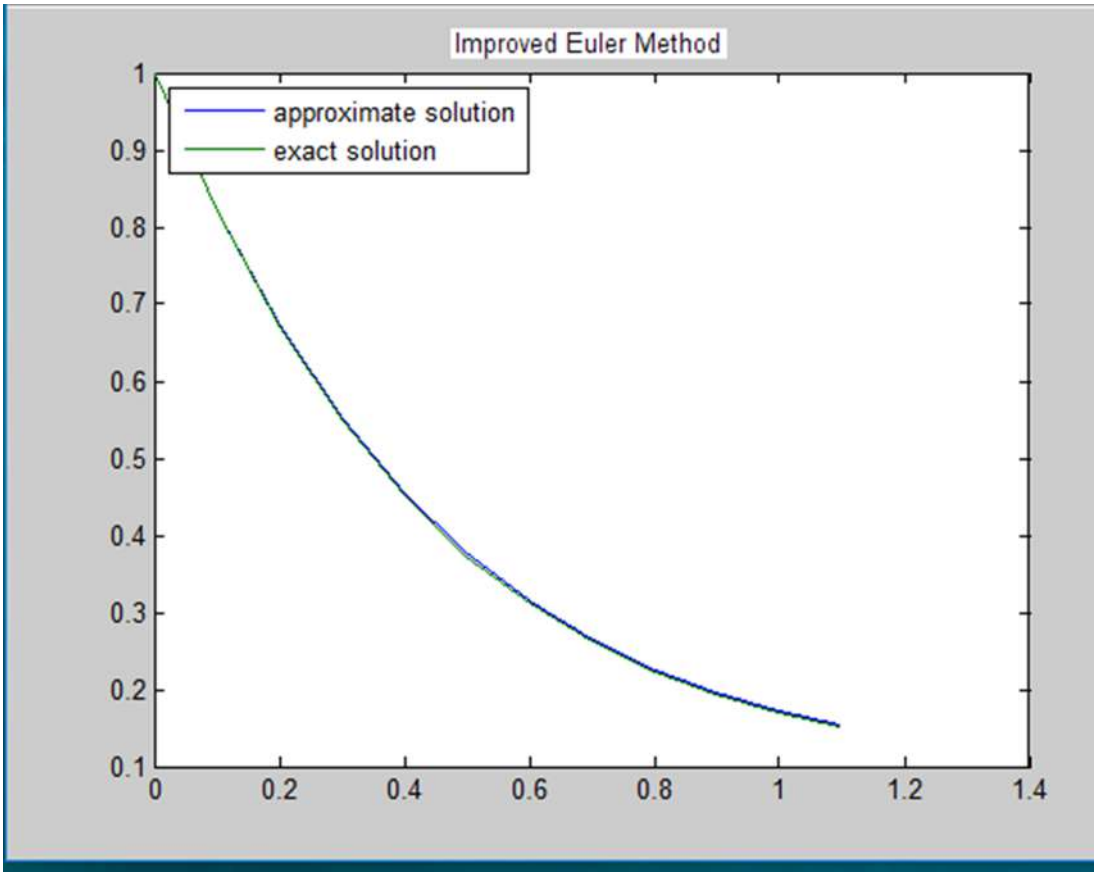

Figure 1 Improved Euler Method

The fourth Order Runge – Kutta Method

In general, if k is any positive integer and f satisfies appropriate assumptions, there are numerical methods with local truncation error $O(h^{k+1})$ for solving an initial value problem

$$y' = f(x, y), \quad y(x_0) = y_0$$

Moreover, it can be shown that a method with local truncation error $O(h^{k+1})$ has global truncation error $O(h^k)$. we studied numerical methods where $k = 1$, and $k = 2$, We'll skip methods for which $k = 3$ and proceed to the Runge-Kutta method, the most widely used method, for which $k = 4$. The magnitude of the local truncation error is determined by the fifth derivative $y^{(5)}$ of the solution of the initial value problem. Therefore the local truncation error will be larger where $|y^{(5)}|$ is large, or smaller where $|y^{(5)}|$ is small. The $Runge - Kutta$ method

