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Practical Reality of SWOT in Telecommunications Companies Worldwide Domain

Ibrahiem M. M. El Emary

IT Deanship, King Abdulaziz university, Jeddah, Saudi Arabia

Mohammed Hassan Shalhoub

Faculty of Arts and Humanities, King Abdulaziz University, Jeddah, Saudi Arabia

Leena A Bin Shalhoub

Faculty of Arts and Humanities, King Abdulaziz University, Jeddah, Saudi Arabia

Maha M. A. Said Ali

Department of Library & Information Science - College of Basic Education -Public
Authority of Applied Education and Training (PAAET)- Kuwait

Khalid S. Al Aqeel

Higher Commission for Industrial Security General Secretariat, Ministry of Interior,
Saudi Arabia

Abstract

The SWOT analysis is an extremely useful tool for understanding and decision-making for all types of situations in business and organizations, especially in developing countries. SWOT is an acronym for the weaknesses, strengths, opportunities, and threats. The objective of this work is to explore the relationship between mobile technologies and social and economic development in various countries around the world based on SWOT analysis.

This article focus its analysis on the application of SWOT on some mobile operators and mobile technologies as these represent a big part of ICT investment throughout the world, and in the same time plays an increasing role in sectors such as education, agriculture, industry, and health sciences. Also, this paper addresses the economic and social consequences in those sectors, and some of returned benefits. The analysis also considers the commitment of the government and industry in influencing mobile technologies and innovative approaches to meet the needs of the market environment.

Finally, we concluded that we can enhance a SWOT analysis through some of critical and solid surveys. We can learn more about our own as well as competitor's sites and businesses. The areas that we can research include (1) customer awareness, interest, trial, and usage levels, (2) brand, site, and/or company image, (3) importance of different site or product attributes to your customers, and (4) product and/or site performance. Whether using a basic or more advanced approach to SWOT analysis, we are sure to come away with

newfound insights. Use these to increase our organization effectiveness and as input into our business or marketing plan.

Keywords: Strategic plan, Mobile Phones, Cross-Cultural Comparative Analysis, ICTs, SWOT analysis, Developed Countries and Developing Countries.

1. Introduction

The SWOT analysis is an extremely useful tool to understand and review the company's position before decisions on the future direction of the company or the implementation of a new business idea. We can complete the SWOT analysis by an individual within the Organization (provided that takes an overview of the current situation), but often the best achievement in team or group. The discussion itself is rich in information, and the quality of the output is best if combined visualizations of a number of people. SWOT stands for strengths, weaknesses, opportunities and threats. It is a way to summarize the current status of the company and help develop a plan for the future, one that employs existing strength, weaknesses, opportunities for exploits and redresses defended against threats.

• Strengths

- Identify skills and capabilities that you have.
- What can you do particularly well, relative to rivals?
- What do analysts consider to be your strengths?
- What resources do you have?
- Is your brand or reputation strong?

• Weaknesses

- What do rivals do better than you?
- What do you do poorly?
- What generates the most customer dissatisfaction and complaints?

- What generates the most employee dissatisfaction and complaints?
and activities can you improve?

• Opportunities

- Where can you apply your strengths?
- How are your customers and their needs changing?
- How is technology changing your business?
- Are there new markets for your strengths? (e.g. foreign)
- Are there new ways of producing your products?
- Are your rivals' customers dissatisfied?

• Threats

- Are customers able to meet their needs with alternative products?
- Are customers needs changing away from your product?
- What are your competitors developing?
- Are your rivals improving their product offerings or prices?
- Is new technology making your product obsolete?
- Is your cash-flow and debt position healthy?
- Are your employees satisfied? Is turnover high?
- Is new competition coming?
- Are sales growing slower than the industry average?

To reap the full benefits of the SWOT analysis, it is important to use

the tool correctly. The first thing to remember is that the analysis should provide you with information that will help In decision-making. As such, lists of laundry, strengths, weaknesses and opportunities Threats are not in themselves useful. It is only when the potential effects of these Information about the organization is beginning to get any sense really Analysis. Secondly, it is most useful to consider only the strengths and weaknesses with respect to the Of the Organization, and the strengths and weaknesses of any internally focused. In addition, opportunities, and threats externally focused, i.e., what are the Opportunities and external threats.

Information and communication technology (ICT) and transforming society. Specifically, mobile phones are revolutionizing access to computer resources and the Internet in developing countries. The mobile industry in many countries has a positive impact on economic growth and development. The mobile industry enables foreign direct investment and multinational corporations are more likely to set up headquarters and factories in countries that provide the best information and communication technology including mobile access [14]. Having discussed the benefits of the mobile phone industry in various sectors with a focus on education and health, and manufacturing (Demeke, Biru, 2002).

Comparison across these four SWOT analysis, we can see that a variety of factors that contribute to the success of the mobile phone industry in developed and developing countries. For developed countries, like the United States, the use of mobile phones, landlines and create a shift in communications also has implications for business and culture. Kuwait, on the other hand, has a lot lately, in a

developed country, where geographical factors limit the geographical distance with the country, and there is great emphasis on landlines compared with mobile phones.

For example, in India, and may skip mobile phones landline, areas that have not been fixed telephone lines now accessible to cell phone towers. Contrast, not Ethiopia so far raise with India in this regard, but its development has followed the telecommunications end up in India given the similarities in their economies and population distributions (However, in Ethiopia, given the concentration of economic and political power in Addis Ababa, it is probably not surprising that landlines more compact still dominate the geography of mobile phones, pointing out that the people in rural regions largely left behind in the information age). Consequently, there are important lessons to be gained from each of these contexts.

To be more precious , there are five steps in a SWOT analysis should be followed to implement an accurate analysis to any organization given as follows:-

- Brainstorming lists, strengths, weaknesses, opportunities, threats (Remember to keep internal focus of strengths and weaknesses and lavers and foreign threats).
- Take the laundry list of ideas within each category and reduction to the top 5 to 10 ideas (for each category).
- Review each category individually and discussing each of these ideas and Potential impacts to the organization.
- Remember that idea with the SWOT analysis is to gain a better understanding of the

How can enterprise on their external environment. As such, the next Step is to look at the strengths and weaknesses of the Organization's internal and See how they relate to opportunities and external threats.

- The last step is to look at the following areas: A. those factors that represent each organization's strengths and Opportunities in the external environment. This is one possible area for the Growth. B. those factors which represent weaknesses of the organization and threats in the external environment. This represents an area that needs to be addressed.

2. Previous Studies and

Literature Review

Played the gap in technological capabilities between the colonial powers that are primarily LDCs today colonial Nations, primarily in developing countries play a key role in geopolitics during the fifteenth century and beyond. As European explorers technological development can be an indicator of the level of technical development of society, and this has played an important role in efforts at colonization (Adass, 1989). Specifically, has developed information and communication technology, and different rates in developed and developing countries.

For example, in the 1970s, he developed the use of computer applications to electronic information processing and access to information in the business sector and the Government sector that provided competitive advantages for the developing countries with access to

information and communication technology (FUNG, 2009). At that time, due to non-supportive economic environment, most developing countries are not benefiting from computer technology. And may cause the "digital divide" large differences in economic development. More recently, however, with the help of national Governments and non-governmental organizations, industries, and international assistance, many developing countries have made some progress in beginning to bridge this gap to some extent, particularly in the case of mobile devices, which do not require telecommunications infrastructure are usually somewhat. User-friendly and easy to use (Heeks, 2009)

Information and communication technology to connect families, processing, and transfer information through many technology applications. This could include, in addition to earlier media such as print, television, radio and the latter such as telephone, mobile and Internet pagers, personal computers (FUNG, 2009). Our research focuses on the use of mobile devices like smart phones in developing countries. These new technological developments available to increasing numbers of developing countries, thus helping to bridge the "digital divide".

In developing information and communication technologies are critical to achieving poverty reduction and the strengthening of the economic and social well-being. Information and communication technology has helped citizens in many developing countries to gain access to information on education, health services, employment and competitiveness in the global market. Information and communication technology is increasingly seen as an enabling tool in

other development needs. Research and studies indicate that culture and national policies play a dominant role in the planning and implementation of information and communication technology in developing countries. There must be a match between ICT and the national culture, in particular in developing countries technologically historically disadvantaged (Heeks, 2009) this research focuses on this aspect of the analysis method of understanding.

All the best management models have four quadrants, and the SWOT matrix is no exception. You use each of the four quadrants in turn to analyze where you are now, where you want to be, and then make an action plan to get there (see Fig.1).

The SWOT Matrix	
Strength GOOD NOW Maintain, Build, Leverage	Weakness BAD NOW Remedy, Stop
Opportunity GOOD FUTURE Prioritise, Optimise	Threat BAD FUTURE Counter

Figure 1. The four axis of SWOT [10]

Regardless of whether you or your team are future planning for specific products, work, personal or any other area, the SWOT analysis process is the same.

- **Step 1** : Here and now... List all strengths that exist now. Then in turn, list all weaknesses that exist now. Be realistic but avoid modesty!

- **Step 2** : What might be... List all opportunities that exist in the future. Opportunities are potential future strengths. Then in turn, list all threats that exist in the future. Threats are potential future weaknesses.
- **Step 3** : Plan of action... Review your SWOT matrix with a view to creating an action plan to address each of the four areas.

3. Potential Uses of SWOT

Analysis

A SWOT analysis can also be used to examine different aspects of the business, in our case examining the businesses solutions, customers, capabilities and organizational capabilities. Each represents a different element of the business, and requires a separate assessment. In the template provided we suggest specific questions that need to be answered relevant to each aspect of the business [12]. As you work with this framework you may add questions that are relevant to the specific context of your business. Importantly, the SWOT analysis can include many different ideas that make it difficult to process decisions. It is therefore useful to define the relevant level of significance you will consider when including a factor before completing the analysis. That said, it is important that you identify at least one factor to go in each box, even if you cannot determine the relative importance of a factor. At the evaluation stage you will be better able to determine this, and will have to do this when you use the summary sheet to incorporate the most important elements and prioritize the outcomes. The first time you perform a SWOT analysis it can be challenging, but like most things, the more you do it, the

easier it gets. The potential uses of SWOT can be targeted to:-

- **Set Objectives**– defining what the organization is intending to do
- **Environmental Scanning:** internal appraisals of the organizations SWOT, this needs to include an assessment of the present situation as well as a portfolio of products/ services and an analysis of the product/ service life cycle
- **Analysis of existing strategies:** this should determine relevance from the results of an internal/external appraisal. This may include gap analysis which will look at environmental factors.
- **Strategic issues defined:** key factors in the development of a corporate plan which needs to be addressed by the organization
- **Develop new/revised strategies:** revised analysis of strategic issues may mean the objectives need to change
- **Establish critical success factors:** the achievement of objectives and strategy implementation
- **Preparation of operational,** resource, projects plans for strategy implementation
- **Monitoring results:** mapping against plans, taking corrective action which may mean amending objectives/strategies

4.The Disadvantages of Using SWOT Analysis in Organizations

While SWOT analysis provides some benefits to an organization, using it in our small business can put us at a disadvantage unless we understand its limits and risks like the following:-

4.1. Other Planning Methods

Perhaps one of the biggest disadvantages of using SWOT analysis when it comes to organizing the decision, whether consciously or not, to rely solely on the analysis of the chart. While they may generate some useful information, planning methods and other tools are useful in helping the organization achieve its mission. The list of items that were created by this analysis provides information or items you need to look deeper into using other tools such as statistical surveys, focus groups or even use test market strategy for a new product or service. SWOT analysis should assist the Department start thinking in the Organization and its future, rather than terminate any other planning efforts.

4.2. Large or Heterogeneous Groups

This type of analysis requires a great deal of time and energy when used in a large enterprise or a small business that is heterogeneous, because trying to agree on a joint mission could lead to infighting between different members of the group. With a common mission to help give guidance to their activities, and the SWOT analysis does not provide any results if members can't agree.

4.3. Weighting Items

SWOT analysis generates lists, strengths, weaknesses, opportunities and threats facing the organization. Although these lists provide elements to consider, it may get used incorrectly list. Items do not carry specific weight or points that represent how important each item is. Members may conclude that a shorter list of threats against a long list of the strengths of the organization is in good condition, while the threats are more important than its strengths.

4.4. List Blindness

This analysis allows the Organization to generate lists of items on the group, but lists alone does not help them achieve their goals. Some organizations, however, after a stop, and think about the planning process has been completed. The organization needs to move beyond lists of SWOT analysis and discuss what activities would help to achieve their goals. May assist in the identification of activities that manages risks and take advantage of the assets of the organization.

5. Methodology of Solution

We can use the strengths, weaknesses, opportunities and threats (SWOT) analysis to examine the relationship between planning and internal and external environmental factors. Through the SWOT analysis, we can estimate the value of mobile phones in the context of existing policy, regulatory and legal framework, particularly in the areas of exchange of information and strengthening the capacity to regulate the sector (World Bank, 2004). You can increase the mobile link technology and provide access to communications across the

country. International experience suggests that expanding the power of communication (through mobile phones) with economic growth, and network access in rural areas urban areas reduces/rural economic disparities, and provide access to market information, and facilitate the provision of services in the areas of education, health, etc., and promoting the reduction of poverty (World Bank, 2004) through this paper.

SWOT Analysis is instrumental in strategy formulation and selection. It is a strong tool, but it involves a great subjective element. It is best when used as a guide, and not as a prescription. Successful businesses build on their strengths, correct their weakness and protect against internal weaknesses and external threats. They also keep a watch on their overall business environment and recognize and exploit new opportunities faster than its competitors. SWOT Analysis helps in strategic planning in following manner-

- It is a source of information for strategic planning.
- Builds organization's strengths.
- Reverse its weaknesses.
- Maximize its response to opportunities.
- Overcome organization's threats.
- It helps in identifying core competencies of the firm.
- It helps in setting of objectives for strategic planning.
- It helps in knowing past, present and future so that by using past and current data, future plans can be chalked out.

SWOT Analysis provide information that helps in synchronizing the firm's resources and capabilities

with the competitive environment in which the firm operates. In the following subsection, we address both internal and external analysis as shown in Fig.2 that represents both sides of the environmental scanning:-

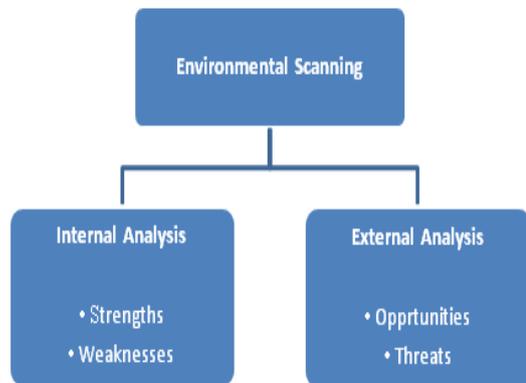


Figure 2 SWOT analysis framework

5.1. Internal Analysis

The ultimate purpose of an internal analysis is to use the information for strategic planning, meaning the company's plan for furthering growth, success, and leadership in the marketplace. Determining the business's strengths and weaknesses translates into the steps necessary for achieving goals. Here, there are some research questions to be addressed [14], such as:

- what strengths they have feature in mobile phone industry?
- what tangible and intangible features to control the country?
- how they see the country internally strengths?
- how they see strangers strengths in the country?
- What are the disadvantages of the mobile phone industry in these countries relative to others?

- What are the distractions, from the point of view of the State, to achieve the desired goal?
- What are the negative characteristics and defects? What are the weaknesses perceived by the country?
- what outsiders consider weaknesses in the country?

5.2. External Analysis

The External Analysis examines opportunities and threats that exist in the environment. Both opportunities and threats exist independently of the firm. The way to differentiate between a strength or weakness from an opportunity or threat is to ask: Would this issue exist if the company did not exist? If the answer is yes, it should be considered external to the firm. Opportunities refer to favorable conditions in the environment that could produce rewards for the organization if acted upon properly. That is, opportunities are situations that exist but must be acted on if the firm is to benefit from them. Threats refer to conditions or barriers that may prevent the firms from reaching its objectives. Here, research issues to be addressed [14] are:-:

- What are the opportunities for these countries to make the mobile phone industry success in the environment, as well as in the external environment?
- What are the chances for the country to grow and sustain?
- what areas there are opportunities?
- What are the factors that prevent opportunities for progress and □?
- What are the external factors that can cause

- problems in these countries for mobile phone industry?
- What are the factors that are beyond the control of the State?
- how to influence the information technology sector and subsector of the mobile phone?

The main limitations of SWOT analysis can be described as: SWOT Analysis is not free from its limitations. It may cause organizations to view circumstances as very simple because of which the organizations might overlook certain key strategic contact which may occur. Moreover, categorizing aspects as strengths, weaknesses, opportunities and threats might be very subjective as there is great degree of uncertainty in market. SWOT Analysis does stress upon the significance of these four aspects, but it does not tell how an organization can identify these aspects for itself. The steps that in planning process of system development life cycle can be benefits from SWOT based on the various stages shown in Fig3. There are certain limitations of SWOT Analysis which are not in control of management. These include-

- Price increase;
- Inputs/raw materials;
- Government legislation;
- Economic environment;
- Searching a new market for the product which is not having overseas market due to import restrictions; etc.
- Insufficient research and development facilities;
- Faulty products due to poor quality control;
- Poor industrial relations;
- Lack of skilled and efficient labour; etc
-

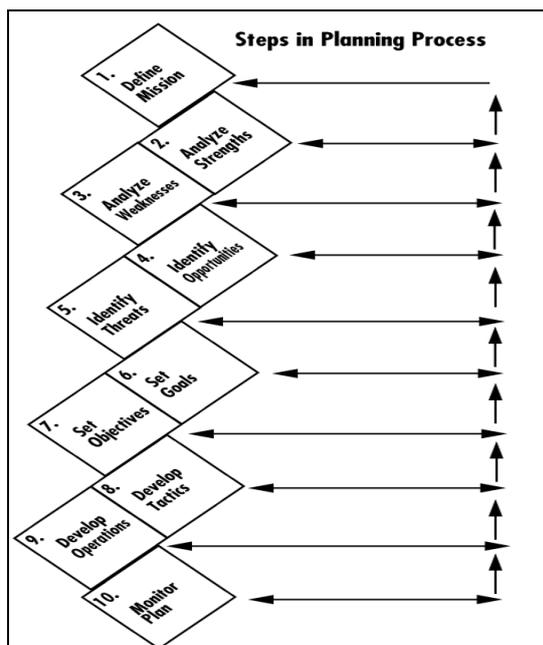


Figure 3. Steps in Planning Process

6. The Main Findings and Major Observations

SWOT analysis should be always a clear session and that it is the responsibility of the project manager to communicate this to all those present at the session. A typical session involving all stakeholders, whenever possible, and key members of the project team. If an analysis at the beginning of the project, the goal is likely to be set fully all required activities and potential hazards so that appropriate plan can be put in place [11]. However, if this is done during the project, the goal is to reassess the budget or schedule.

