An Intelligent Mechanism for GIS Contract Automation

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***Abstract*— Geographic Information System (GIS) contracts are specialized in nature. GIS diffusion within organizations from developing countries is much low, that is why, organizations do not have the capability to validate GIS contract which is prepared by service provider hence promoting boilerplate contract. Boilerplate contract is relied upon all in the development, operational, and maintenance phases of GIS in organizations for developing countries. A number of different problems are generated during the execution of GIS project, for instance: 1) No indicators are explicitly defined to measure the performance of client and service provider. 2) Due to the lack of these indicators, both parties remain unable to reach on an agreement for measuring the performance of each other. 3) No mechanism exists to track the progress in both sides. 4) Penalty cost due to negligent behavior is not accepted, supposing that penalties are rather imposed. Thus, this paper proposes an automatically intelligent mechanism to regulate technical parts of GIS contract. In order to create an electronic contract processing our approach proposes firstly to convert already existing signed contract by scanning it and extracting lexemes using optical character recognition methods. For all new contract creation, a Graphical User Interface (GUI) is provided to take into account preferences of users. This information is stored in a database and shared published across involved parties. A mechanism to track the contracts based on performance indicators is also incorporated. Back propagation artificial neural network (BNN) is initially trained by providing specific ranges of valid values and rectifying these values on the basis of user's input. The framework is also able to track performance from both parties based on indicators compiled by liabilities and obligations against each other.**

***Index Terms*— Intelligent automation, Back propagation neural network, Service contracts, Geographic Information System**

I. Introduction

Performance indicators of social ability of an intelligent agent cannot be made explicit. However agreements can be reached as a measure. Reactive and proactive behavior of intelligent agents is quantifiable. The agent becomes social by generating lists of options to mutually agreeing terms and contract conditions. Moving away from traditional development to packaged approach, simple or shrink wrap licenses have evolved to complex agreements [Kaminski and Perry, 2007]. These agreements are meant to classify the liabilities and obligations of the stakeholders. Contracts are important in the context of loosely coupled structures [Abdel and Salle, 2002] like supply chains that involve independent entities. No central authority exists that coordinates activities of entities resulting from a supply chain in which each one is responsible to arrange a contract with their partner defining the collaboration in which they engage for instance a service under a term of contract.

Nowadays, contracts define rights and obligations of parties as well as conditions under which they arise and become discharged. The rights and obligations concern either states of the affairs or actions that should be carried out. Contracts define both primary and secondary obligations. Secondary obligation is considered when primary obligation is not brought into the matter. The commitments are shaped in contracts in different ways. Some commitments are time bound and tracked with respect to its deadline while others are resource bound [Abdel and Salle, 2002].

GIS is emerging domain which is utilizing state of the art technology to enable visualization of networks on satellite imagery. GIS is diffusing rapidly in pipeline industries, railway track management, air travel management, urban units, etc. The development phases of GIS differ from that of conventional information systems [Longley et.al, 2002]. Obviously the performance indicators of the former become specialized. In addition, research on electronic contract management is becoming more dynamic with the advent of Internet and e-commerce [Kwok and Nguyen, 2005].

GIS contract can be divided into three terms: Service, Technical, and Resource. **Service** contract sets out terms and conditions required as part of services provided by a consultant to a client. Terms can define liabilities and obligations of the contractor as well as of the client.

Technical terms contract is the backbone of information system contract, covering core concept of information system development. GIS has its own life cycle which differs from the conventional software development life cycle. GIS development is step wise procedure and the terms of contract should be reviewed at each step of the procedure. Technical term contract of GIS includes data processing services [Xiao and Fu, 2003], GPS data collection [Ibboston and Sachs, 1999], programming requirements [Landa, 2008], digitization [Barbieri et.al, 2004], implementation of planning services [IBM golbal services, 2007], map coding services, real time GPS data collection [Ibboston and Sachs, 1999], spatial data

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integration [Xiao and Fu, 2003], [Longely et. al, 2002], and satellite image procurement.

Resource term contract defines required physical and human resources which should ensure the compliance with the service and technical terms contract. Resource terms contract are not necessarily included in a GIS contract but can help specifying the requirements of GIS mapping center and different groups of specialist required for the development and operation phases.