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computes approximate values $y_1, y_2, \dots\dots, y_n$ of the solution of $y' = f(x,y)$, $y(x_0) = y_0$ at $x_0, x_0 + h, \dots\dots, x_0 + nh$ as follows: Given y_i, compute

$$k_{1i} = f(x_i, y_i)$$

$$k_{2i} = f\left(x_i + \frac{h}{2}, y_i + \frac{h}{2}k_{1i}\right)$$

$$k_{3i} = f\left(x_i + \frac{h}{2}, y_i + \frac{h}{2}k_{2i}\right)$$

$$k_{4i} = f(x_i + h, y_i + hk_{3i})$$

and

$y_{i+1} = y_i + \frac{h}{6}(k_{1i} + 2k_{2i} + 2k_{3i} + k_{4i})$ (William F. Trench, 2000.)

Example

Use the $Runge - Kutta$ method with $h = 0.1$ to find approximate values for the solution of the initial value problem

$$y' + 2y = x^3 e^{-2x}, \quad y(0) = 1$$

At $x = 0.1, 0.2$, (William F. Trench, 2000.)

Solution:

Again we rewrite as

$$y' = -2y + x^3 e^{-2x}, \quad y(0) = 1$$

$$f(x,y) = -2y + x^3 e^{-2x}, \quad x_0 = 0, and \ y_0 = 1$$

The $Runge - Kutta$ method yields

$$k_{10} = f(x_0, y_0) = f(0,1) = -2,$$

$$k_{20} = f\left(x_0 + \frac{h}{2}, y_0 + \frac{h}{2}k_{10}\right) = f\left(0.05, 1 + (0.05)(-2)\right)$$

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$$= f\ (0.05, 0.9) = \ -2(0.9) + \ (0.05)^3 e^{-0.1}$$

$$= -1.799886895$$

$$k_{30} = f\left(x_0 + \frac{h}{2}, y_0 + \frac{h}{2}k_{20}\right) = f\ (0.05, 1\ +\ (0.05)(-1.799886895))$$

$$= f\ (0.05, 0.910005655) = \ -2(0.910005655) + (0.05)^3 e^{-0.1}$$

$$= -1.819898206$$

$$k_{40} = f(x_0 + h, y_0 + hk_{30})$$

$$= \ f\ (0.1, 1\ +\ (0.1)(-1.819898206))$$

$$= f\ (0.1, 0.818010179) = \ -2(0.818010179) + (.1)^3 e^{-0.2}$$

$$= -1.63520162$$

$$y_1 = y_0 + \frac{h}{6}(k_{10} + 2k_{20} + 2k_{30} + k_{40}),$$

$$= 1 + \frac{0.1}{6}(-2 + 2(-1.799886895) + 2(-1.819898206) - \ 1.635201628)$$

$$= \ 0.818753803$$

$$k_{11} = f(x_1, y_1)\ = f\ (0.1, 0.818753803)$$

$$= \ -2(0.818753803))\ + (0.1)^3 e^{-0.2}$$

$$= -1.636688875$$

$$k_{21} = f\left(x_1 + \frac{h}{2}, y_1 + \frac{h}{2}k_{11}\right)$$

$$= \ f\left(0.15, 0\ .818753803\ +\ (0.05)(-1.636688875)\right)$$

$$= f\ (0.15, 0.736919359) = -2(0.736919359) + (0.15)^3 e^{-0.3}$$

$$= -1.471338457$$

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$$k_{31} = f\left(x_1 + \frac{h}{2}, y_1 + \frac{h}{2}k_{21}\right)$$

$$= f\left(0.15, 0.818753803 + (0.05)(-1.471338457)\right)$$

$$= f\,(0.15, .745186880) = -2(0.745186880) + (0.15)^3 e^{-0.3}$$

$$= -1.487873498$$

Matlaby solution

Problem

using the $Runge - Kutta$ method with step size to find approximate values of the solution of the initial value problem

$$y' + 2y = x^3 e^{-2x}\,, \quad y(0) = 1$$

at $x = 0.0.1,0.2,0.3, \ldots \ldots, 1.0$, and the values of the exact solution

$$y = \frac{e^{-2x}}{4}(x^4 + 4)$$

Table 2 Numerical solution of $y' + 2y = x^3 e^{-2x}\,, \quad y(0) = 1$ by $Runge - Kutta$ method.