The objectives of the SWOT analysis can vary the questions used to obtain the required information. For this reason there is a standard set of predetermined questions that will satisfy every situation, but it should be each set of questions written down before the session to ensure attendees remained focused. This, again, is the responsibility of the project manager. Depending on the urgency to complete the analysis and start at the planning

stage of the project, it may be necessary to send questions in advance will allow attendees the opportunity to collect any relevant information in advance.

First state using this SWOT is India, where the Indian mobile market with strong steps to improve the economy and consumer confidence [14]. It is expected that the total market for communications and information technology products and services in India to increase from \$ 16.3 billion in 2010 to \$ 34.3 billion in 2014, which will affect the mobile phone industry in the country. Although excessive government regulations, mobile industry growth remains strong. As of December 2010, India mobile phones 791381574, equivalent to 66.36% of population (business monitor international, 2010). By landlines and cell phones is important (35770000 landlines compared with 791, 000, 000) and the country's gross national income in 2008 was only 1040 € (business monitor international, 2010a).

The rapid spread of mobile telephony in India is the most obvious manifestation of the benefits of telecom sector liberalization. Fixed line penetration is in fact showing signs of decline, and future growth will come from mobile. Given that about 10 million wireless subscribers are being added every month, the impact of telecoms on state-level growth rates can be explored through the impact of mobile telephony. Mobiles are primarily used for work and social purposes and to some extent for emergencies; respondents found little use of them for entertainment, playing games or as an information device.

Nearly 60% of the user households reported highest or high use for work

related use, while nearly 51% reported highest or high use for social interaction (talking to friends relatives in a non-work related context). The primacy of the use of mobile for work over social interaction is also reflected in the usage score that gives the weighted average over a 6 point scale (0–5), though the difference is small. Further, 24% of user households reported highest use of mobile for work, while only 19% have rated social interaction as the primary use. This differs from some survey results elsewhere which report social purposes as the principal use of mobiles, but there are many possible explanations in either the context or survey design which might explain this difference.

In terms of strength and the Indian market with a large number of mobile phone users. Cell phone have benefited in the Indian market from competition. The market hosts a large number of strategic investors including Singapore and administrative and operational support, Singh and Vodafone in the United Kingdom and Malaysia Telekom, and Norway, and administrative and operational support, links from U.A.E. and Japan, and administrative and operational support, it is expected that NTT DoCoMo and Russia and demand management and operational support system for mobile services with strong added value, and to grow. Finally, there are also a lot of availability of skilled manpower and technically qualified with English language proficiency (business monitor international, 2010a). In terms of weaknesses, and the mobile market is still strongly tend to prepaid users [14].

Where opportunity a great boost to expand and upgrade to 3 g. License fees will be reduced by 33% to cover larger areas, which is encouraging for

the industry. Finally, the Government can enhance the competitiveness of the mobile communications sector through increased trade liberalization and deregulation (business monitor international, 2010a). In terms of threats, and the Conservative Government having procedures for licensing and other processes of 3 grams. Network capacity can struggle to keep up with demand. If you make the migration easier, but it will lead to pressure on operators to retain existing customers. Finally, the global economic slowdown and the high cost of slow growth (business monitor international, 2010a).

The second uses the SWOT is Ethiopia. In terms of the phone industry, in 2009, 915, 000 landlines Ethiopia, mobile phone subscribers 50369 (World Bank, 2006), and much less for mobile phones in India. Gross national income (GNP) has a strong influence on this aspect, which in 2009 was \$ 330. In terms of force and Ethiopia was keen to absorb new technology, and the Government was making aggressive plans [14]. And the Ethiopian Telecommunications (ETC) in the information and communication industry of technology fees and incentives to push the mobile industry [14]. As a result, there was significant growth in both governmental and non-governmental projects for mobile application development. Specifically, there is a strong development in the capital Addis Ababa and Nazreth cities close oil wedibret. And the promotion of electronic commerce have a positive impact on the mobile industry (Demeke, Biru, 2002).

Ethiopia is one of the last countries in Africa allowing its national telco, Ethio-Telecom (ETC) a monopoly on all telecom services

including fixed, mobile, Internet and data communications. This monopolistic control has stifled innovation and retarded expansion. A management contract with France Telecom has led to dramatically improved performance and is seen as a first step towards privatization and the introduction of competition, but the two companies are blaming each other for weaknesses in quality of service.

With a population of almost 90 million, Ethiopia is Africa's second most populous country. Its mobile market almost tripled in 2011, and yet market penetration is still less than half the African average, so enormous growth potential remains. The country's broadband market is also set for a boom following massive improvements in international bandwidth, national fiber backbone infrastructure and 3G mobile broadband services [14]. After years of low uptake due to prohibitive pricing, retail prices are now comparable to other markets in the region that are already more developed.

Ethiopia is also the latest low-cost location for mobile phone manufacturing. Three companies have started manufacturing in the country with a combined capacity of almost five million units per year and will soon start exporting to other African markets. The first locally manufactured smartphone is expected to hit the market in the second half of 2012. Another 20 companies have been licensed for local mobile phone manufacturing. The government is encouraging foreign investment in a broad range of industries by allowing up to 100% foreign equity ownership.

In terms of weaknesses and lack of resources for development. Customs

regulations are very rigid. Not dealing with hackers and smuggled goods. There is a shortage of trained professionals. Finally, most of the focus on Addis Ababa and surrounding towns, which ignores the other regions (Demeke, Biru, 2002). In terms of opportunities, Ethiopia could become a big player in the great desert belt. And cooperation with external suppliers help the mobile industry grow. And inviting investors from outside resources. There is also the possibility to build capacity through the training of local personnel. Investment in the mobile industry will lead to increased social and economic returns. Finally, there is an opportunity to expand mobile services to other regions, especially rural areas, to cover the whole nation. In terms of threats, one important consideration is the political instability.

Third country Kuwait is the application of SWOT. According to 2009 figures and Kuwait 553500, phones 3876, which is surprisingly low, especially considering that the country's gross national income in 2009 amounted to 43, 930 \$ (business monitor international, 2011). In terms of strengths and Kuwait boasts relatively high hack IT. Kuwait boasts liberal market access policies. Kuwait is one of the most advanced States in the Gulf region. The Government has invested heavily in infrastructure.

The Information and communication technology expenditure per capita (US dollar) in Kuwait was reported at 1756.95 in 2008, according to the World Bank. Information and communications technology expenditures include computer hardware (computers, storage devices, printers, and other peripherals); computer software (operating systems,

programming tools, utilities, applications, and internal software development); computer services (information technology consulting, computer and network systems integration, Web hosting, data processing services, and other services); and communications services (voice and data communications services) and wired and wireless communications equipment.

Kuwait is one of the wealthiest countries in the Middle East due to its oil dependent economy, which represents approximately 50% of GDP and almost all government revenue. Kuwait's government is heavily involved in the economy, largely due to its control of the oil industry. A similar situation exists in the telecom sector due to the lack of market liberalization. Recognizing the potential of applying ICT to improve both social and economic development, Kuwait has taken steps to develop a digital economy; national level policies for e-health and e-government have been developed, with a number of services available online.

Finally, arguably the most democratic State in the Kuwait Bay area (business monitor international, 2011). Where weaknesses, there is a small domestic market with a low level of participants. Services are expensive, and reflecting on a limited degree of competition. Currently, mobile phone services are still under the control of the State monopoly with strict government controls. Finally, the economic dependence on oil has slowed down other sectors of the economy (business monitor international, 2011). In terms of opportunities, and rising oil prices around the world further strengthen the economy. There is considerable

emphasis on e-Government. Kuwait is a key player in regional trade. Finally, increasing contacts Kuwait investment and privatization bring new skills to access (business monitor international, 2011). In terms of threats, there are large regional instability, especially during "spring year.

The fourth State is applied to United States, in 2004 it was found according to [15] that mobile voice services generated productivity gains to the U.S. economy worth \$157 billion per year. And in the forthcoming years, it is given as follows:-

- In 2005, mobile wireless broadband services generated productivity gains to the U.S. economy worth \$28 billion per year.
- In 2005, the productivity value of all mobile wireless services was worth \$185 billion, greater than the total value of the U.S. pharmaceutical industry (according to BizStats.com).
- Between 2004 and 2005, the productivity enhancements generated by the use of mobile wireless broadband tripled in value.
- In 2005, 68.8 million US enterprise users had mobile wireless services, with only a quarter using mobile wireless broadband. By 2016, the US is projected to have 81.9 million mobile enterprise users, with 83 percent using wireless broadband.
- Health care and small businesses are the big winners. In 2005, productivity improvements due to use of mobile broadband solutions across the U.S. health care industry were worth almost \$6.9 billion. By 2016, that number will triple to \$27.2 billion, or twice the size (according to Bizstats.com) of the current vocational rehabilitation sector of the health care industry. As demonstrated in several case

studies provided in this Report, small businesses are uniquely empowered by implementation and use of wireless broadband technologies and applications.

- To put this information into context, consider that by 2016, the value of the combined mobile wireless voice and broadband productivity gains to the US economy -- \$427 billion per year -- will exceed today's motor vehicle manufacturing and pharmaceutical industries combined.

In terms of communication, in 2009 the numbers America 141 million land phones and 286 mobile phone. Strong growth in the mobile phone market in the United States is part of the data-centric mobile phones increase, especially smartphones. Verizon is leading the market with 35.7% of wireless revenues. AT & T, was second with 34.8%. Sprint and T-Mobile are two companies in the mobile market (business monitor international, 2010b). In terms of power and dominate the mobile market in the United States in terms of the number of postpaid subscribers and revenue generation per user average. There is a healthy competition with four national companies and many smaller regional players. It has helped smart phones such as the iPhone and the various Android phones to promote 3 g and 4 g service.

Mobile devices may interact with other systems in terms of data synchronization and storage [13]. Local system interaction generally involves connecting a mobile device to a desktop or laptop via a cable for charging and/or syncing. Remote system interaction most often involves automatic backups of data to a cloud-based storage solution. When all of these components are under the

organization's control, risk is generally acceptable, but often one or more of these components are external. Examples include attaching a personally-owned mobile device to an organization-issued laptop, attaching an organization-issued mobile device to a personally-owned laptop, and attaching an organization-issued mobile device to a remote backup service. In all of these scenarios, the organization's data is at risk of being stored in an unsecured location outside the organization's control; transmission of malware from device to device is also a possibility.

In terms of weaknesses, and national operators is growing stronger with much room for regional players. Moreover, the market is split between two technologies: CDMA and GSM (business monitor international, 2010b). In terms of opportunities, and the expansion of mobile networks, in particular for G 3 services and 4G services, and offers significant growth opportunities. And mobile phone growth has shown a significant increase in recent years, adding further growth, while fixed phones dropped significantly. The United States has the largest economy in the world with an impressive record of initiative and innovation and dynamism and high R D. & legal system friendly to business support of entrepreneurial activities (business monitor international, 2010b). In terms of threats, there is increased competition from China and other low-wage economies. And the impact of the global economic slowdown on the economy, particularly in terms of job growth. Problems.

The telecom sector in Saudi Arabia is growing rapidly. Telecom service revenues have been steadily increasing at a cumulative average rate of around

15% annually. The reason for which Saudi Arabia is so attractive to all the telecom operators is the combination of its population size and wealth. While the total population is nowhere near as high as that of Turkey or Iran, its GDP per capita is much higher and while the smaller Gulf countries are richer per capita, their populations are tiny. In addition, its market has been slower to develop than some others in the region such as the UAE or Qatar, leaving room for growth [16]. Fixed line penetration has remained steady for some years rather than falling as it has in some other countries in the region. Internet user penetration is nearly 40% but DSL broadband subscriber penetration is only around five percent. However, the number of DSL subscribers doubled in the two years to end-2010.

Mobily is making an extensive push with mobile broadband. The expansion of existing infrastructure and implementation of new technology platforms such as WiMax are expected to improve penetration of internet and broadband. As competition becomes fierce in its home market, STC has used its considerable resources to expand abroad. It has direct interests in Malaysia, Kuwait and Bahrain and, through its purchase of a 35% share in Oger Telecom, also in Turkey and South Africa. Intense competition in the mobile market with all regional major players involved [16]. Mobile broadband and WiMAX broadband subscribers exceed the number of ADSL subscribers. Saudi Telecom Company, Etisalat, Zain and Baud Telecom Company are the top players in the industry. Etisalat has considerably more than a toehold in the market. It won the second GSM/3G mobile license and, operating as Mobily, now has over one-third of the GSM market and three-quarters of the 3G market. In this industry scenario,

Taiyou Research analyzes the Saudi Arabian telecom sector in its research report Telecom Industry in Saudi Arabia. The report covers the following:

An analysis of the global telecom industry through an industry definition, industry statistics, industry value & volume analysis, industry segmentation, and a look at the competition in the global telecom industry. We also include an industry forecast for the years 2011-2016

2. An in-depth analysis of the major global telecom players such as AT&T Inc, Deutsche Telekom, and others. Each player is analyzed through a company overview, analysis of their businesses, a financial analysis and a SWOT analysis.

3. Moving on to the analysis of the Telecom Industry in Saudi Arabia, we analyze the industry starting with an overview of the business conditions in Saudi Arabia for the telecom sector. We include an ARPU analysis of the Saudi Arabian telecom sector, along with an overview of the mobile services sector in Saudi Arabia, fixed line telecom sector in Saudi Arabia and an overview of broadband services in Saudi Arabia.

4. An analysis of the mobile telecom sector in Saudi Arabia is carried out through the analysis of industry statistics, the growth in the market, ARPU analysis of this sector, the expansion and development of the mobile network in the country, the launch of 3G services in the country, the growing role of mobile content and VAS facilities in the market, and the statistics of the major players in the mobile services sector in Saudi Arabia.

An outlook for the sector is also included.

7. Concluded Remarks and

Future Works

SWOT analysis is very important in the process of strategy formulation. Analysis of opportunities and threats is the basis for assessing whether the enterprise can seize opportunities and avoid threats when uncontrollable environment. Analysis of internal strengths and weaknesses are mainly for internal work institution, such as, research management, and the efficiency of work and development. SWOT. Able to help companies assess their status in the competition, and can be used as a basis for policy analysis. In this study, based on the SWOT analysis quantified style shows similarities with the concept of GSM. So, you can combine quantitative with the SWOT analysis GSM for strategy formulation and selection. In this research, and explore the impact of mobile technology for social and economic development. The analysis showed varying degrees of impact on sectors such as education, agriculture, industry, and health sciences in the four countries, namely, development environments

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Evaluation of Artificial Neural Networks Used for Pattern Recognition Systems

MusbahJ. Aqel , Ziad AlQadi

Department of Electrical and Computer Engineering
Faculty of Engineering, Applied Science University, Amman, Jordan
e-mail: musbhaqel@yahoo.com

Dr. Mohammed Abu Zalata , Dr. Rushdi Abu Zneit
Department of Computer Engineering
Albalqa Applied University, Amman, Jordan

ABSTRACT

Criteria are proposed for selecting the best architecture for different artificial neural networks with different architectures were implemented and tested using Mat lab. It was shown that one layer artificial neural network is good for pattern recognition, but these networks were very sensitive to the training rate values.

Multilayer neural networks were also implemented and tested, and was shown that they were not sensitive to training rate values, but choosing the appropriate architecture is a focal point in the process of designing pattern recognition systems

Key words: Neural Network, network architecture, training rate, training time, recognition ratio, one layer networks, multilayer networks.

1. Introduction

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is also true for ANNs as well.

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or

other computer techniques [3]. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. This expert can then be used to provide projections given new situations of interest and answer "what if" questions.

Other advantages include:

1. Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.
2. Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
3. Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.
4. Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.

The memorization of patterns and the subsequent response of the network can be categorized into two general paradigms:

- **Associative mapping** in which the network learns to produce a particular pattern on the set of input units whenever another particular pattern is applied on the set of input units.

Every neural network possesses knowledge which is contained in the values of the connections weights. Modifying the knowledge stored in the network as a function of experience implies a learning rule for changing the values of the weights.

Information is stored in the weight matrix W of a neural network. Learning is the determination of the weights. Following the way learning is performed, we can distinguish two major categories of neural networks:

- **Fixed networks** in which the weights cannot be changed, i.e. $dW/dt=0$. In such networks, the weights are fixed a priori according to the problem to solve.
- **Adaptive networks** which are able to change their weights, is $dW/dt \neq 0$.

All learning methods used for adaptive neural networks can be classified into two major categories:

- **Supervised learning**
- **Unsupervised learning**

The behavior of an ANN (Artificial Neural Network) depends on both the weights and the input-output function (transfer function) that is specified for the units. This function typically falls into one of three categories:

- linear (or ramp)

- threshold
- sigmoid

For **linear units**, the output activity is proportional to the total weighted output.

For **threshold units**, the output are set at one of two levels, depending on whether the total input is greater than or less than some threshold value.

For **sigmoid units**, the output varies continuously but not linearly as the input changes. Sigmoid units bear a greater resemblance to real neurons than do linear or threshold units, but all three must be considered rough approximations.

2. Evaluation Criteria

To make a neural network that performs some specific task, criteria were proposed that assist the designer to choose how the units are connected to one another, and how to set the weights on the connections appropriately. The connections determine whether it is possible for one unit to influence another. The weights specify the strength of the influence. So, the following should be considered:

- I. Training rate
- II. Training rate
- III. Training time
- IV. Way of processing output (i.e. rounding or shareholding)

A three-layer network can be taught to perform a particular task by using the following procedure:

1. We present the network with training examples, which consist of a pattern of activities for the input units together with

the desired pattern of activities for the output units.

2. We determine how closely the actual output of the network matches the desired output.
3. We change the weight of each connection so that the network produces a better approximation of the desired output.

3. Theoretical Consideration

When a set of patterns is put to visual recognition, it is expected to be consisting of printed (or handwritten) characters pertaining to one or more Scripts or fonts. This set however, may contain information besides optical characters alone. For example, it may contain pictures and colors that do not provide any useful information in the instant sense of pattern recognition. In addition, patterns which need to be singly analyzed may exist as word clusters or may be located at various points in the document. Such an image is usually processed for noise-reduction and separation of individual characters from the document. It is convenient for comprehension to assume that the submitted image is freed from noise and that individual characters have already been located (using for example, a suitable clustering algorithm). This situation is synonymous to the one in which a single noise-free character has been submitted to the system for recognition. Thus patterns need to be processed using image processing techniques in order to get a clear and suitable for recognition purposes.