Contract can also be interpreted as performance measurement grid between client and service provider. A single contract can encompass a large number of collateral documents including master and customer agreements, supplements, addenda, and the like. Merging different organization documents into one is a tedious job and subject to human error. For example, in a typical case, a user must first convert all individual documents into a uniform file format. This is one of the solution that we go to describe here.

The existing contract management is either manual or electronic. The former do not have a mechanism to measure the performance of service provider, neither to penalize the negligence shown by both parties. The manual contract process is also time consuming. Analyzing state of the art, it is observed that the electronic contract management is an automated form of the manual. Agreement and evaluation on performance indicators is not included in electronic contract management. We have found very few cases where the performance measurement mechanism is defined. Even in those studied cases the indicators were used only to keep account of violation of legal obligations. Secondly, most of the measures in these contracts are not specific, quantifiable and accurate. Thirdly, the studies were only made to automate general information system contracts. We already had mentioned that the technical part of geographic information system is quite different from that of the conventional information system. Our approach is aimed to provide an intelligent framework for GIS contract automation. The performance of parties is tracked on the basis of performance indicators which are fed to Backpropagation neural network (BNN) so that the actual progress can be matched with the forecasted. For this purpose, the contract is first converted into a quantifiable electronic format so that the performance can clearly be indicated. BNN learns the extracted quantities and measures from new as well as converted contracts to match the desired standards with actual practice.

In Section 2, we discussed related work. In Section 3, framework of intelligent contract management is discussed. This section also includes conversion mechanism for signed contracts into the format that can be quantified and stored in the database. The section also discusses the formatting of new planned contracts into a format that can be stored in the database. In Section 4, the implementation of BNN is discussed. In Section 5, we present pipeline industry's GIS case. Finally, conclusion and future work are given.

II. Related Work

All the previous efforts related to efficient contract management is infact the conversion of manual documented contracts to electronic contracts. Different aspects of electronic contract management are addressed like Tan et.al [Tan and Thoen, 2002] proposed a method for electronic contract preparation, Perrin et.al [Perrin and Godart, 2004] worked on contract binding and Pong et.al worked on negotiation part of electronic contracts [Pong and Signgate, 2001]. M-C Pong et.al and Griffel et.al also addressed different aspects of electronic contract management including contract creation, negotiation and execution. proposed a method for electronic signing of contracts [Pong and Signgate, 2001][Griffel, Boger, Weinreich, Lamersdorf, Merz, 1998]. The state of the art techniques for efficient contract management is related to the conversion of paper contracts to electronic contracts without focusing upon intelligent automation based on certain performance indicators. Our approach differs from the existing approaches in the sense that a mechanism for intelligent contract preparation and performance measurement is introduced. The approach also devised a mechanism for conversion of signed manual contracts into an intelligent automated format.

There exist a few approaches which have not only automated the contracts but also included data mining and other analytical techniques for contract creation, negotiation and execution. Thomas Kwok et.al [Kwok and Nguyen, 2005] proposed an architectural framework for electronic contract management. He divided electronic contract manager into an administrator and user module. Administrator module authorizes user to use certain predefined templates in his own schema. User module maintains user schema consisting of graphical user interfaces (GUI) and configuration files. An algorithm for task execution in administrator and user schema was also developed. Further to this approach Thomas et.al [Kwok and Nguyen, 2006] extended the framework to include contract creation, negotiation, execution and data mining module by setting an application server with remote common database and many web-based individual user systems. The application server consists of a central neural network, contract generators, exchanger, negotiation engine, signing engine, generic index and search engines.

Another mechanism for intelligent contract automation was proposed by Kaminski et.al [Kaminski and Perry, 2007] who argued that service level agreements and objectives should be made explicit to ensure compliance with the contract. His framework consists of an intelligent agent to make negotiations on Service Level Agreements (SLA). Many researchers realized that intelligent software agent can be incorporated to stipulate contracts [Pacheco and Carmo, 2003]; [Dignum et. Al, 2002]; [Dellarocas, 2001] as they are able to communicate, negotiate, react, and mitigate situations which are essential for contract management.

Contract can also be well managed by establishing message based interaction among parties. Abdel et.al [Abdel and Salle, 2002] designed a framework for message based interaction among various stakeholders within an organization. Such an interaction is beneficial to eliminate communication overhead and genuine compliance with contract's terms and conditions but it does not provide any mechanism to automate performance measurement. Abdel also proposed to automate such interactions by incorporating web portals.