i	x_i	y_i	$Exact$ (i)	Error (i)
0	0	1	1	0
1.000000000	0.10000000	0.818753803	0.818751221	0.0000025814
2.000000000	0.20000000	0.670592417	0.670588174	0.0000042432
3.000000000	0.30000000	0.549928221	0.549922980	0.0000052417
4.000000000	0.40000000	0.452210430	0.452204669	0.0000057608
5.000000000	0.50000000	0.373633492	0.373627557	0.0000059347
6.000000000	0.60000000	0.310958768	0.310952904	0.0000058632
7.000000000	0.70000000	0.261404568	0.261398947	0.0000056216

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8.000000000	0.80000000	0.222575989	0.222570721	0.0000052672
9.000000000	0.90000000	0.192416882	0.192412038	0.0000048437
10.00000000	1.00000000	0.169173489	0.169169104	0.0000043845

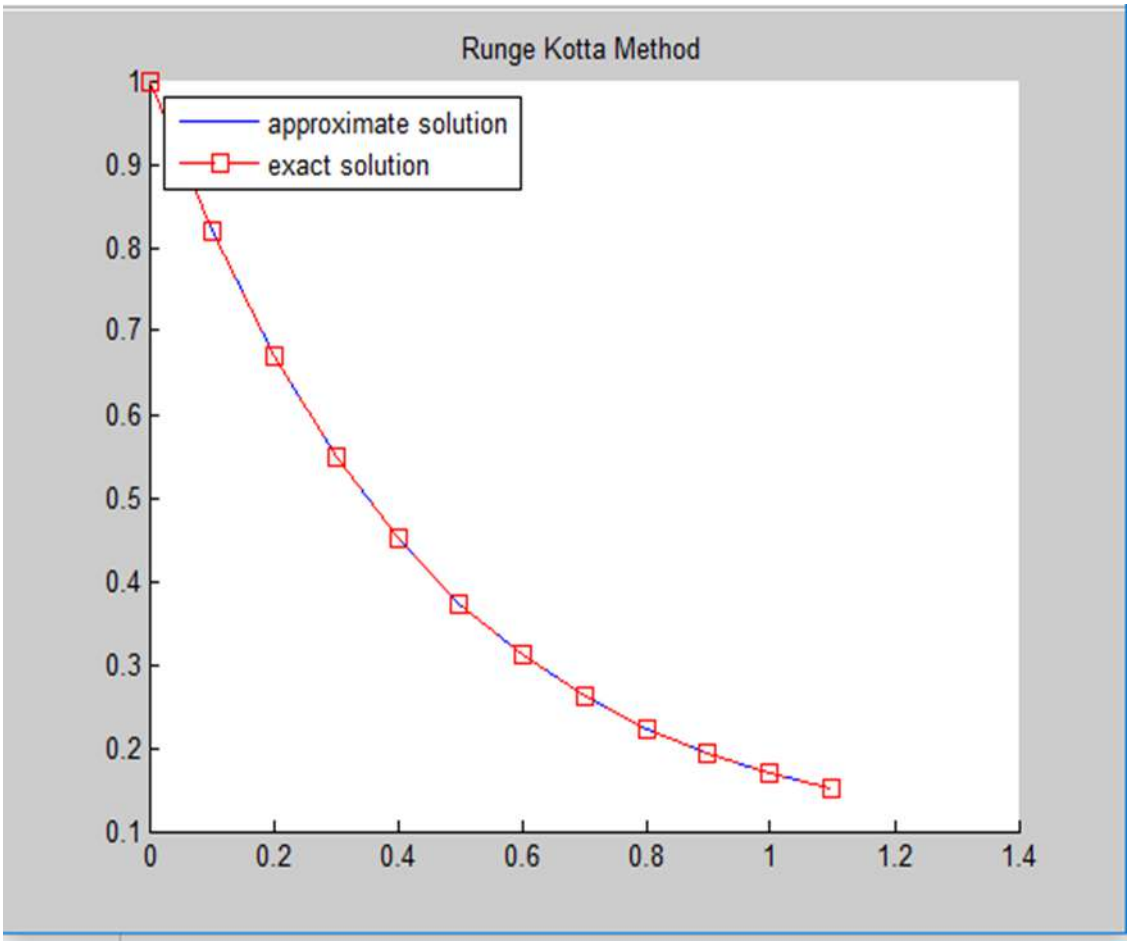

Figure 2 Runge – KuttaMethod

Program of Improved Euler's method

```
function r=modified_euler()
f=inline('(y-x^2+1)');
disp('enter the initial value');
disp('enter the initial condition');
y(1)=input ('y(1)=');
```

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```
real(1)=y(1);
error(1)=real(1)-y(1);
disp('enter the intervals [a..b]');
a=input('a=');
b=input('b=');
x(1)=a;
disp('enter the value N');
n=input('n=');
h=(b-a)/n;
disp('    ''i''      ''x(i)''    ''y(i) ''real(i)''
''error(i)');
disp([ 0   a   y(1)  real(1)  error(1) ])
for i=1:1:n+1
    x(i+1)=a+(i*h);
end
for i=1:1:n+1

y(i+1)=y(i)+(h/2)*(f(x(i),y(i))+(f(x(i+1),y(i)+h*f(x(i),y(i)))
));
      x(i+1)=a+(i*h);
end
for i=1:1:n+1
   x(i+1)=a+(i*h);
   real(i+1)=(x(i+1)+1)^2-0.5*exp(x(i+1));