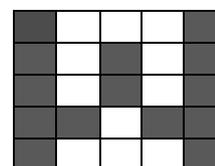
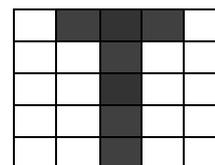
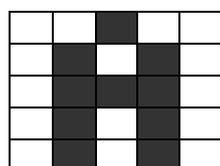
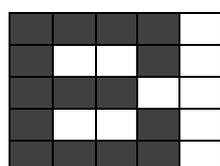


Figure (1): Representation of A, B, T, and W

The process of digitization is important for the neural network used in the system. In this process, the input image is sampled into a binary window which forms the input to the recognition system. In figure 1, the alphabet A has been digitized into 5X5=25 digital cells, each having a single color, either black or white. It becomes important for us to encode this information in a form meaningful to a computer. For this, we assign a value +1 to each black pixel and 0 to each white pixel and create the binary image matrix I which is shown in the Figure 2.. So much of conversion is enough for neural networking which is described next. Digitization of an image into a binary matrix of specified dimensions makes the input image invariant of its actual dimensions. Hence an image of whatever size gets transformed into a binary matrix of fixed pre-determined dimensions. This establishes uniformity in the dimensions of the input and stored patterns as they move through the recognition system.



0	0	1	0	0
0	1	0	1	0
0	1	1	1	0
0	1	0	1	0
0	1	0	1	0



1	1	1	1	0
1	0	0	1	0
1	1	1	0	0
1	0	0	1	0
1	1	1	1	0

0	1	1	1	0
0	0	1	0	0
0	0	1	0	0
0	0	1	0	0
0	0	1	0	0

1	0	0	0	1
1	0	1	0	1
1	0	1	0	1
1	1	0	1	1
1	0	0	0	1

Figure(2): Binary representation of the patterns(A, B, T, W).

4. Testing and implementation

In order to evaluate artificial neural networks used for pattern recognition the following should be followed:

- Digitize the patterns
- Define the artificial neural net work architecture: Define the input stream, define the targets, and define the number of layers and the number of neurons in each layer.
- Train the neural network after defining the network parameters such as the goal, training rate, number of training iterations, activation functions (logsig or tansig), and learning functions.
- Simulate the neural network using different forms for each individual input pattern.

The input matrix PP is fed as input to the neural network. It is typical for any neural network to learn in a supervised or unsupervised manner by adjusting its weights. In the current method of learning, each candidate character taught to the network possesses a corresponding weight matrix. For a certain pattern to be taught to the network, the weight matrix is to be updated. As learning of the pattern progresses, it is this weight matrix that is updated. At the commencement of teaching (supervised training), this matrix is initialized to zero. Whenever a pattern is to be taught to the network, an input pattern representing that character is submitted to the network. The network is then instructed to identify this pattern as, say, the kth character in a knowledge base of characters.

The following Matlab code illustrates the above mentioned steps using a linear neural network with only 1 output layer:

```

% input definition
A=[0;0;1;0;0;0;1;0;1;0;0;1;1;1;0;0;1;0;1;0;0;1;0;
1;0];
B=[1;1;1;1;0;1;0;0;1;0;1;1;1;1;0;0;1;0;0;1;0;1;1;1;
:0];
C=[0;1;1;1;0;1;0;0;0;0;1;0;0;0;0;1;0;0;0;0;0;1;1;
:0];
D=[1;1;1;1;0;0;1;0;0;1;0;1;0;0;1;0;1;0;0;1;1;1;
1;0];
E=[0;1;1;1;0;0;1;0;0;0;0;1;1;1;0;0;1;0;0;0;0;1;1;
:0];
F=[0;1;1;1;0;0;1;0;0;0;0;1;1;1;0;0;1;0;0;0;0;1;0;
:0];
G=[0;1;1;1;0;1;0;0;0;0;1;0;1;1;0;1;0;0;1;0;1;1;
1;1];
H=[0;1;0;1;0;0;1;0;1;0;0;1;1;1;0;0;1;0;1;0;0;1;0;
1;0];
I=[0;1;1;1;0;0;0;1;0;0;0;0;1;0;0;0;0;1;0;0;0;1;1;
0];
J=[0;0;1;1;1;0;0;0;1;0;0;0;0;1;0;0;1;0;1;0;0;1;1;
0];
K=[0;0;1;0;1;0;0;1;1;0;0;0;1;0;0;0;0;1;1;0;0;0;1;
0;1];
L=[0;1;0;0;0;0;0;0;0;0;1;0;0;0;0;1;0;0;0;0;1;1;
:0];
M=[1;0;0;0;1;1;1;0;1;1;1;0;1;0;1;1;0;0;0;1;1;0;0;
0;1];
N=[1;0;0;0;1;1;1;0;0;1;1;0;1;0;1;1;0;0;1;1;1;0;0;
0;1];
O=[0;1;1;1;0;1;0;0;0;1;1;0;0;0;1;1;0;0;0;1;0;1;1;
1;0];
P=[0;1;1;1;0;0;1;0;1;0;0;1;1;1;0;0;1;0;0;0;0;1;0;
:0];
Q=[0;1;1;0;0;1;0;0;1;0;1;0;1;1;0;0;1;1;1;0;0;0;0;
1;1];
R=[0;1;1;1;0;0;1;0;1;0;0;1;1;1;0;0;1;1;0;0;0;1;0;
:0];
S=[0;1;1;1;0;0;1;0;0;0;0;1;1;1;0;0;0;0;1;0;0;1;1;
:0];
T=[1;1;1;1;0;0;1;0;0;0;0;1;0;0;0;0;1;0;0;0;0;1;0;
:0];
U=[1;0;0;0;1;1;0;0;0;1;1;0;0;0;1;1;0;0;0;1;0;1;1;
1;0];
V=[1;0;0;0;1;1;0;0;0;1;1;1;0;1;1;0;1;0;1;0;0;0;1;
0;0];
W=[1;0;0;0;1;1;0;1;0;1;1;0;1;0;1;1;1;0;1;1;1;0;0;
0;1];
X=[1;0;0;0;1;0;1;0;1;0;0;0;1;0;0;0;1;0;1;0;1;0;0;
0;1];
Y=[1;0;0;0;1;0;1;0;1;0;0;0;1;0;0;0;1;0;0;0;1;0;0;
0;0];
Z=[1;1;1;1;0;0;0;1;0;0;0;1;0;0;0;1;0;0;0;1;1;1;
:1];
PP=[A B C D E F G H I G K L M N O P Q R S
T U V W X Y Z];

%targets definition
target=[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 1;
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 1;
1;

```

```
0 0 0 0 1 1 1 1 1 0 0 0 0 1 1 1 1 1 0 0 0 0 1 1 1 1 1 0
0;
0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0
0;
0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0
1];
```

% define the network architecture and parameters

```
net = newlin(minmax(PP), 5,0,0.001);
net.trainParam.goal = 10e-5; % training stops if
goal achieved
net.trainParam.epochs = 500;
%train the network
net = train(net, PP, target);
%simulate the network
a = sim(net, PP);
testZ = round(sim(net, Z))
testZ = sim(net, Z)
```

While the following mat lab code illustrates the above mentioned steps using a multilayer neural network with only with 1 or more hidden layers and 1 output layer:

```
%create inputs and targets
A=[0;0;1;0;0;0;1;0;1;0;0;1;1;1;0;0;1;0;1;0;0;1;0;1;0;1;0
];
B=[1;1;1;1;0;1;0;0;1;0;0;1;1;1;0;0;1;0;0;1;0;0;1;1;1;1;0
];
C=[0;1;1;1;0;1;0;0;0;0;1;0;0;0;0;0;1;0;0;0;0;0;1;1;1;0
];
D=[1;1;1;1;0;0;1;0;0;1;0;0;1;0;0;1;0;0;1;0;0;1;1;1;1;0
];
E=[0;1;1;1;0;0;1;0;0;0;0;1;1;1;0;0;1;0;0;0;0;1;1;1;0
];
F=[0;1;1;1;0;0;1;0;0;0;0;0;1;1;1;0;0;1;0;0;0;0;1;0;0;0
];
G=[0;1;1;1;1;0;1;0;0;0;0;1;0;0;1;0;0;1;0;0;1;0;1;1;1;1
];
H=[0;1;0;1;0;0;1;0;1;0;0;1;1;1;0;0;1;0;1;0;0;1;0;1;0;1;0
];
I=[0;1;1;1;0;0;0;1;0;0;0;0;1;0;0;0;0;1;0;0;0;1;1;1;0]
;
J=[0;0;1;1;1;0;0;0;1;0;0;0;0;1;0;0;1;0;0;1;0;0;1;1;1;0]
;
K=[0;0;1;0;1;0;0;0;1;1;0;0;0;1;0;0;0;0;1;1;0;0;0;1;0;1
];
L=[0;1;0;0;0;0;0;0;0;0;0;0;1;0;0;0;0;1;0;0;0;0;1;1;1;0
];
M=[1;0;0;0;1;1;1;0;1;1;1;0;1;0;1;1;0;0;0;1;1;0;0;0;1
];
N=[1;0;0;0;1;1;1;0;0;1;1;0;1;0;1;1;0;0;0;1;1;1;0;0;0;1
];
O=[0;1;1;1;0;1;0;0;0;1;1;0;0;0;1;1;0;0;0;1;0;1;1;1;0
];
P=[0;1;1;1;0;0;1;0;1;0;0;1;1;1;0;0;1;0;0;0;0;1;0;0;0
];
Q=[0;1;1;0;0;1;0;0;1;0;1;0;0;1;1;0;0;0;1;1;1;0;0;0;1;1
];
```

```
R=[0;1;1;1;0;0;1;0;1;0;0;1;1;1;0;0;1;1;0;0;0;1;0;1;0
];
S=[0;1;1;1;0;0;1;0;0;0;0;1;1;1;0;0;0;0;1;0;0;1;1;1;0
];
T=[1;1;1;1;0;0;1;0;0;0;0;1;0;0;0;0;1;0;0;0;0;1;0;0;0
];
U=[1;0;0;0;1;1;0;0;0;1;1;0;0;0;1;1;0;0;0;1;0;1;1;1;0
];
V=[1;0;0;0;1;1;0;0;0;1;1;1;0;1;1;0;1;0;1;0;0;0;1;0;0
];
W=[1;0;0;0;1;1;0;1;0;1;1;0;1;0;1;1;1;0;1;1;1;0;0;0;0
];
X=[1;0;0;0;1;0;1;0;1;0;0;0;1;0;0;0;1;0;1;0;1;0;0;0;0
];
Y=[1;0;0;0;1;0;1;0;1;0;0;0;1;0;0;0;1;0;0;0;1;0;0;0;0
];
Z=[1;1;1;1;0;0;0;1;0;0;0;1;0;0;0;1;0;0;0;1;0;0;0;1;1;1
];
PP=[A B C D E F G H I G K L M N O P Q R S T
U V W X Y Z];
```

```
target=[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1
1 1 1;
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 1;
0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0;
0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0;
0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1];
%backpropagation
```

```
net2 = newff(minmax(PP),[5 5],{'logsig' 'logsig'
'traingdx'});
net2.trainParam.epochs = 500; % training stops if
epochs reached
net2.trainParam.goal = 10e-6;
net2.trainParam.lr=0.01;
net2.trainParam.show = 10; % plot the performance
function at every epoch
net2 = train(net2, PP, target);
c = sim(net2, PP);
testC = round(sim(net2, C))
testD = round(sim(net2, D))
```

5. Experimental results

Several single layer and multiple layer neural networks were implemented and tested using the input stream representing the patterns to be recognized. Our evaluations were where focused on the following measures:

- Recognition ratio
- Training time
- Simulation time

The following tests were made:

Test 1(Net 1:500 training iterations):
Net1 with single output layer of 5 neurons (0 to 25) was created and tested with a training rate

=0.1, this net was simulated using the actual input patterns.

The same net was trained with a training rate =0.01, 0.001, and 0.0001. The results are shown in table1:

Table (1): results of test1

Train. rate	Train. Time(sec)	Simulation time(sec)	No of correct recognized patterns	Recognition ratio (%)
0.1	5.86	0.219	0	0
0.01	1.859	0.219	22	84.61
0.001	1.89	0.219	26	100
0.0001	1.969	0.219	23	88.46

Test2 (Net2):

The same thing was done as in test 1, but the number of training iterations=1000. Table 2 shows the results of test 2:

Table 2: results of test2

Train. rate	Train. Time(sec)	Simulation time(sec)	No of correct recognized patterns	Recognition ratio(%)
0.1	7.016	0.282	0	0
0.01	3.718	0.282	26	84.61
0.001	4.203	0.282	26	100
0.0001	4.344	0.282	25	88.46

Test3: From the results in table 1 and 2 we take the best results (achieving 100% of recognition ratio)(number of training iteration=500 and training rate=0.001) and train this network using samples which are near to the actual pattern.

For each pattern we take 20 samples and simulate the net using these samples. Table 3 shows the results of training for the patterns A, B, and C.

Table (3): Results of training A, B, and C

Pattern	Desired output	Worst Computed output	Ro un di ng	Thr esh old	Out put usi ng thre sho ld
A	0	0.3402	0	0.4	0
	0	0.2097	0	6	0
	0	0.3459	0		0
	0	0.3882	0		0

	0	0.4540	0		0
B	0	0.4423	0	0.5	0
	0	0.2901	0		0
	0	0.3912	0		0
	0	0.4915	0		0
	1	0.7193	1		1
C	0	0.0939	0	0.2	0
	0	0.2818	0	9	0
	0	0.2051	0		0
	1	0.8323	1		1
	0	0.1642	0		0

Test4 (Net4)

The following multilayer neural net work was implemented and tested using training rates 0.5, 0.1, 0.01 using the actual inputs and it gives 100% recognition ratio:

```
net2 = newff(minmax(PP),[5 5],{'logsig' 'logsig' 'traingdx'});
net2.trainParam.epochs = 500; % training stops if epochs reached
net2.trainParam.goal = 10e-6;
net2.trainParam.lr=0.1;
net2.trainParam.show = 10; % plot the performance function at every epoch
net2 = train(net2, PP, target);
```

Using this net to recognize different samples of the patterns gives us a better solution and the computed outputs for A, B, and C were(but the training time was = 11.891):

```
A =
    0.0000
    0.0001
    0.0000
    0.0012
    0.0000
B =
    0.1369
    0.0000
    0.0000
    0.0000
    1.0000
C =
    0.0000
    0.0001
    0.0000
    1.0000
    0.0000
```

Which are much closed to the desired output.

TEST5 (Net5):

Net 5 is similar to Net 4 but with different activation function as show below:

```
net2 = newff(minmax(PP),[5 5],{'tansig' 'tansig'
'traingdx'});
net2.trainParam.epochs = 500; % training stops if
epochs reached
net2.trainParam.goal = 10e-6;
net2.trainParam.lr=0.1;
net2.trainParam.show = 10; % plot the
performance function at every epoch
net2 = train(net2, PP, target);
```

Using this net to recognize different samples of the patterns gives us a poor solution comparing with the results obtained for Net4, and the computed outputs for A, B, and C were(the training time was = 13.203000 seconds):

A =
0.0000
0.1138
-1.0000
-1.0000
1.0000

B =
0.3000
-0.0007
0.9745
1.0000
-1.0000

C =
0.1900
0.1128
0.3265
1.0000
0.5764

These results need theshoding or rounding in order to get the desired outputs.

Test 6(Net 6):

Net6 is similar to Net 4 but we increase the number of neurons in the hidden layer as follows:

```
net2 = newff(minmax(PP),[10 5],{'logsig'
'logsig' 'traingdx'});
net2.trainParam.epochs = 500; % training
stops if epochs reached
net2.trainParam.goal = 10e-6;
net2.trainParam.lr=0.1;
net2.trainParam.show = 10; % plot the
performance function at every epoch
```

net2 = train(net2, PP, target);
Using this net to recognize different samples of the patterns gives us a good solution (but not better than Net4 results and the computed outputs for A, B, and C were (but the training time was = 33.703000 seconds):

A =
0.0000
0.0004
0.5264
0.0000
0.0000
B =
0.0002
0.0000
0.0000
0.0000
1.0000
C =
0.0986
0.0000
0.0000
0.9974
0.0025

These results need rounding or thresholding.

Test 7(Net 7):

To create Net7 we use Net 4 by adding 1 extra hidden layer with 5 neurons.

Using this net to recognize different samples of the patterns gives us a solution comparing which needs some extra processing. The results obtained for Net7, and the computed outputs for A, B, and C were(the training time was = 15.312000seconds):

A =
0.3309
0.0040
-0.0516
-0.5920
-1.8610
B =
1.2462
-0.4829
-0.0605
0.7447
3.3070
C =

6. Results discussion

From the results obtained in Tables (1, 2, 3), it could be concluded that the one layer artificial neural networks:

- Are very sensitive to the value of the training ratio
- Choosing the appropriate value of the training rate is a focal task.
- Training rate value must be small.
- Training time is small
- Obtained actual outputs must be processed by rounding or thresholding.

From the results obtained in Tables 4, 5, 6 and 7 we can say that the multilayer artificial neural networks:

- Are not sensitive to the value of the training ratio
- Adding a hidden layer improve the network performance.
- Choosing the number of neurons in the hidden layer is a focal task.
- When the number of neurons in the hidden layer equal to those in the output layer we can reach the best network architecture and the computed outputs do not need any extra processing.
- Adding an extra hidden layer does not improve the network performance.

7. Conclusion

Using a one layer artificial neural network can lead to better performance if select the suitable training rate and perform some extra manipulation to the computed output. Choosing multilayer artificial neural network with 1 hidden layer leads to correct calculated outputs but with mush training time.

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A Study of friction factor formulation in pipes using artificial intelligent techniques and explicit equations

Rahman KHATIBI, Farzin SALMASI¹, Mohammad Ali GHORBANI
Department of Water Engineering, Faculty of Agriculture, Tabriz university, Tabriz, IRAN. e-mail: Salmasi@Tabrizu.ac.ir

Abstract

The hydraulic design and analysis of flow conditions in pipe networks is dependent upon estimating friction factor, f . The performance of its explicit formulations and those of Artificial Intelligence Techniques (AI) are studied in this paper. The AI techniques used here include Artificial Neural Networks (ANN) and Genetic Programming (GP) and both use the same data generated numerically by systematically changing the values of Reynolds numbers, R_e , and relative roughness ε/D and solving the Colebrook-White equation for f -value using the successive substitution method. The tests included the transformation of R_e and ε/D using a logarithmic scale. The study shows that some of the explicit formulations for friction factor induce undue errors but the accuracy of a number of them is good. The ANN formulation of the problem of solving for the friction factor in the Colebrook-White equation is less successful than that by GP. The implementation of GP offers another explicit formulation for friction factor, the performance of GP in terms of R^2 (0.997) and RMSE (0.013) is good but its values are slightly perturbed around its numerically-obtained values.

Key Words: Artificial Neural Network, Darcy-Weisbach, Genetic programming; Pipe resistance.

1. Introduction

Flow equations in closed conduits are well developed in hydraulics with the subject reaching its maturity in the early 20th century. Flows in such systems are driven by pressure differences between two different locations and the equation is referred to as the Darcy-Weisbach equation the problem includes an empirical friction parameter, f , for which the Colebrook-White equation is one of its well-known implicit formulations, i.e. the factor appears on both sides of the equation. This implicit problem is not intractable, as it can be treated by iterative techniques although it is cumbersome. Until the wide application of Artificial Intelligence (AI) in the 1990s, the challenge was to develop its explicit formulations but since then the application of AI techniques is also a focus of research.