The literature revealed that manual contract management has been evolved to electronic contract management that is an automated form of manual contracts. Agreement on performance indicators and evaluation on the basis of those indicators is a dimension to be analyzed has still not been studied. Secondly the modeling of business contracts in Information Technology (IT) industry has changed the paradigms [Jain et. al, 1996]. Few efforts of including performance indicators have been observed but those are specific to deal with legal issues only. These measures are not specific, quantifiable, and accurate. The previous studies are mostly related with the automation rather than with the intelligent automation. They are meant only for general information system contracts whereas GIS contracts are specialized and not dealt herein forth. Industry in information system especially in GIS contract has not been relying blindly upon the boilerplate conditions offered by the service providers [Griffel et.al, 1998].Our approach deals with an intelligent framework in which the contracts are first converted into a quantifiable electronic format and then the performance of both parties is measured on the basis of predefined performance indicators. The indicators and contract terms are learned by Back Propagation Neural Networks so that intelligent tracking of performance become possible.

III. Framework for Intelligent Contract Automation

GIS contract is divided in three terms: 1) Technical, 2) Service, and 3) Resource. The framework has a layered architecture (see Figure 1 and 2).

The technical, service, and resource terms of the contract reside at the first layer. In the second layer, the partition of the first layer is exfoliated. For Technical term, the contract includes essential steps of building agreement between service provider and the client. GIS technical term contract is related to the technical steps involved in building GIS. These steps are explicitly mentioned in Figure 1. Satellite image procurement is the first step in which the client provides specific area for which the image is to be procured. In order to complete the procurement the service provider hires the services of 3rd party. After the procurement, the target of service provider is coded to satellite image. The process to convert the image on real ground coordinates is named as Rectification/Geo-coding. At this point, the client remains a silent observer. However, in certain cases the client ought to select projection system on which the geo-coding is to be done. The client provides the network mapping either in the form of diagrams or engineering designs. Mapping diagrams are digitized by the service provider. Each activity of GIS mapping specifies the client and consultant responsibilities. In turn, each responsibility is measured by different performance indicators. Depending upon the type of GIS, the criteria to measure the performance of service provider and the client can be quantitative, for instance the Rectification, or qualitative, for instance, geo-coding (see Figure 3).

The digitization of these maps on ground base map which is in the form of satellite imagery generates spatial and non-spatial data. Spatial data is planned and handled at service provider's end mostly whereas for non-spatial attribute data the client is supposed to propose attributes and database management system. The Consultant takes the responsibility to incorporate both. In this case, cost and quality matter for both soft and hard resources. In the next step, the successful preparation of the database sets a new milestone for service provider that is Graphical User Interfaces (GUI). GUI at this stage is meant only to provide a better platform for interfacing with database attributes. Along with dependencies of attributes on each other, formatting of GUI and relationship among attributes also affect the performance of automated application. As the practice of GUI development is not unusual in information system industry so the phase of GUI development is considered as quantitative matter in most of the contracts. Despite, the format of GUI needs due attention by both the parties. The database structure is also validated by the client.