    end
for i=1:1:n
      error(i+1)=abs(real(i+1)-y(i+1));
    disp([  i   x(i+1)   y(i+1)  real(i+1) error(i+1)]);
end
for i=1:1:n+1
x(i)=a+((i-1)*h);
plot(x,y,x,real);
legend('approximate solution','exact solution',2);
end
```

Program of Runge – KuttaMethod

```
function  r=rung4()

f=inline('(y-x^2+1)');
disp('enter the initial value');
%x(1)=input ('x(1)=');
```

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```
disp('enter the initial condition');
y(1)=input ('y(1)=');
a=input ('a=');
b=input ('b=');
x(1)=a;
disp('enter the value N');
n=input('n=');
h=(b-a)/n;
real(1)=1;
disp('    ''i''      ''x(i)''     ''y(i)''    ''real''
''error');
disp([0  0  1  1  0])
for i=1:1:n+1
k1=h*f(x(i),y(i));
k2=h*(f(x(i)+(h/2),y(i)+(k1)/2));
k3=h*(f(x(i)+(h/2),y(i)+(k2)/2));
k4=h*(f(x(i)+h,y(i)+k3));
y(i+1)=(y(i)+(k1+2*k2+2*k3+k4)/6);
x(i+1)=x(i)+h ;
end
for i=1:1:n+1
    x(i+1)=a+(i*h);
    real(i+1)=(x(i+1)+1)^2-0.5*exp(x(i+1));
end
for i=1:1:n
      error(i+1)=abs(y(i+1)-real(i+1));
   disp([i x(i+1) y(i+1)  real(i+1) error(i+1)]);
end
hold on
for i=1:1:n+1
    x(i)=a+((i-1)*h);
   plot(x,y)
   plot(x,real,'--rs');
   legend('approximate solution','exact solution',2);
   hold on
end
```

Results

- fourth-order Runge-Kutta method is more accurate than the improved Euler method.
- the MATLAB solution is faster and more accurate than the manual solution

- the error rate decreases as the value of h decreases.

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