The Colebrook-White equation integrates important theoretical work by von Karman and Prandtl by accounting for both smooth and turbulent flow regimes in terms of the two parameters of Reynolds number, Re , and the relative roughness, as a measure of friction $\frac{\epsilon}{D}$. Alternative methods of solving the Colebrook-White equation include: iterative methods, analytical solutions using the Lambert W function, using an explicit equation, *soft computing* techniques recognizing that f -values are not precise, and a host of AI techniques used in recent years including the Artificial Neural Network (ANN) technique and Genetic Programming (GP) but these assume that f -values are precise.

ANNs are parallel information processing system and emulate the working processes in the brain. Neural network consists of a set of neurons or nodes arranged in layers and in the case that weighted inputs are used, these nodes provide suitable inputs by conversion functions (Kisi, 2005). Each neuron in a layer is connected to all the neurons of the next layer but without any interconnection among the neurons in the same layer.

developed in terms of pressure drop, which is directly a measurable quantity. As pressure drop is a measure of friction, this provides a method to study the flow under a wide range of conditions. The hydraulics of the problem is well understood and serves the basis for hydraulic design and However, the mathematical formulation of Applications of ANN to hydraulics go back to the 1990s and still active.

The GP methods, first proposed by Koza (1992), are wide-ranging and similar to Genetic Algorithms (GA) (Goldberg, 1989). GP techniques are robust applications of optimization algorithms and represent one way of mimicking natural selection. These techniques derive a set of mathematical expressions to describe the relationship between the independent and dependent variables using such operators as mutation, recombination (or crossover) and evolution. These are operated in a population evolving in generations through a definition of fitness and selection criteria. Applications of GP suit a wide range of problems and in particular to cases where: (i) the interrelationships among the relevant variables are poorly understood or suspected to be wrong; (ii) conventional mathematical analyses are constrained by restrictive assumptions but approximate solutions are acceptable, (Banzhaf et al., 1998).

In smooth pipes, friction factor, f , depends only on Re , and Gulyani (1999) provides a revision and discussion of the correlations more commonly used to estimate its value. However, the focus of recent research works is largely on the full the Colebrook-White equation. More (2006) applied an analytical function. Fadare and Ofidhe (2009) study the Artificial Neural Network (ANN) technique for the estimation of friction factor in pipe flows and report a high correlation factor, R -value, of 0.999.

An-Shik et al. (2003) use ANN to predict phase transport characteristics in high-pressure two-phase turbulent bubbly flows. Their investigation aimed to

demonstrate the successful use of neural networks in the real-time determination of two-phase flow properties at elevated pressures. Three back-propagation neural networks, trained with the simulation results of a comprehensive theoretical model, are established to predict the transport characteristics (specifically the distributions of void-fraction and axial liquid–gas velocities) of upward turbulent bubbly pipe flows at pressures covering 3.5–7.0 MPa. Comparisons of the predictions with the test target vectors indicate that the Root Mean Squared Error (RMSE) for each one of three back-propagation neural networks is within 5% to 6%.

To date, the application of GP in hydraulic engineering has been limited. Davidson et al. (1999) determined empirical relationships for the friction in turbulent pipe flows and the additional resistance to flow induced by flexible vegetation, respectively. Giustolisi (2004) determined Chezy resistance coefficient in corrugated channels. The authors are not

aware of the application of GP to the Colebrook-White equation.

The focus of this paper is on treating friction factor as having precise values but in reality this parameter is variable over time and often data are insufficient, ambiguous and uncertain for its precise treatments. Therefore, Yıldırım and Ozger (2009), Yıldırım (2009) and Ozger and Yıldırım (2009) investigate this parameter by soft computing techniques using various formulations of friction factor, enabling them to identify precise values of friction values using neuro-fuzzy techniques.

The overall objective of the present study is to evaluate the performances of explicit formulations for estimating the friction factor, f , in the Darcy-Weisbach equation, as well as using ANN and GP as a mean to avoid the need for a time-consuming and iterative solution of the Colebrook-White equation. The study involves generation of data and comparisons between of the various techniques with the numerical solutions of Colebrook-White equation.

2. Models and methodology

2.1. Flow Equation

The energy loss due to friction in Newtonian liquids flowing in a pipe is usually calculated through the Darcy–Weisbach equation:

$$h_f = f \frac{L V^2}{D 2g}$$

In this equation, f is referred to as the Moody or Darcy friction factor. This may be reformulated as follows:

2.2 Explicit Formulations

The Colebrook–White equation is valid for R_e ranging from 2000 to 10^8 , and values of relative roughness ranging from 0.0 to 0.05. The formula is often used in pipe network simulations. Its form is notably implicit, in which the value of f appears on both sides of the equation and often its accurate solution is very time consuming for requiring many iterations. An

$$f = \frac{D}{L} \frac{g h_f}{1/2 V^2} = \frac{D}{L} \frac{\Delta P}{1/2 \rho V^2} \quad (2)$$

The friction factor depends on the Reynolds number, R_e , and on the relative roughness of the pipe, ϵ/D .

(1) For both smooth and turbulent flows, the friction factor is estimated through the equation developed by Colebrook and White (1937):

$$\frac{1}{\sqrt{f}} = -2 \log \left(\frac{\epsilon}{3.7D} + \frac{2.523}{R_e \sqrt{f}} \right) \quad (3)$$

approximate equation for f that does not require iteration can be used to improve the speed of simulation software. These were an active subject of research in the past leading to a range of explicit formulations are summarized in A study of the performance of these explicit equations is one of the aims of this paper.

2. Models and methodology

2.1. Flow Equation

The energy loss due to friction in Newtonian liquids flowing in a pipe is usually calculated through the Darcy–Weisbach equation:

$$h_f = f \frac{L}{D} \frac{V^2}{2g} \quad (1)$$

In this equation, f is referred to as the Moody or Darcy friction factor. This may be reformulated as follows:

$$f = \frac{D}{L} \frac{g h_f}{1/2 V^2} = \frac{D}{L} \frac{1/2 \rho V^3}{\rho V^2} \quad (2)$$

The friction factor depends on the Reynolds number, R_e , and on the relative roughness of the pipe, ϵ/D .

For both smooth and turbulent flows, the friction factor is estimated through the equation developed by Colebrook and White (1937):

$$\frac{1}{\sqrt{f}} = -2 \log \left(\frac{\epsilon}{3.7D} + \frac{2.523}{R_e \sqrt{f}} \right) \quad (3)$$

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2.3 Data Specification and Implementations of the AI Models

The data in this modeling study were generated using the numerical procedure based on Equation 3. The data generation includes (i) a systematic variation of R_e

ranging from 2000 to 10^8 (using 74 values of R_e) and (ii) varying ϵ/D ranging from 10^{-6} to 0.05 (28 values). This gives rise to many combinations of R_e and ϵ/D and serve as inputs to f , where the f -value for each set of data is calculated by the numerical solution of the Colebrook-White equation using the successive substitution method. A dataset consisting of a total of 2072 points. Input variables were ϵ/D and R_e and output was f . Some of the generated data is shown in Appendix II, Table II.1.

2.4 Artificial Neural Networks

Any layer consists of pre-designated neurons and each neural network includes one or more of these interconnected layers. Figure 1 shows a three layered structure that consists of one input layer, I, one hidden layer, H, and one output layer, O. All the neurons within a layer act synchronously. The operation process of these networks is so that the input layer accepts the data and the intermediate layer(s) processes them and finally the output layer displays the resultant outputs of the model application. During the modeling stage, the coefficients related to the present errors in the nodes are corrected through comparing the model outputs with the recorded input data (Rakhandehroo et al., 2010).

The data for training the ANN model were generated using the numerical procedure described above. A dataset consisting of a total of 2072 points, of which only 70% of total data (1450 point data) were selected for the training process and 30% of total input data were selected as test data (622 point data). The optimal ANN configuration was selected from amongst various ANN configurations based on their predictive performance. The two error measures used to compare the performance of the various ANN configurations were: determination coefficient, R^2 and Root Mean Square Error, RMSE.

2.5 Genetic Programming (GP)

Implementation of GP models involves a number of preliminary decisions including the selection of a set of basic operators such as $\{+, -, *, /, ^, \sqrt{\quad}, \log, \exp, \sin, \arcsin, \dots\}$ to construct a function, such as the reconstruction of an explicit equation for f , traditionally expressed by equation 3. The GP modelling programs provide operators like crossover and mutation to the winners, “children” or “offspring” to emulate natural selection, in which crossovers are responsible for maintaining identical features from one generation to another but mutations cause random changes. The evolution starts from an initially selected random population of models, where the relationship, f , between the independent and dependent variables is often referred to as the “model,” the “program,” or the “solution.” The population is allowed to evolve from one generation to another by the virtue of a selected fitness criterion and All computations were performed using the three parameters for the error estimation as the following:

Relative Error (RE):

$$RE = |f_{True} - f_{Estimated}| / f_{True}$$

Root Mean Square Error (RMSE):

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (f_{True} - f_{Estimated})^2}{N}}$$

3 Results

3.1 Performances of Explicit Equations

The performance of explicit equations for the Colebrook-White equations (described in Appendix I) are investigated by comparing them against the numerical solution of the Colebrook-White equations for f -values using the data created in this study and presented in Appendix II. The results are presented in Figures 3 and their

new models replace the old ones in this evolutionary process by having demonstrably better performance.

This study was carried out by using GeneXpro software application, (Ferreira, 2001a,b), which uses a gene expression method. Although this has differences with GP, in principle both are inspired by natural selection. For more detail on the implementation of GP models see Ghorbani et al. (2010).

In this study, four basic arithmetic operators (+, -, *, /) and some basic mathematical functions ($\sqrt{\quad}$, log and e^x) were used. Like ANN, input variables were $\frac{e}{D}$ and R_e and output was f . Large number of generations (5000) were tested. The three error measures used to compare the performance of GP were R^2 , RMSE and RE (RE is Relative Error).

2.6 Performance Measures

Determination coefficient (R^2):

$$R^2 = \frac{\left(\sum_{i=1}^N (f_i^{True} - \bar{f}^{True})(f_i^{Estimated} - \bar{f}^{Estimated}) \right)^2}{\sqrt{\sum_{i=1}^N (f_i^{True} - \bar{f}^{True})^2 \sum_{i=1}^N (f_i^{Estimated} - \bar{f}^{Estimated})^2}}$$

Where f_{True} is calculated from Colebrook-White equation by successive substitution method, $f_{Estimated}$ is from GP or

ANN models, \bar{f} in mean of f and N is total data point equal to 2072.

performances are summarized in Table 1 by categorizing them into three sets: of having inadequate, adequate and good performances.

3.2 Implementation of ANN

The initial identification of the model configurations did not employ any transformation of either data input or output. Its optimum configuration was selected by trial-and-error by testing a set of them shown in Table 2. The identified architecture is: 2-5-1 (input layer: 2 neurons; one hidden layer: 5 neuron; output layer: 1 neuron), for which its RMSE=0.0379 is the lowest and its $R^2=0.977$ is the highest. This led to inadequate predictions of f -values when the model was implemented in its prediction mode and in particular, unacceptably high errors were obtained for the predicted f -values corresponding to R_e values at the lower end of the chosen range. This indicated that the ANN model was unable to capture the initial curvature in the f curves at the specified lower range of R_e .

Although ANN models do not require any prior knowledge of the relationships among inputs and outputs, a “warm start”

3.3 Implementation of GP

The GP model was implemented by using the data in Appendix II. The functional setting and default parameters used in the GP modeling during this study are listed in Table 5. The GP model resulted in highly nonlinear relationship with high accuracy and relatively low errors. The simplified analytic form of the proposed GP model in testing may be expressed as:

$$f = -0.0575 + \varepsilon / D + e^{-11.764(\varepsilon/D) - \log(2R_e)} + e^{-2.567+9.065/R_e - \varepsilon/D} \quad (4)$$

Figure 6 shows the Relative Error (RE) by using the GP model (equation 4).

Figure 6 shows that RE in GP model is less than 0.1 for all the ε / D and R_e range except for very smooth pipe with $\varepsilon / D = 0.00002$. That is GP model (equation 4) can be used for $0.00004 \leq \varepsilon / D \leq 0.08$ and

$$2000 \leq R_e \leq 10^9 \text{ with RE} < 7\%$$

The error statistics of the GP model shows that its RMSE and R^2 are 0.013 and 0.997 respective compared to those of ANN with

is helpful to fine-tune the ANN model. For instance, it is clear from (3) that the parameter f is a logarithmic function of both input parameters (i.e. R_e and ε/D). For this reason, another set of test runs were carried out to improve the performance of the ANN model by transforming both input data parameters. The R_e and ε/D parameters were transformed using a logarithmic function to the base 10. The results in Table 3 show that the optimum ANN configuration is improved markedly as its RMSE reduced to 0.0218 and its R^2 increased to 0.995.

These results demonstrate the importance of choosing the right transformation of input data parameters and the significant impact this may have on the overall performance of the ANN model.

quantitative performance values of RMSE =0.022 and $R^2 = 0.995$. Therefore, the prediction accuracy of the GP model is generally better than that of the ANN model.

4 Discussion of the Results

Engineering practices on pipe systems require the calculation of head losses and flows and a common practice is to embed iterative methods for the calculation of f -values in the computer programs.

However, this study shows that some of the explicit methods perform well and may replace the Colebrook-White equation, particularly in manual calculation, which can rapidly calculate f -values for given ε/D and R_e . The investigations here show a sharp contrast in the performance of the explicit equations when compared with one another but the accurate ones are attractive.

The performance of the ANN model in calculating friction factor, f , is investigated by plotting the scatter diagram, as shown in Figure 4. Overall, the results are comparatively acceptable for calculating f but the ANN model is less capable than

some of the explicit equations like Chen (1979), Barr (1981), Zigrang (1982) and Romeo et al. (2002).

The performance of GP model in calculating friction factor, f , is investigated by plotting the scatter diagram, as shown in Figure 5 based on scatter plots. Overall, the GP model of the friction factor has some edge over its ANN model both visually and quantitatively but at the same time the GP model is not performing as good as some of the explicit formulations. Future work will be directed at improving Colebrook-White equation for modern commercial pipes, like spiral and GRP pipes.

5 Conclusion

The paper applies Artificial Intelligence (AI) techniques to predict the friction factor, f , in the Colebrook-White equation for calculating flows in pipes under pressure, where the techniques selected are Artificial Neural Networks (ANN) and genetic Programming (GP) techniques. These are complemented with testing the performance of a range of explicit formulations of the Colebrook-White equation. The data are generated systematically for different values of R_e and ε/D parameters using the Colebrook-White equation, the solution of which for f -values were obtained using the successive substitution method.

I.1. Explicit methods

The Colebrook-White equation is a formula often used in pipe network simulation software. Many explicit expressions have been developed to replace it, in which the value of f appears on both sides of the equation. These explicit formulations are approximations for f that do not require iteration and hence they can be used to improve the speed of simulation software.

Preliminary test runs identified optimum ANN and GP models. The ANN model involves a neural network with one hidden layers and 5 neurons in that layer. Following the logarithmic transformations of the input data parameters, the trained network was able to predict the response with R^2 and RMSE 0.995 and 0.022 respectively (Table 2). The testing performance of the proposed GP model revealed a high generalization capacity with $R^2=0.997$ and RMSE=0.013. This model allows for an explicit solution of f without the need to employ a time-consuming iterative or trial-and-error solution scheme, an approach that is usually associated with the solution of the Colebrook equation in the turbulent flow regime of closed pipes.

Explicit equations remove the need for the iterative required for solving for friction factor in the Colebrook-White equation but this study shows that a number of them induce some undue errors. However, this study identifies that some of the explicit formulations are accurate. The ANN formulation of the problem of solving for the friction factor in the Colebrook-White equation is less successful than that by GP. Although the performance of GP in terms of R^2 and RMSE is good, its values are slightly perturbed around its numerically-obtained values and the GP model does not perform as good as some of the explicit equations.

Appendix I

Equation 3 reduces to the Prandtl-von Karman equation for smooth pipes, $\varepsilon = 0$ (I.1.a), or fully developed turbulent flow (I.1.b):

$$\frac{1}{\sqrt{f}} = -2 \log \left(\frac{2.523}{R_e \sqrt{f}} \right) \quad (\text{I.1.a})$$

$$\frac{1}{\sqrt{f}} = -2 \log \left(\frac{\varepsilon / D}{3.71} \right) \quad (\text{I.1.b})$$

If the flow is fully developed, it is verified that $R_e(\varepsilon / D)\sqrt{f} > 200$. In this case, the

friction factor depends only on the R_e , and can be calculated through the equation deduced by von Karman:

$$\frac{1}{\sqrt{f}} = -2 \log(R_e \sqrt{f}) - 0.8 = 2 \log\left(\frac{R_e \sqrt{f}}{2.523}\right) \quad (I.2)$$

Unless the Karman number, $R_e \sqrt{f}$, is previously known, i.e. the pressure drop of the fluid in the pipe is known, Equations (3) and (I.2) are implicit with respect to the value of f , and are solved using numerical methods. Thus, if the auxiliary variable F is defined as $1/\sqrt{f}$, the Colebrook–White equation (Equation 3) can be re-written to be solved by a method of successive substitution:

$$F_{n+1} = -2 \log\left(\frac{\varepsilon}{3.7D} + \frac{2.523}{R_e} F_n\right) \quad (I.3)$$

Equation (I.3) converges very rapidly, especially if there is a good initial estimation of the friction factor. For this the graph produced by Moody (1947) or any of the explicit equations available in the literature can be used. The most widely used equations postulated since the end of the 1940s are stated below in the order of publication:

(a) Moody (1947) proposed the following empirical equation:

$$f = 0.0055 \left[1 + \left(2 * 10^4 \frac{\varepsilon}{D} + \frac{10^6}{R_e} \right)^{\frac{1}{3}} \right] \quad (I.4)$$

According to the author, this equation is valid for R_e ranging from 4000 to 10^8 and values of ε/D ranging from 0.0 to 0.01.

(b) Later, Wood (1966) proposed the following correlation:

$$f = a + b.R_e^{-c}$$

$$a = 0.094 \left(\frac{\varepsilon}{D}\right)^{0.225} + 0.53 \left(\frac{\varepsilon}{D}\right)$$

$$b = 0.88 \left(\frac{\varepsilon}{D}\right), C = 1.62 \left(\frac{\varepsilon}{D}\right)^{0.134}$$

This equation is recommended for R_e between 4000 and 10^7 and values of ε/D

ranging from 0.00001 to 0.04.

(c) Churchill (1973), using the transport model, deduced the following expression:

$$e^{-1/0.869\sqrt{f}} = \frac{\varepsilon/D}{3.7} + \left(\frac{7}{R_e}\right)^{0.9} \Leftrightarrow \frac{1}{\sqrt{f}} = -2 \log\left(\frac{\varepsilon/D}{3.7} + \left(\frac{7}{R_e}\right)^{0.9}\right) \quad (I.6)$$

(d) Swamee (1976) proposed the following correlation:

$$f = \frac{1.325}{\left[\ln\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{R_e^{0.9}}\right) \right]^2} \quad (I.7)$$

(e) Churchill (1977), again proposed the following equation valid for the whole range of R_e (laminar, transition and turbulent):

$$f = 8 \left[\left(\frac{8}{R_e}\right)^{12} + (A + B)^{-\frac{3}{2}} \right]^{\frac{1}{12}}$$

$$A = \left[-2 \log\left(\left(\frac{\varepsilon/D}{3.7}\right) + \left(\frac{7}{R_e}\right)^{0.9}\right) \right]^{16}$$

$$B = \left(\frac{37530}{R_e}\right)^{16} \quad (I.8)$$

(f) Chen (1979) proposed the following equation:

$$\frac{1}{\sqrt{f}} = -2 \log\left(\frac{\varepsilon/D}{3.7065} - \frac{5.0452}{R_e} \log\left(\frac{(\varepsilon/D)^{1.1098}}{2.8257} + \frac{5.8506}{R_e^{0.8981}}\right)\right) \quad (I.9)$$

This method involves carrying out two iterations of the Colebrook–White equation. The accuracy of the results obtained from this equation is high due to the fact that the initial estimate is good.

(g) The equation proposed by Chen (1979) is valid for R_e ranging from 4000 to $4 * 10^8$ and values of ε/D between 0.0000005 and 0.05.

(g) Barr (1981), by a method analogous to that used by Chen (1979), proposed the following expression:

$$\frac{1}{\sqrt{f}} = -2 \log \left(\frac{\varepsilon/D}{3.7} - \frac{4.518 \log \left(\frac{R_e}{7} \right)}{R_e \left(1 + \left(R_e^{0.52} \left(\frac{\varepsilon/D}{7} \right)^{0.7} \right) \right)} \right)$$

(h) Zigrang and Sylvester (1982) also followed the same method as that used by Chen (1979), but carried out three internal iterations. They proposed the following equation:

$$\frac{1}{\sqrt{f}} = -2 \log \left(\frac{\varepsilon/D}{3.7} - \frac{5.02}{R_e} \log \left(\frac{\varepsilon/D}{3.7} - \frac{5.02}{R_e} \log \left(\frac{\varepsilon/D}{3.7} + \frac{13}{R_e} \right) \right) \right)$$

(i) Manadilli (1997) using what he calls *signomial-like* equations, proposed the following expression valid for R_e ranging from 5235 to 10^8 , and for any value of ε/D :

$$(I.10) \quad \frac{1}{\sqrt{f}} = -2 \log \left(\frac{\varepsilon/D}{3.70} - \frac{95}{R_e^{0.983}} - \frac{96.82}{R_e} \right) \quad (I.12)$$

(j) Based on Romeo et al. (2002) work, the best predictions for friction factor are achieved with those equations obtained from two or three internal iterations of the Colebrook–White equation. This method could be extended to a larger number of internal iterations but the expressions obtained would be too complex. From a statistical point of view, the following equation provides the best results:

$$(I.11) \quad \frac{1}{\sqrt{f}} = -2 \log \left(\frac{\varepsilon/D}{3.7065} - \frac{5.0272}{R_e} \log \left(\frac{\varepsilon/D}{3.827} - \frac{4.567}{R_e} \log \left(\left(\frac{\varepsilon/D}{7.7918} \right)^{0.9924} + \left(\frac{5.3326}{208.815 + R_e} \right)^{0.9345} \right) \right) \right)$$

(I.13)

Appendix II

Table II.1. Sample of data with combination of ε/D , R_e and f .

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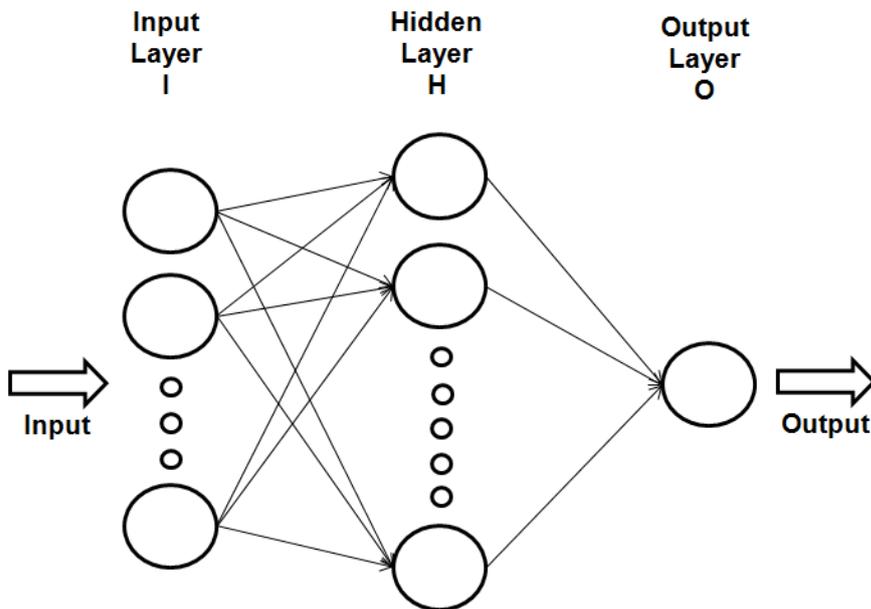


Figure 1. Neuron Layout of Artificial Neural Networks (ANN)

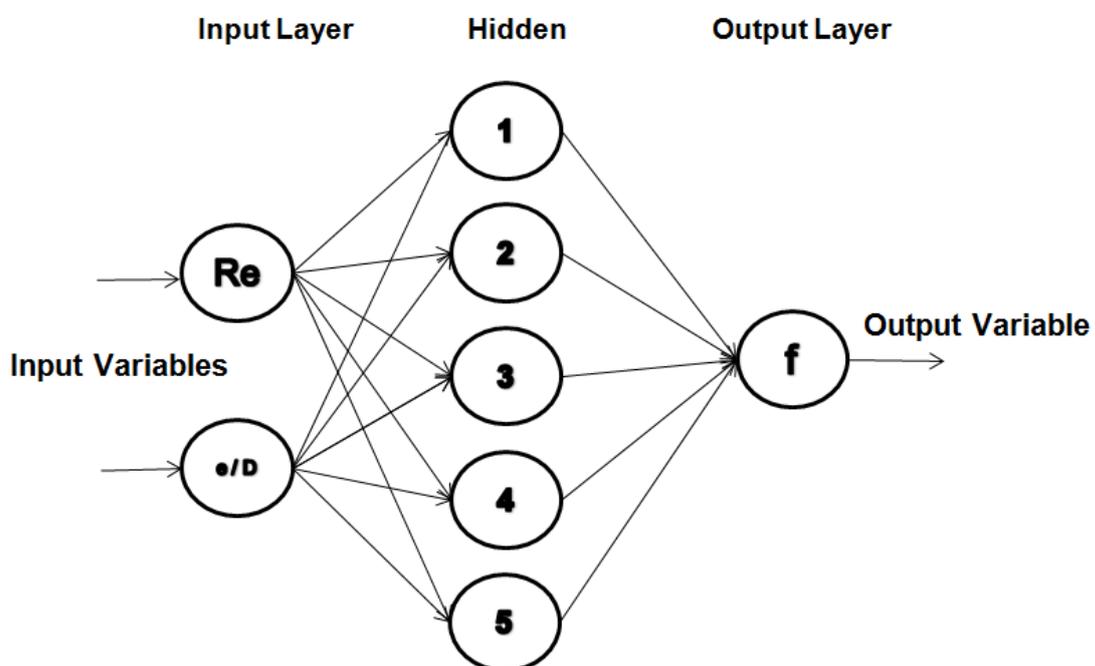


Figure 2. Three-layer Feed-forward Artificial Neural Network Architecture

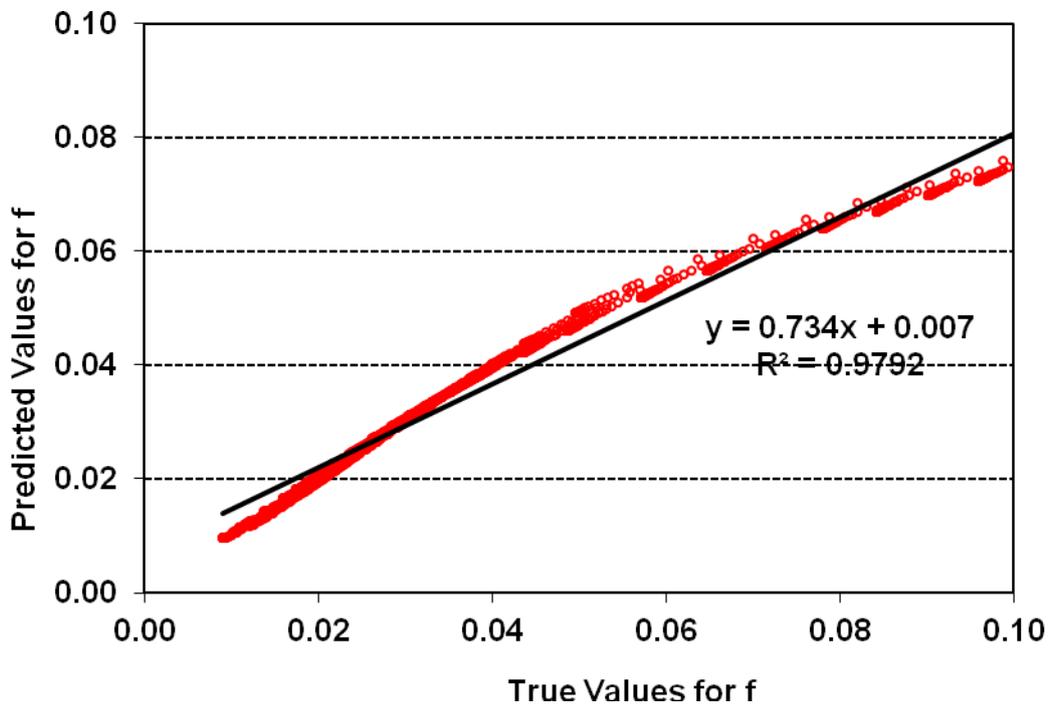


Figure 3.a. Performance of Moody's Explicit Equation by Moody, 1947 (Equation I.4)

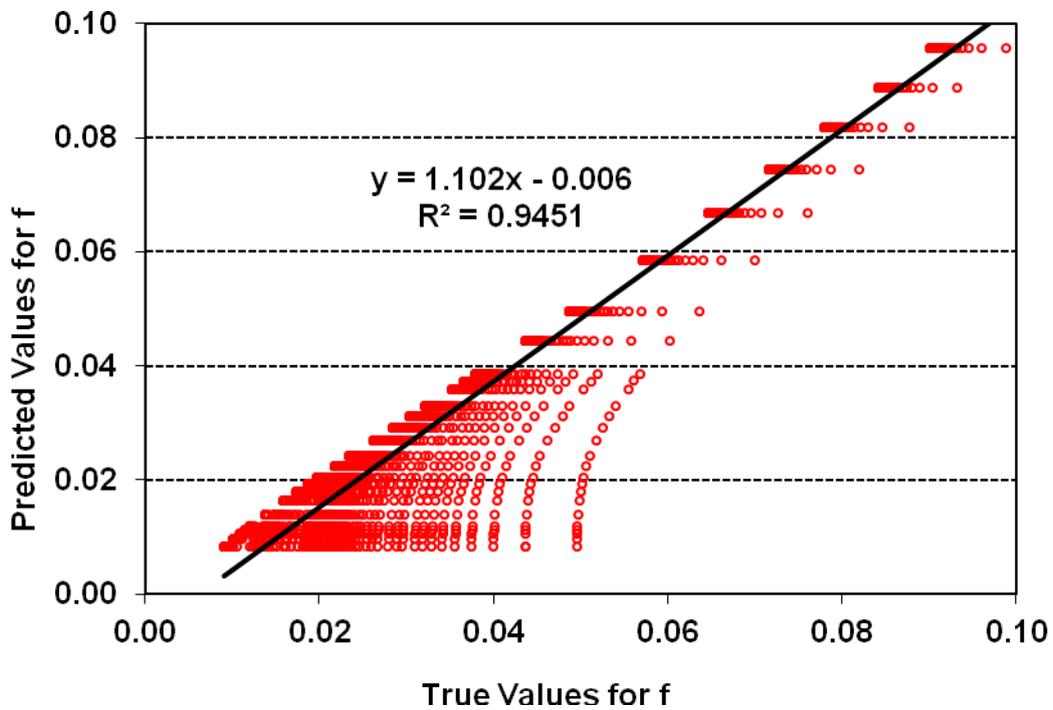


Figure 3.b. Performance of Explicit Equation by Wood, 1966 (Equation I.5)

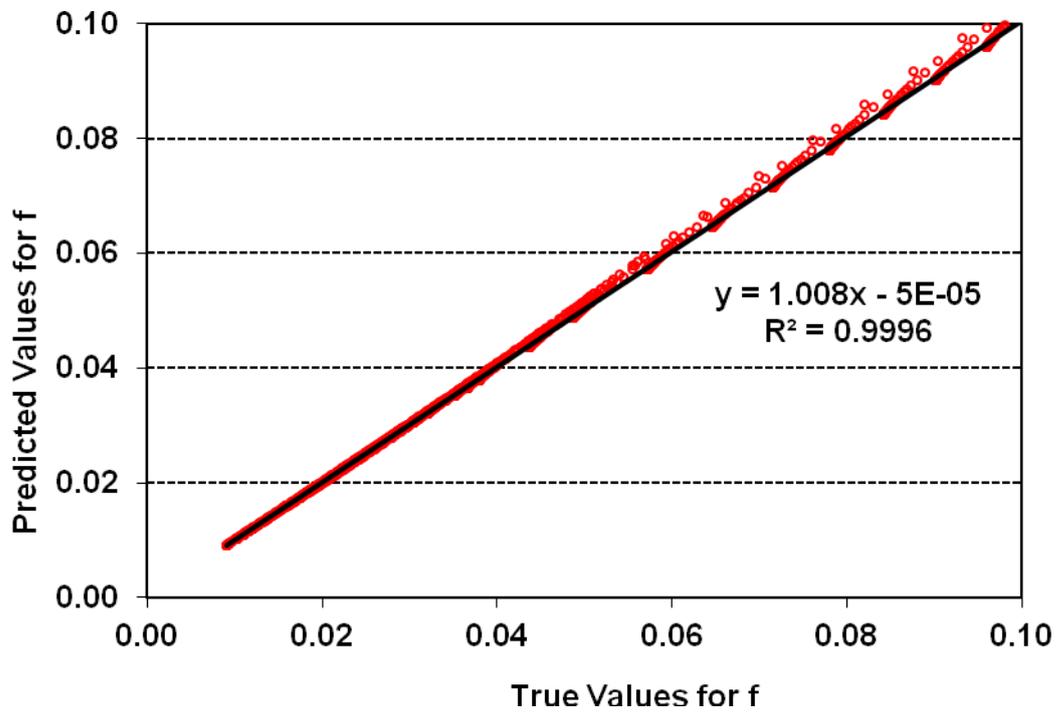


Figure 3.c. Performance of Explicit Equation by Churchill, 1973 (Equation I.6)

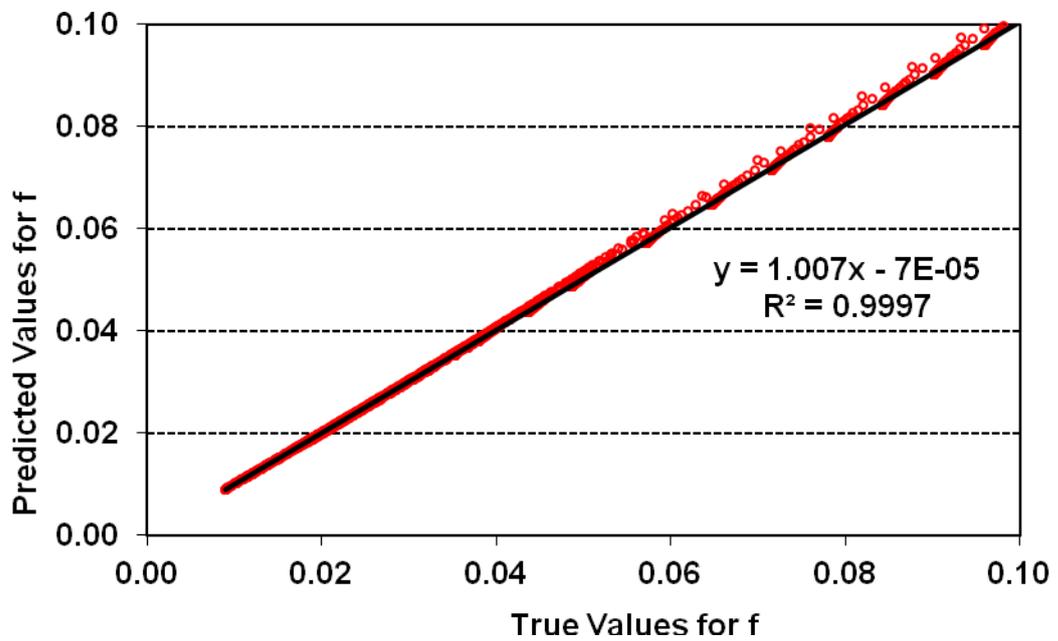


Figure 3.d. Performance of Explicit Equation by Swamee, 1976 (Equation I.7)

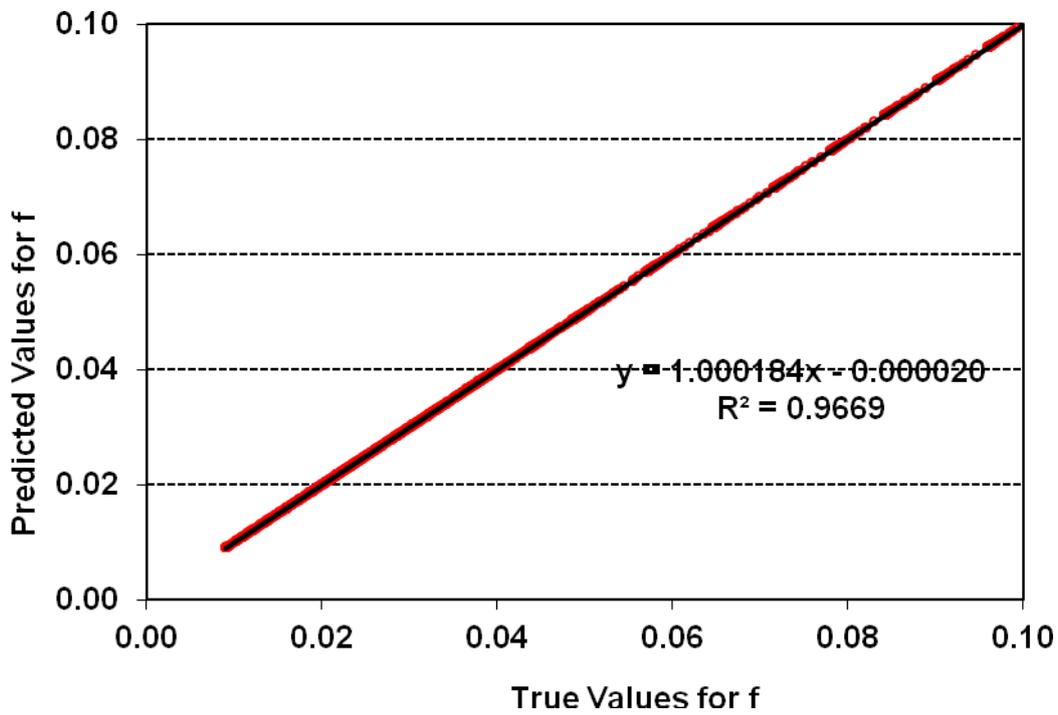


Figure 3.e. Performance of Explicit Equation by Churchill, 1977 (Equation I.8)

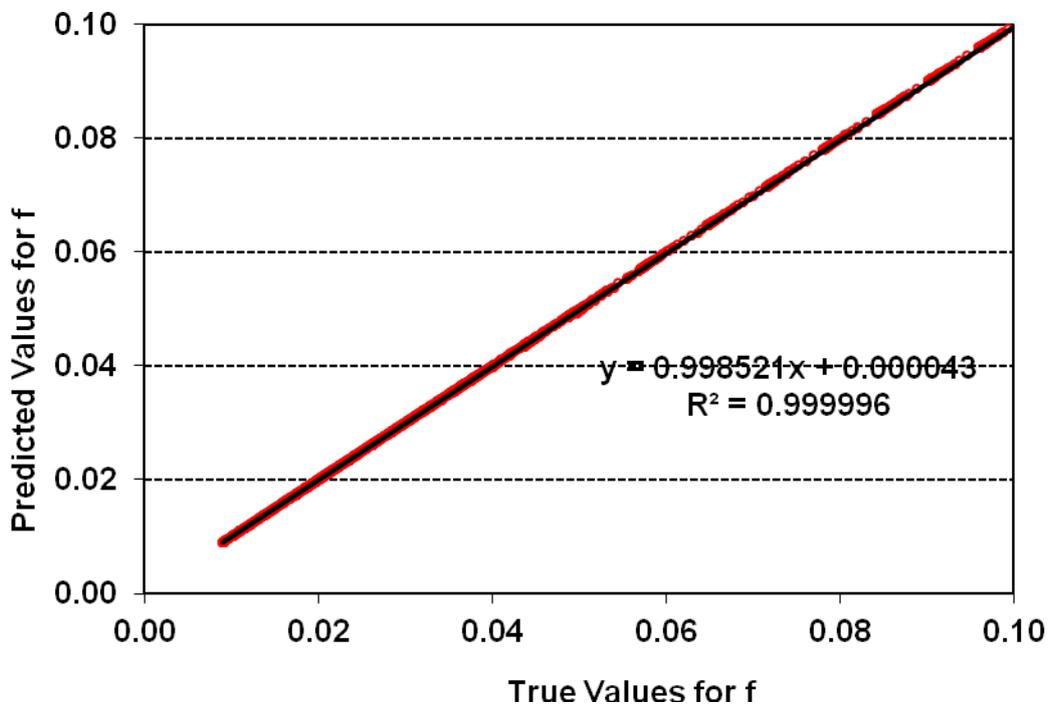


Figure 3.f. Performance of Explicit Equation by Chen, 1979 (Equation I.9)

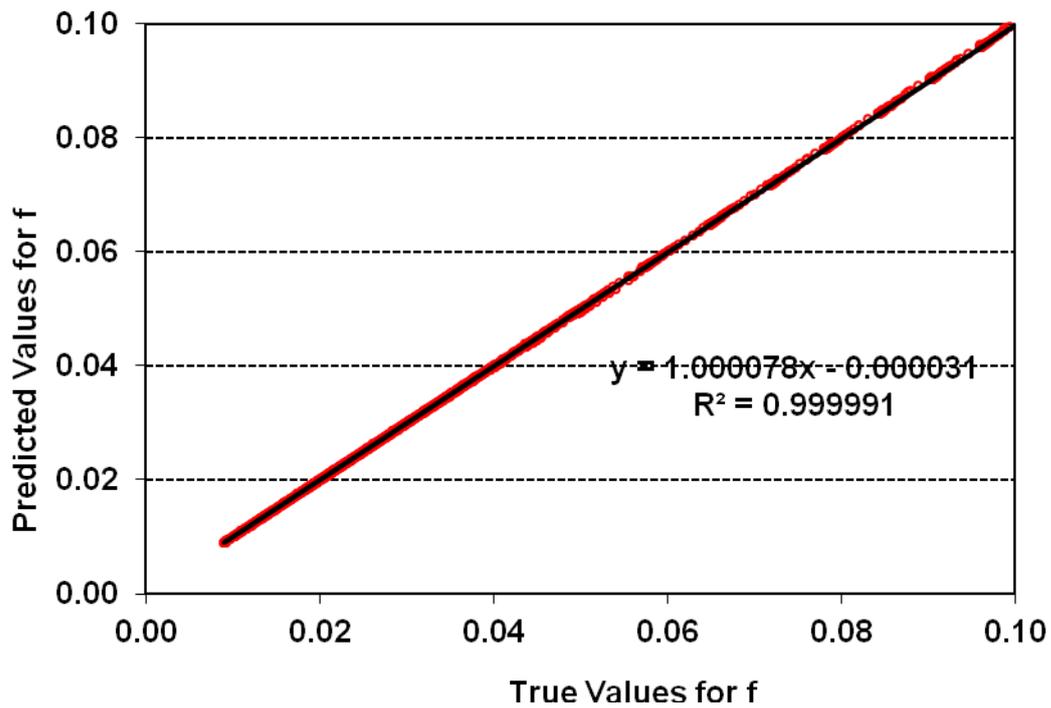


Figure 3.g. Performance of Explicit Equation by Barr, 1981 (Equation I.10)

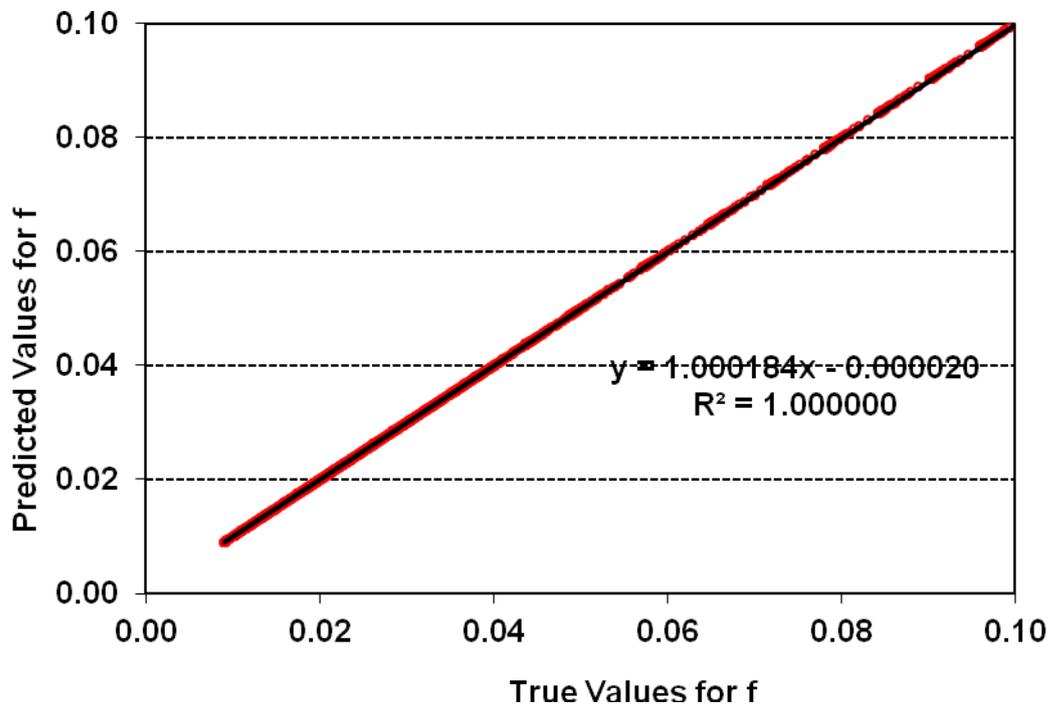


Figure 3.h. Performance of Explicit Equation by Zigrang, 1982 (Equation I.11)

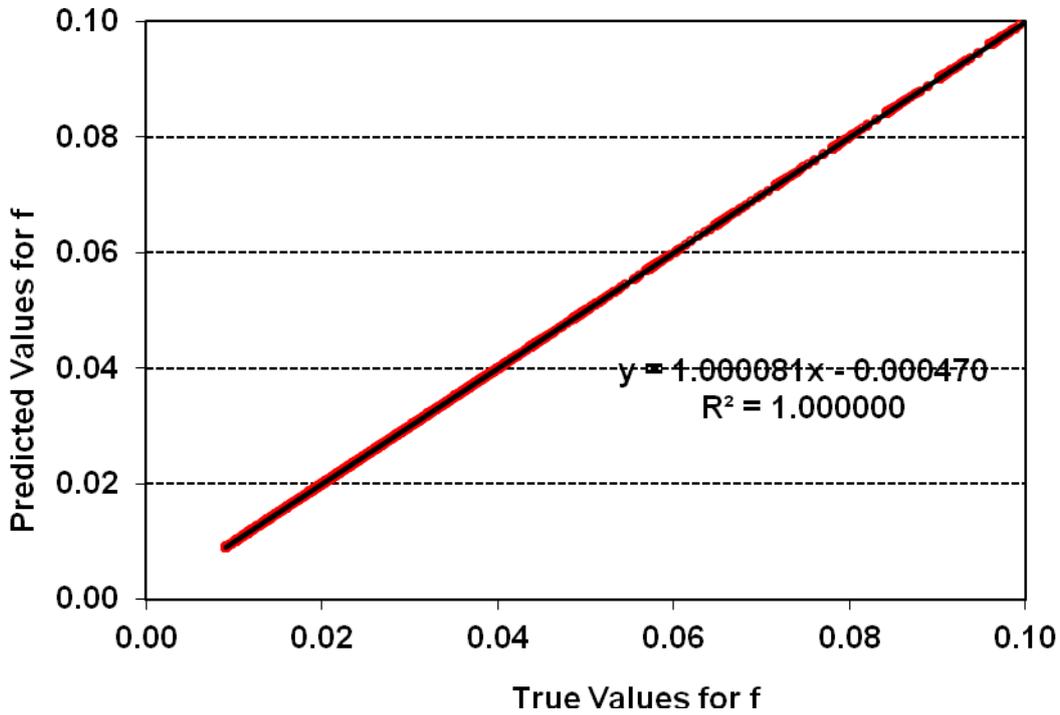


Figure 3.i. Performance of Explicit Equation by Manadilli, 1997 (Equation I.12)

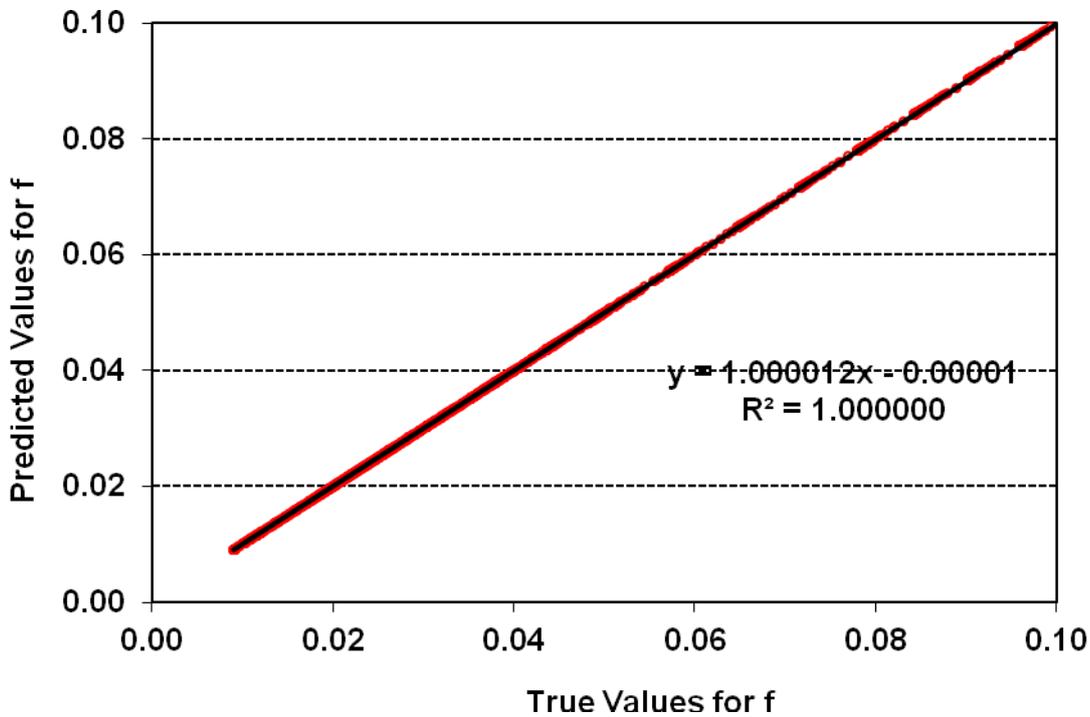


Figure 3.j. Performance of Explicit Equation by Romeo, 2002 (Equation I.13)

Figure 3. Performance of Explicit Equation against Numerical Solution of Colebrook-White Equation in Treating f -values

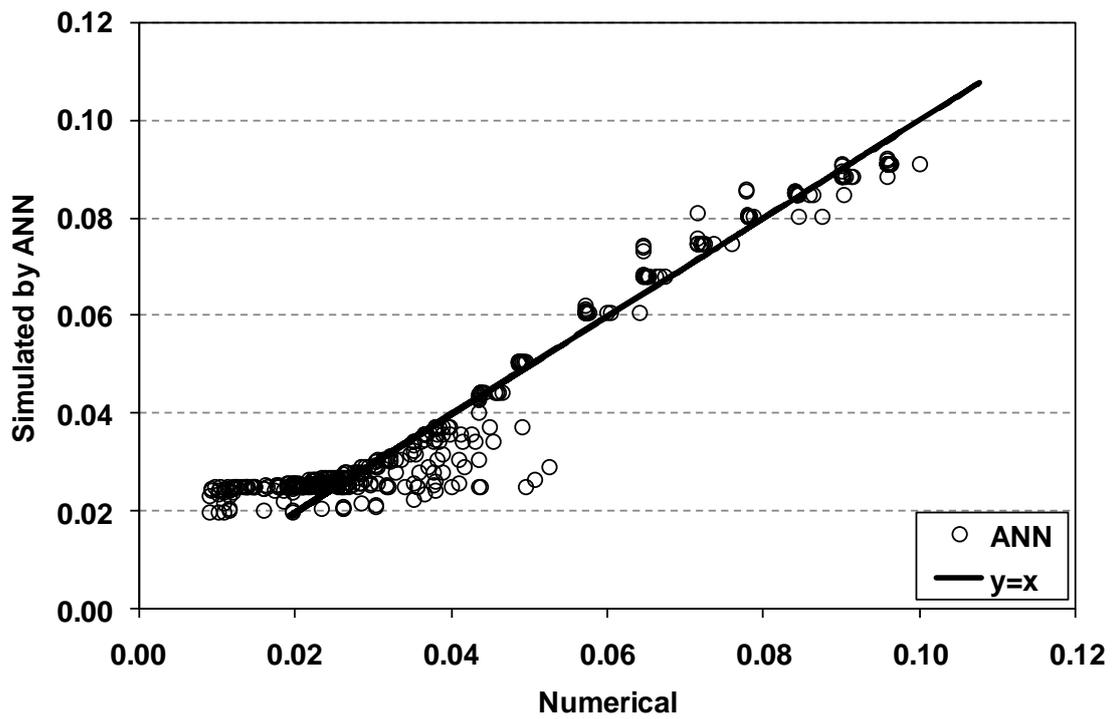


Figure 4. Performance of ANN and numerical solution of Colebrook-White equation

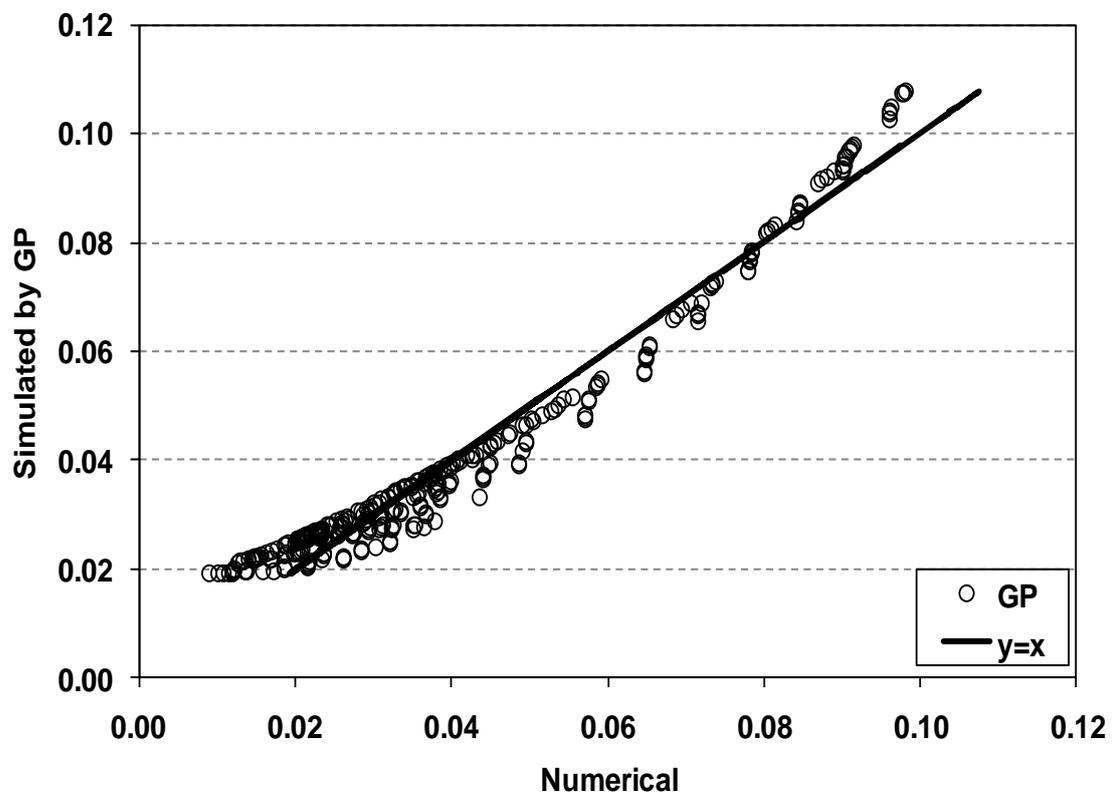


Figure 5. Performance of GP and numerical solution of Colebrook-White equation

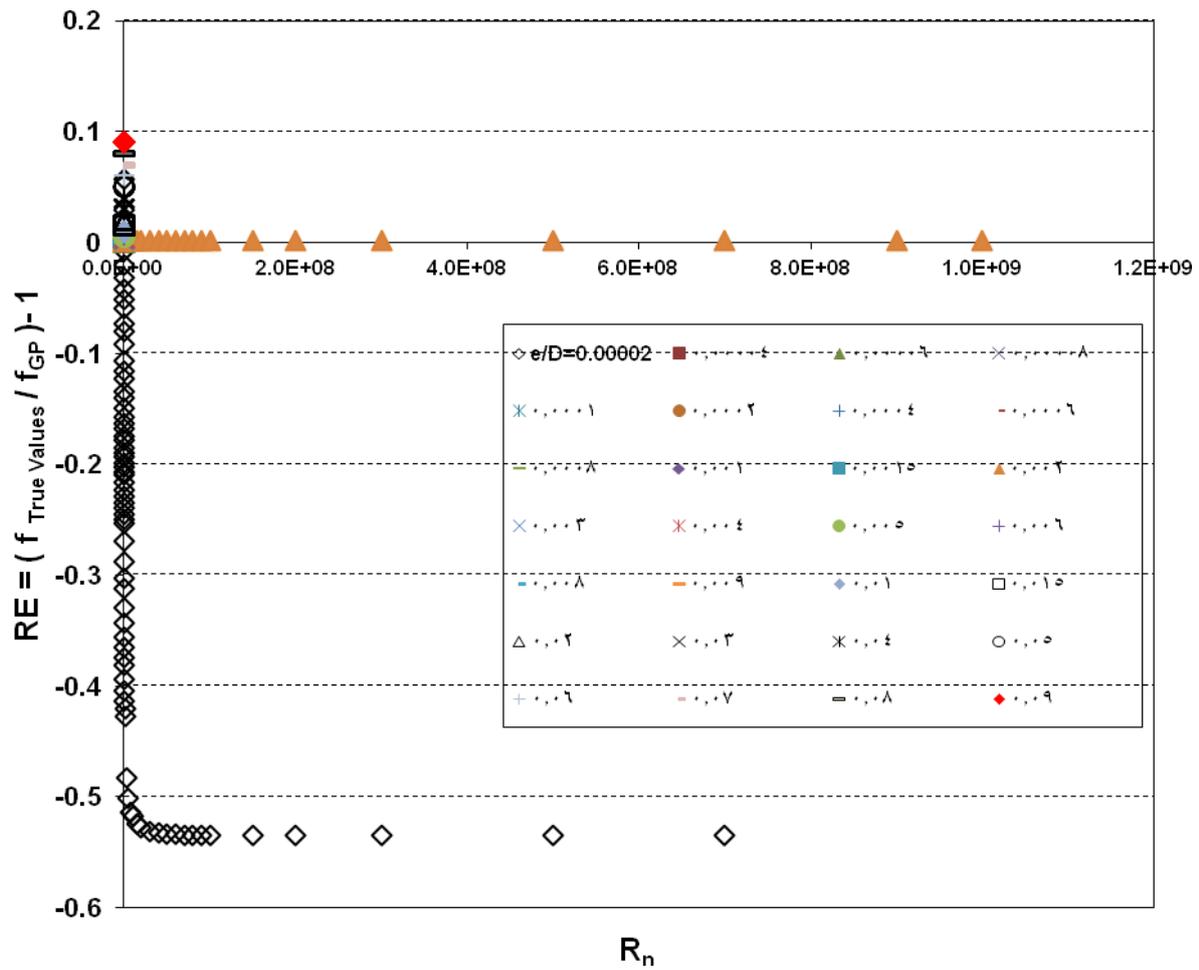


Figure 6. The relative error using the GP simulation

Table 1. Error measurements in explicit equations, GP and ANN respect to numerical calculation

Name	R ²	RMSE	Precision	Equation
Moody (1947)	0.9792	0.00787	Inadequate	I.4
Wood (1966)	0.9451	0.00735	Inadequate	I.5
Churchill (1977)	0.9669	0.00702	Inadequate	I.8
Churchill (1973)	0.9996	0.00062	Adequate	I.6
Swamee (1976)	0.9997	0.00055	Adequate	I.7
Barr (1981)	0.999991	0.0000792	Adequate	I.10
Chen (1979)	0.999996	0.0000617	Good performance	I.9
Zigrang and Sylvester (1982)	1.000000	0.0000213	Good performance	I.11
Manadilli (1997)	1.000000	0.0000102	Good performance	I.12
Romeo (2002)	1.000000	0.0000092	Good performance	I.13
ANN	0.9951	0.02236	Inadequate	-

GP	0.9974	0.01324	Adequate	4
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Table 2. Prediction Errors for Training and Testing Dataset of Friction Factor – different ANN configurations without transformations of the input parameters

Transfer function	No. of hidden layers	No. of neurons/layer	Training		Test	
			RMSE	R ²	RMSE	R ²
Sigmoid	1	2	0.0384	0.978	0.0422	0.968
Sigmoid	1	3	0.0375	0.978	0.0406	0.974
Sigmoid	1	4	0.0383	0.977	0.0386	0.977
Sigmoid	1	5	0.0379	0.977	0.0396	0.976
Sigmoid	1	6	0.0388	0.977	0.0382	0.976
Sigmoid	1	8	0.0369	0.977	0.038	0.977
Sigmoid	1	10	0.0399	0.976	0.038	0.974
Hyperbolic Tangent	1	5	0.0372	0.978	0.0388	0.976
Gaussian	1	5	0.0404	0.974	0.0374	0.979
Sigmoid	2	2, 2	0.0385	0.977	0.0411	0.973
Sigmoid	2	2, 3	0.0401	0.974	0.0374	0.979

Table 3. Predicted Errors for Training and Testing Dataset of Friction Factor – different ANN configurations with transformations of input parameters

Transfer function	No. of hidden layers	No. of neurons/layer	Training		Test	
			RMSE	R ²	RMSE	R ²
Sigmoid	1	2	0.0325	0.981	0.0409	0.97
Sigmoid	1	3	0.0262	0.988	0.0266	0.987
Sigmoid	1	4	0.0353	0.989	0.0258	0.988
Sigmoid	1	5	0.0218	0.995	0.0234	0.99
Sigmoid	1	6	0.022	0.992	0.023	0.991

Table 4. Parameters of Optimized GP Model

Parameter	Description of parameter	Setting of parameter
p1	Function set	+, -, *, /, $\sqrt{\quad}$, e ^x , log
p2	Population size	250
p3	Mutation frequency (%)	96
p4	Crossover frequency (%)	50
p5	Number of replication	10
p6	Block mutation rate (%)	30
p7	Instruction mutation rate (%)	30
p8	Instruction data mutation rate (%)	40
p9	Homologous crossover (%)	95
p10	Program size	Initial 64, maximum 256

Appendix II

Table II.1. Sample of data with combination of ε/D , R_e and f .

Row	ε/D	R_n		Row	ε/D	R_n		Row	ε/D	R_n	
1	0.00002	2000	0.049549	49	0.00006	2000	0.04958	925	0.08	2000	0.098746
2	0.00002	3000	0.043606	50	0.00006	3000	0.043642	926	0.08	3000	0.095999
3	0.00002	4000	0.039988	51	0.00006	4000	0.040029	927	0.08	4000	0.094587
4	0.00002	5000	0.037471	52	0.00006	5000	0.037515	928	0.08	5000	0.093726
5	0.00002	6000	0.035579	53	0.00006	6000	0.035627	929	0.08	6000	0.093146
6	0.00002	7000	0.034085	54	0.00006	7000	0.034137	930	0.08	7000	0.092728
7	0.00002	8000	0.032862	55	0.00006	8000	0.032918	931	0.08	8000	0.092414
8	0.00002	9000	0.031836	56	0.00006	9000	0.031894	932	0.08	9000	0.092168
9	0.00002	10000	0.030956	57	0.00006	10000	0.031018	933	0.08	10000	0.091971
10	0.00002	2000	0.029515	58	0.00006	2000	0.029582	934	0.08	2000	0.091674
11	0.00002	3000	0.028913	59	0.00006	3000	0.028983	935	0.08	3000	0.091559
12	0.00002	5000	0.02788	60	0.00006	5000	0.027955	936	0.08	5000	0.091375
13	0.00002	8000	0.02664	61	0.00006	8000	0.026723	937	0.08	8000	0.091176
14	0.00002	20000	0.02596	62	0.00006	20000	0.026047	938	0.08	20000	0.091076
15	0.00002	22000	0.025366	63	0.00006	22000	0.025458	939	0.08	22000	0.090994
16	0.00002	25000	0.0246	64	0.00006	25000	0.024698	940	0.08	25000	0.090895
17	0.00002	27000	0.024156	65	0.00006	27000	0.024258	941	0.08	27000	0.090842
18	0.00002	30000	0.023566	66	0.00006	30000	0.023674	942	0.08	30000	0.090775
19	0.00002	33000	0.02305	67	0.00006	33000	0.023164	943	0.08	33000	0.09072
20	0.00002	35000	0.02274	68	0.00006	35000	0.022858	944	0.08	35000	0.090688
21	0.00002	37000	0.022453	69	0.00006	37000	0.022574	945	0.08	37000	0.09066
22	0.00002	40000	0.022206	70	0.00006	40000	0.022186	946	0.08	40000	0.090623
23	0.00002	42000	0.021818	71	0.00006	42000	0.021948	947	0.08	42000	0.090602
24	0.00002	45000	0.021484	72	0.00006	45000	0.021618	948	0.08	45000	0.090573
25	0.00002	48000	0.021178	73	0.00006	48000	0.021317	949	0.08	48000	0.090548
26	0.00002	50000	0.020988	74	0.00006	50000	0.02113	950	0.08	50000	0.090533
27	0.00002	53000	0.020721	75	0.00006	53000	0.020868	951	0.08	53000	0.090512
28	0.00002	55000	0.020553	76	0.00006	55000	0.020704	952	0.08	55000	0.0905
29	0.00002	58000	0.020317	77	0.00006	58000	0.020472	953	0.08	58000	0.090483
30	0.00002	60000	0.020169	78	0.00006	60000	0.020327	954	0.08	60000	0.090472
31	0.00002	65000	0.019824	79	0.00006	65000	0.019989	955	0.08	65000	0.090449
32	0.00002	70000	0.019513	80	0.00006	70000	0.019685	956	0.08	70000	0.090429
33	0.00002	75000	0.019231	81	0.00006	75000	0.019409	957	0.08	75000	0.090411
34	0.00002	80000	0.018972	82	0.00006	80000	0.019157	958	0.08	80000	0.090396
35	0.00002	85000	0.018733	83	0.00006	85000	0.018925	959	0.08	85000	0.090383
36	0.00002	90000	0.018513	84	0.00006	90000	0.018711	960	0.08	90000	0.090371
37	0.00002	95000	0.018308	85	0.00006	95000	0.018512	961	0.08	95000	0.09036
38	0.00002	100000	0.018117	86	0.00006	100000	0.018327	962	0.08	100000	0.090351
39	0.00002	120000	0.017462	87	0.00006	120000	0.017695	963	0.08	120000	0.09032
40	0.00002	150000	0.01671	88	0.00006	150000	0.016975	964	0.08	150000	0.09029
41	0.00002	180000	0.016134	89	0.00006	180000	0.016427	965	0.08	180000	0.09027
42	0.00002	200000	0.015815	90	0.00006	200000	0.016127	966	0.08	200000	0.090259
43	0.00002	250000	0.015175	91	0.00006	250000	0.015529	967	0.08	250000	0.090241
44	0.00002	300000	0.014685	92	0.00006	300000	0.015077	968	0.08	300000	0.090229
45	0.00002	350000	0.014292	93	0.00006	350000	0.014719	969	0.08	350000	0.09022
46	0.00002	400000	0.013967	94	0.00006	400000	0.014426	970	0.08	400000	0.090214
47	0.00002	450000	0.013692	95	0.00006	450000	0.014182	971	0.08	450000	0.090209
48	0.00002	500000	0.013454	96	0.00006	500000	0.013973	972	0.08	500000	0.090205
49	0.00002	500000	0.013063	97	0.00006	500000	0.013634	973	0.08	500000	0.090199

50	0.00002	700000	0.01275	98	0.00006	700000	0.013369	974	0.08	700000	0.090194
51	0.00002	800000	0.012493	99	0.00006	800000	0.013155	975	0.08	800000	0.090191
52	0.00002	900000	0.012276	200	0.00006	900000	0.012978	976	0.08	900000	0.090188
53	0.00002	1000000	0.01209	201	0.00006	1000000	0.012828	977	0.08	1000000	0.090186
54	0.00002	8000000	0.010555	202	0.00006	8000000	0.011713	978	0.08	8000000	0.090174
55	0.00002	5000000	0.010074	203	0.00006	5000000	0.011419	979	0.08	5000000	0.090172
56	0.00002	8000000	0.009743	204	0.00006	8000000	0.011236	980	0.08	8000000	0.09017
57	0.00002	10000000	0.009619	205	0.00006	10000000	0.011172	981	0.08	10000000	0.09017
74	0.00002	1000000000	0.009019	209	0.00006	1000000000	0.010899	998	0.08	1000000000	0.090168
75	0.00004	2000	0.049564	223	0.00008	2000	0.049595	999	0.09	2000	0.10416
76	0.00002	3000	0.043606	224	0.00008	3000	0.04366	2000	0.09	3000	0.101525
77	0.00004	4000	0.040009	225	0.00008	4000	0.040049	2001	0.09	4000	0.100175
78	0.00004	5000	0.037493	226	0.00008	5000	0.037538	2002	0.09	5000	0.099353
79	0.00004	6000	0.035603	227	0.00008	6000	0.035652	2003	0.09	6000	0.098801
80	0.00004	7000	0.034111	228	0.00008	7000	0.034163	2004	0.09	7000	0.098403
81	0.00004	8000	0.03289	229	0.00008	8000	0.032945	2005	0.09	8000	0.098104
82	0.00004	9000	0.031865	230	0.00008	9000	0.031923	2006	0.09	9000	0.09787
83	0.00004	10000	0.030987	231	0.00008	10000	0.031048	2007	0.09	10000	0.097683
84	0.00004	12000	0.029549	232	0.00008	12000	0.029616	2008	0.09	12000	0.097401
85	0.00004	13000	0.028948	233	0.00008	13000	0.029018	2009	0.09	13000	0.097292
86	0.00004	15000	0.027918	234	0.00008	15000	0.027993	2010	0.09	15000	0.097118
87	0.00004	18000	0.026681	235	0.00008	18000	0.026764	2011	0.09	18000	0.096929
88	0.00004	20000	0.026003	236	0.00008	20000	0.02609	2012	0.09	20000	0.096834
89	0.00004	22000	0.025412	237	0.00008	22000	0.025503	2013	0.09	22000	0.096756
90	0.00004	25000	0.024649	238	0.00008	25000	0.024747	2014	0.09	25000	0.096663
91	0.00004	27000	0.024207	239	0.00008	27000	0.024309	2015	0.09	27000	0.096612
92	0.00004	30000	0.02362	240	0.00008	30000	0.023728	2016	0.09	30000	0.096548
93	0.00004	33000	0.023107	241	0.00008	33000	0.023221	2017	0.09	33000	0.096496
94	0.00004	35000	0.022799	242	0.00008	35000	0.022916	2018	0.09	35000	0.096467
95	0.00004	37000	0.022514	243	0.00008	37000	0.022634	2019	0.09	37000	0.09644
96	0.00004	40000	0.022123	244	0.00008	40000	0.022248	2020	0.09	40000	0.096405
97	0.00004	42000	0.021883	245	0.00008	42000	0.022012	2021	0.09	42000	0.096385
98	0.00004	45000	0.021551	246	0.00008	45000	0.021685	2022	0.09	45000	0.096358
99	0.00004	48000	0.021248	247	0.00008	48000	0.021386	2023	0.09	48000	0.096334
100	0.00004	50000	0.021059	248	0.00008	50000	0.021201	2024	0.09	50000	0.096319
101	0.00004	53000	0.020794	249	0.00008	53000	0.020941	2025	0.09	53000	0.0963
102	0.00004	55000	0.020629	250	0.00008	55000	0.020778	2026	0.09	55000	0.096288
103	0.00004	58000	0.020395	251	0.00008	58000	0.020549	2027	0.09	58000	0.096272
104	0.00004	60000	0.020248	252	0.00008	60000	0.020404	2028	0.09	60000	0.096262
105	0.00004	65000	0.019907	253	0.00008	65000	0.020071	2029	0.09	65000	0.09624
106	0.00004	70000	0.0196	254	0.00008	70000	0.01977	2030	0.09	70000	0.096221
107	0.00004	75000	0.01932	255	0.00008	75000	0.019497	2031	0.09	75000	0.096204
108	0.00004	80000	0.019065	256	0.00008	80000	0.019248	2032	0.09	80000	0.09619
109	0.00004	85000	0.01883	257	0.00008	85000	0.019019	2033	0.09	85000	0.096177
110	0.00004	90000	0.018612	258	0.00008	90000	0.018808	2034	0.09	90000	0.096166
111	0.00004	95000	0.018411	259	0.00008	95000	0.018612	2035	0.09	95000	0.096156
112	0.00004	100000	0.018222	260	0.00008	100000	0.01843	2036	0.09	100000	0.096147
113	0.00004	120000	0.017579	261	0.00008	120000	0.017809	2037	0.09	120000	0.096118
114	0.00004	150000	0.016844	262	0.00008	150000	0.017103	2038	0.09	150000	0.096089
115	0.00004	180000	0.016282	263	0.00008	180000	0.016569	2039	0.09	180000	0.09607
116	0.00004	200000	0.015973	264	0.00008	200000	0.016277	2040	0.09	200000	0.096061
117	0.00004	250000	0.015355	265	0.00008	250000	0.015698	2041	0.09	250000	0.096043

18	0.00004	000000	0.014884	266	0.00008	000000	0.015262	2042	0.09	000000	0.096032
19	0.00004	050000	0.01451	267	0.00008	050000	0.01492	2043	0.09	050000	0.096024
20	0.00004	000000	0.014202	268	0.00008	000000	0.014641	2044	0.09	000000	0.096018
21	0.00004	050000	0.013943	269	0.00008	050000	0.014409	2045	0.09	050000	0.096013
22	0.00004	000000	0.013721	270	0.00008	000000	0.014212	2046	0.09	000000	0.096009
23	0.00004	000000	0.013358	271	0.00008	000000	0.013894	2047	0.09	000000	0.096003
24	0.00004	000000	0.013071	272	0.00008	000000	0.013647	2048	0.09	000000	0.095999
25	0.00004	000000	0.012838	273	0.00008	000000	0.013449	2049	0.09	000000	0.095996
26	0.00004	000000	0.012643	274	0.00008	000000	0.013286	2050	0.09	000000	0.095993
27	0.00004	0000000	0.012477	275	0.00008	0000000	0.01315	2051	0.09	0000000	0.095992
28	0.00004	0000000	0.01119	276	0.00008	0000000	0.012162	2052	0.09	0000000	0.09598
29	0.00004	0000000	0.010827	277	0.00008	0000000	0.011913	2053	0.09	0000000	0.095978
30	0.00004	0000000	0.010594	278	0.00008	0000000	0.011762	2054	0.09	0000000	0.095976
31	0.00004	00000000	0.01051	279	0.00008	00000000	0.011709	2055	0.09	00000000	0.095976
48	0.00004	000000000	0.010141	283	0.00008	000000000	0.01149	2072	0.09	000000000	0.095974

A Proposed methodology for image objects recognition using Artificial neural networks

Ziad AlQadi, Yehya Abded Allatif, .Musbah J. Aqel

Department of Electrical and Computer Engineering
Faculty of engineering, Applied Science University, Amman, 11923, Jordan
e-mail: musbhaqel@yahoo.com

Abstract

A sequence of steps, which are formed the proposed methodology were implemented and tested. From the obtained results some conclusions were made, and the proposed methodology achieved high performance by increasing the recognition ratio of the artificial neural network, which can be used for image recognition.

Key words: proposed methodology, image cropping, image resizing, dilation, edge detection, artificial neural network, recognition ratio.

1. Introduction

1.1 Artificial neural networks

Artificial Neural Networks (ANNs) are a new approach that follows a different way from traditional computing methods to solve problems. Since conventional computers use algorithmic approach, if the specific steps that the computer needs to follow are not known, the computer cannot solve the problem. That means, traditional computing methods can only solve the problems that we have already understood and knew how to solve. However, ANNs are, in some way, much more powerful because they can solve problems that we do not exactly know how to solve. That's why, of late, their usage is spreading over a wide range of area including, virus detection, robot control, intrusion detection systems, pattern (image, fingerprint, noise..) recognition and so on. ANNs have the ability to adapt, learn, generalize, cluster or organize data. There are many structures of ANNs including, Perceptron, Adaline, Madaline, Kohonen, Back Propagation and many others. Probably, BackPropagation ANN is the most commonly used, as it is very simple to implement and effective. In this work, we will deal with BackPropagation ANNs. Back Propagation ANNs

contain one or more layers each of which are linked to the next layer. The first layer is called the "input layer" which meets the initial input (e.g. pixels from a letter) and so does the last one "output layer" which usually holds the input's identifier (e.g. name of the input letter). The layers between input and output layers are called "hidden layer(s)" which only propagate the previous layer's outputs to the next layer and [back] propagates the following layer's error to the previous layer. Actually, these are the main operations of training a BackPropagation ANN which follows a few steps.

A typical BackPropagation ANN is as depicted in figure 1. The black nodes (on the extreme left) are the initial inputs. Training such a network involves two phases. In the first phase, the inputs are propagated forward to compute the outputs for each output node. Then, each of these outputs are subtracted from its desired output, causing an error [an error for each output node]. In the second phase, each of these output errors is passed backward and the weights are fixed. These two phases is continued until the sum of [square of output errors] reaches an acceptable value.

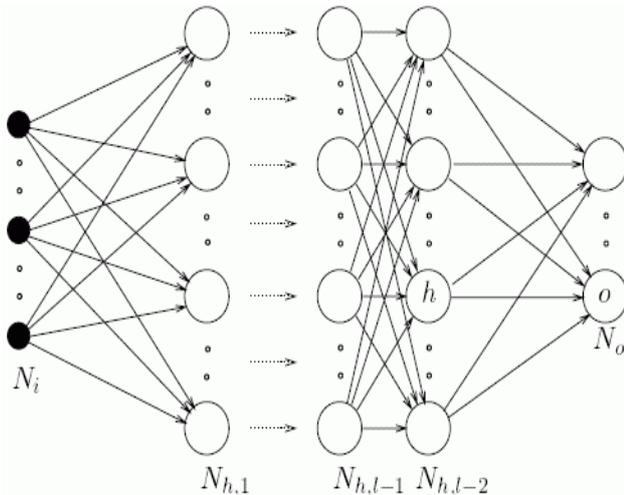


Figure 1: A typical BackPropagation ANN

The recognition performance of a simple image recognition system is not the best in comparison with other biometric-based systems, and such a system can be relatively easily deceived. There are many works devoted to the image recognition problem. But most of them are oriented on obtaining higher recognition rate for some test face databases in the prejudice of identification robustness and stability for real applications [1, 2, 3, and 4].

Multilayer Perception (MLP) Neural Network is a good tool for classification purposes [5,6]. It can approximate almost any regularity between its input and output. The NN weights are adjusted by supervised training procedure called back propagation. Back propagation is a kind of the gradient descent method, which searches an acceptable local minimum in the NN weight space in order to achieve minimal error. Error is defined as a root mean square of differences between real and desired outputs of NN.

During the training procedure MLP builds separation hyper surfaces in the input space. After training, MLP can be successfully applied for simulation purposes such as image recognition. It has good extrapolative and interpolative abilities. Typical architecture has a number of layers following one by one [5, 6, and 7]. MLP with one layer can build linear hyper surfaces; MLP with two layers can build convex hyper surfaces and MLP with three layers – hyper surfaces of any shape.

1.2 Image preprocessing

Image pre-processing is the term for operations on images at the lowest level of abstraction. These operations do not increase image information content but they decrease it if entropy is an information measure [8, 9]. The aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis task. Image pre-processing uses the redundancy in images. Neighboring pixels corresponding to one real object have the same or

similar brightness value. If a distorted pixel can be picked out from the image, it can be restored as an average value of neighboring pixels. Image pre-processing methods can be classified into categories according to the size of the pixel neighborhood that is used for the calculation of new pixel brightness.

There are a lot of operations used in image pre-processing phase, and we will focus on those that may be used to enhance the recognition ratio of the image recognition systems, such operations are:

-Image cropping

Image cropping refers to removing unwanted areas from an image, it is performed in order to remove an unwanted subject or irrelevant detail from the image, change its aspect ratio, or to improve the overall composition. An image is cropped to magnify the primary subject and further reduce the angle of view when a lens of sufficient focal length to achieve the desired magnification directly is not available. It is considered one of the few editing actions permissible in modern photojournalism along with tonal balance, color correction and sharpening. A crop made from the top and bottom of a photograph may produce an aspect which mimics the panoramic format (in photography) and the widescreen format in cinematography and broadcasting. Both of these formats are not cropped as such, rather the product of highly specialized optical configuration and camera design.

- Image resizing or shrinking

When you set the physical size of the image in inches in the Crop operation, and you don't change the resolution, the pixel dimensions change based on the ratio of the number of pixels you drew in the crop selection to the original pixel dimensions of the original image. Thus we can use resize operation, so that the resolution then changes to fit the extra pixels into each inch of the image, based on the image's original size.

- Image dilation

DILATE operation returns the dilation of *Image* by the structuring element *Structure*. This operation is commonly known as "fill", "expand", or "grow." It can be used to fill "holes" of a size equal to or smaller than the structuring element. Used with binary images, where each pixel is either 1 or 0, dilation is similar to convolution. Over each pixel of the image, the origin of the structuring element is overlaid. If the image pixel is nonzero, each pixel of the structuring element is added to the result using the "or" operator.

- Edge detection

The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world. It can be shown that under rather general assumptions for an image formation model, discontinuities in image brightness are likely to correspond to [10]:

- discontinuities in depth,
- discontinuities in surface orientation,
- changes in material properties and
- Variations in scene illumination.

In the ideal case, the result of applying an edge detector to an image may lead to a set of connected curves that indicate the boundaries of objects, the boundaries of surface markings as well curves that correspond to discontinuities in surface orientation. Thus, applying an edge detector to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, while preserving the important structural properties of an image. If the edge detection step is successful, the subsequent task of interpreting the information contents in the original image may therefore be substantially simplified. Unfortunately, however, it is not always possible to obtain such ideal edges from real life images of moderate complexity. Edges extracted from non-trivial images are often hampered by *fragmentation*, meaning that the edge curves are not connected, missing edge segments as well as *false edges* not corresponding to interesting phenomena in the image – thus complicating the subsequent task of interpreting the image data.

- Image segmentation

A central problem, called *segmentation*, is to distinguish objects from background [11]. For intensity images (i.e., those represented by point-wise intensity levels) four popular approaches are: threshold techniques, edge-based methods, region-

based techniques, and connectivity-preserving relaxation methods. Threshold techniques, which make decisions based on local pixel information, are effective when the intensity levels of the objects fall squarely outside the range of levels in the background. Because spatial information is ignored, however, blurred region boundaries can create havoc.

Edge-based methods center around contour detection: their weakness in connecting together broken contour lines make them, too, prone to failure in the presence of blurring.

A region-based method usually proceeds as follows: the image is partitioned into connected regions by grouping neighboring pixels of similar intensity levels. Adjacent regions are then merged under some criterion involving perhaps homogeneity or sharpness of region boundaries. Over stringent criteria create fragmentation; lenient ones overlook blurred boundaries and over merge. Hybrid techniques using a mix of the methods above are also popular.

2. The proposed methodology

To recognize the objects within an image the following methodology can be proposed, this methodology contains the sequences of steps needed for accurate object recognition:

- Image capturing.
- Converting the gray image to binary.
- Edge detection
- Edge dilation and filling the holes.
- Image segmentation and extracting all the components into a cell array.
- Image cropping:
 1. Finding the boundary of the image
 2. Finding left side blank spaces
 3. Finding right side blank spaces
 4. Finding upper side blank spaces
 5. Finding lower side blank spaces
 6. Cropping the image to the edge
- Image resizing
- ANN definition
- ANN creation
- ANN training
- ANN simulation

3. Materials and methods

The proposed methodology was implemented using mat lab. Several ANN were designed and implemented using the above mentioned methodology and the following mat lab codes were written using the proposed methodology and were

implemented in different variations as discussed in (4).

%% object Recognition Training a Simple NN for

%% classification

%% Read the image

I = imread('sample.bmp');

%% Image Preprocessing

img = edu_imgpreprocess(I);

for cnt = 1:50

 bw2 = edu_imgcrop(img{cnt});

 charvec = edu_imgresize(bw2);

 out(:,cnt) = charvec;

end

%% Create Vectors for the components (objects)

P = out(:,1:40);

T = [eye(10) eye(10) eye(10) eye(10)];

Ptest = out(:,41:50);

%% Creating and training of the Neural Network

net = edu_createnn(P,T);

%% Testing the Neural Network

[a,b]=max(sim(net,Ptest));

disp(b);

function img = edu_imgpreprocess(I)

Igray = rgb2gray(I);

Ibw = im2bw(Igray,graythresh(Igray));

Iedge = edge(uint8(Ibw));

se = strel('square',3);

Iedge2 = imdilate(Iedge, se);

Ifill= imfill(Iedge2,'holes');

[Ilabel num] = bwlabel(Ifill);

Iprops = regionprops(Ilabel);

Ibox = [Iprops.BoundingBox];

Ibox = reshape(Ibox,[4 50]);

Ic = [Iprops.Centroid];

Ic = reshape(Ic,[2 50]);

Ic = Ic';

Ic(:,3) = (mean(Ic.^2,2)).^(1/2);

Ic(:,4) = 1:50;

% Extra lines compare to example2 to extract all the components into an

% cell array

Ic2 = sortrows(Ic,2);

for cnt = 1:5

 Ic2((cnt-1)*10+1:cnt*10,:) = sortrows(Ic2((cnt-1)*10+1:cnt*10,:),4);

end

Ic3 = Ic2(:,1:2);

ind = Ic2(:,4);

for cnt = 1:50

 img{cnt} = imcrop(Ibw,Ibox(:,ind(cnt)));

end

function bw2 = edu_imgcrop(bw)

% Find the boundary of the image

[y2temp x2temp] = size(bw);

x1=1;

y1=1;

```

y2=y2temp;

% Finding left side blank spaces

cntB=1;

while (sum(bw(:,cntB))==y2temp)

    x1=x1+1;

    cntB=cntB+1;

end

% Finding right side blank spaces

cntB=1;

while (sum(bw(cntB,:))==x2temp)

    y1=y1+1;

    cntB=cntB+1;

end

% Finding upper side blank spaces

cntB=x2temp;

while (sum(bw(:,cntB))==y2temp)

    x2=x2-1;

    cntB=cntB-1;

end

% Finding lower side blank spaces

cntB=y2temp;

while (sum(bw(cntB,:))==x2temp)

    y2=y2-1;

    cntB=cntB-1;

end

% Crop the image to the edge

bw2=imcrop(bw,[x1,y1,(x2-x1),(y2-y1)]);

```

```

function lett = edu_imgresize(bw2)

% This function will take the cropped binary
image and change it to 5 x 7

% object representation in single vector.

bw_7050=imresize(bw2,[70,50]);

for cnt=1:7

    for cnt2=1:5

        Atemp=sum(bw_7050((cnt*10-
9:cnt*10),(cnt2*10-9:cnt2*10)));

        lett((cnt-1)*5+cnt2)=sum(Atemp);

    end

end

lett=((100-lett)/100);

lett=lett';

function net = edu_createnn(P,T)

alphabet = P;

targets = T;

[R,Q] = size(alphabet);

[S2,Q] = size(targets);

%linear

net = newlin(minmax(alphabet), S2,0,0.0001);

net.trainParam.goal = 10e-5; % training stops if
goal achieved

net.trainParam.epochs = 1000;

net = train(net, alphabet, targets);

%S1 = 10;

%net = newff(minmax(alphabet),[S1
S2],{'tansig' 'purelin'});

```

```
%net.LW{2,1} = net.LW{2,1}*0.001;
```

```
%net.b{2} = net.b{2}*0.001;
```

```
%net.performFcn = 'sse';
```

```
%net.trainParam.goal = 0.00001;
```

```
%net.trainParam.show = 20;
```

```
%net.trainParam.epochs = 10000;
```

```
%net.trainParam.mc = 0.95;
```

```
%net.trainParam.lr = 0.01;
```

```
P = alphabet;
```

```
T = targets;
```

```
[net,tr] = train(net,P,T);
```

4. Experimental results

Experiment 1:

The following image (figure 2) was implemented using the proposed methodology in order to recognize the objects 0, 1, 2... 9.

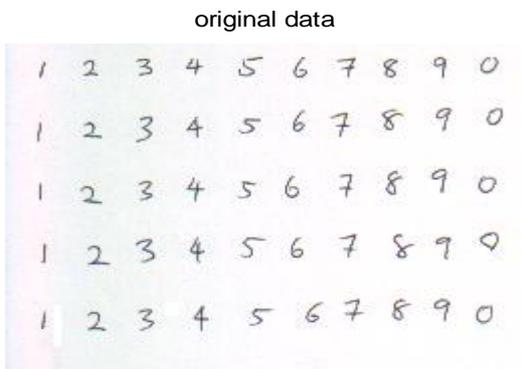


Figure 2: Original image

The following ANN were designed and implemented (Number of training iterations=1000):

Net1 (Linear ANN): 40 inputs, 10 outputs with training rate=0.1 (Applying the whole methodology).

Net2 (Linear ANN): 40 inputs, 10 outputs with training rate=0.01 (Applying the whole methodology).

Net3 (Linear ANN): 40 inputs, 10 outputs with training rate=0.001 (Applying the whole methodology).

Net4 (Linear ANN): 40 inputs, 10 outputs with training rate=0.0001 (Applying the whole methodology).

Net 5:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.1 (Applying the whole methodology).

Net 6:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.01 (Applying the whole methodology).

Net 7:6:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.001 (Applying the whole methodology).

Net 8:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.0001 (Applying the whole methodology).

Net 9:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.0001 (Applying the whole methodology).

Net 10:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.0001 (Applying the whole methodology).

Net 11:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.0001 (Applying the whole methodology).

Net 12:1 hidden layer with 10 neurons, 40 neurons output with training rate=0.0001 (Applying the whole methodology).

The experimental results are shown in table 1:

Table 1: Results of experiment 1

Artificial neural network	Number of correct recognized objects	Number of incorrect recognized objects	Recognition ratio (%)
Net1	1	9	10
Net2	1	9	10
Net3	9	1	90
Net4	10	0	100
Net5	6	4	60
Net6	6	4	60
Net7	7	3	70
Net8	9	1	90
Net9	5	5	50
Net10	5	5	50
Net11	5	5	50
Net12	7	3	70

Experiment 2:

The same image shown in figure 2 was taken and Net 4, Net 8, And Net 12 (As the best from the results of experiment1) were implemented using the proposed methodology omitting the cropping step. Table 2 shows the results of this experiment:

Table 2: Results of experiment 2:

Artificial neural network	Number of correct recognized objects	Number of incorrect recognized objects	Recognition ratio (%)
Net4	9	1	90
Net8	6	4	60
Net12	6	4	60

The same image shown in figure 3 was taken and Net 4, Net 8, And Net 12 (As the best from the results of experiment1) were implemented using the proposed methodology omitting the edge dilation step. Table 3 shows the results of this experiment:

Table 3: Results of experiment 3

Artificial neural network	Number of correct recognized objects	Number of incorrect recognized objects	Recognition ratio (%)
Net4	9	1	90
Net8	6	4	60
Net12	6	4	60

	zed objects	d objects	
Net4	9	1	90
Net8	6	4	60
Net12	6	4	60

5. Results discussions

From the results which are shown in tables 1, 2 and 3 we can prove the following points:

- Using the proposed methodology increases the recognition ratio for different ANN architecture.
- Decreasing the training rate increases the recognition ratio for both linear and feed forward ANN.
- Some time we can get better results of recognition using linear ANN.
- Increasing the number of neurons in the hidden layer does not lead to better utilization.
- Omitting one step from the proposed methodology decreases the recognition ratio of ANN used for image recognition.

Conclusions

The proposed methodology was implemented and tested. The experimental results show that using the proposed methodology leads to increase the recognition ratio of ANN used for image processing. Also it was seen that the entire methodology step must be used in order to achieve high system performance.

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