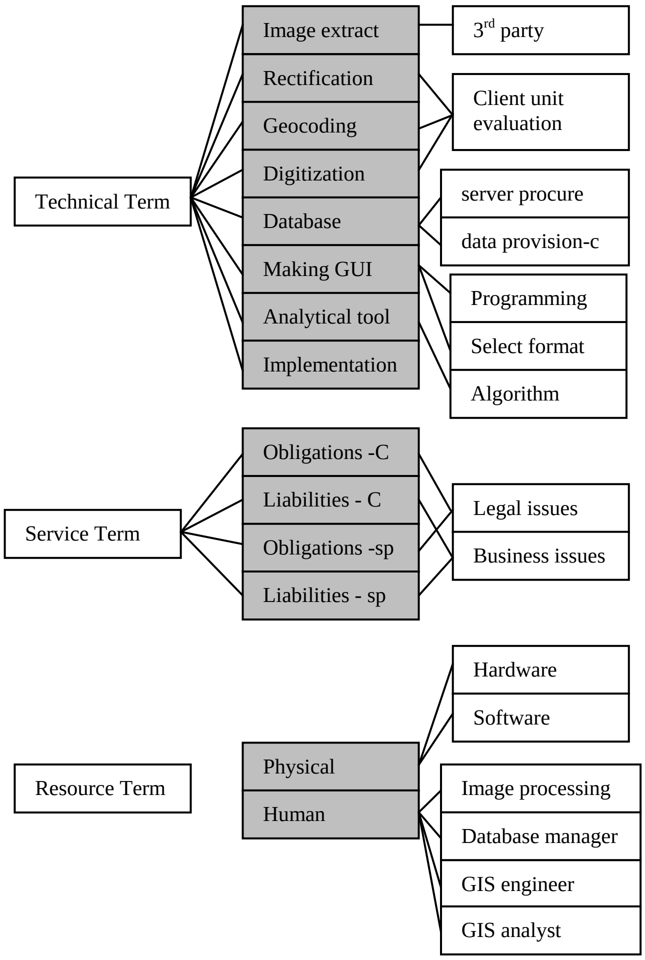

Fig. 1**.** Framework for GIS Technical Contract Management

The trends in GIS development are rapidly changing. The clients in most of the cases are interested for integration of other automated systems with GIS. Some analytical tools are also developed to support GIS. These tools enable GIS to perform network analysis, load management, contingency plans etc. The business and technical logic of required analytical tools is solely determined by the clients. The consultant is only responsible to convert the pseudo code to a structured programmed module. By following the above mentioned steps, an operational GIS comes into being which is installed and implemented at client's premises. The implementation phase varies in different set of circumstances.

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GIS can either be implemented as a desktop solution or distributed. Desktop solution is cost effective and free of concurrency issues. But the technical requirements of clients are not usually satisfied by desktop solution. Distributed solution is either server based or browser based. These solutions are measured on: 1) Security, 2) Ease of management, 3) Cost, and 4) Long run benefits. The security and ease of management are qualitative measures whereas, cost is considered as quantitative. The GIS contract explicitly specifies the type of implemented solution. The time allocated to the activity is dependent upon the type of solution. A few of performance measures in technical term are intersecting with the performance indicators of resource term. There are also some indicators in technical term contracts that intersect each other. Figure 2 depicts the performance measures on various paradigms of the technical contract.

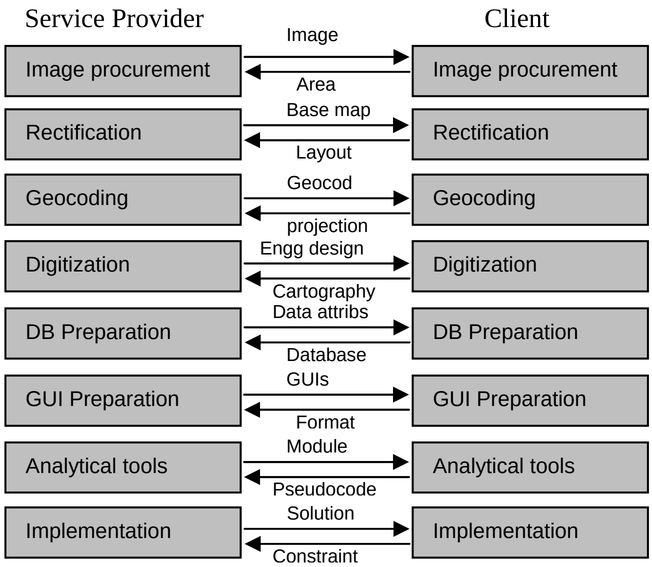

Fig. 2. Performance Measures

In GIS contract, service terms deal with legal issues and business rules of particular organizations, defining obligations and liabilities of both service provider and client. Legal issues are common for both the companies as these issues are taken from the practiced law in the state [Gisler et.al, 2000]. Business rules and ethics for each organization are defined according to the scope and objective of that particular organization. There are number of available templates for defining service terms contracts [Ariba, 2008] [Bohnenstiehl, 2000]. However, in the framework, service term is only considered. These templates can help defining the format for taking input from user. The operations on service term are beyond the scope of the paper.

Resource term contract conceptualizes physical and human resources to be procured and hired for the client. The former includes computers, printers, plotters, scanners, and large image scanners. The human resources can be categorized as image processing personal, database manager, GIS engineer, and analyst. Most of the companies hire consultant's services for establishing its GIS mapping center. The execution phase of GIS still needs design efforts for which a premise equipped with technical resources and personals would be required.

3.1. Conversion of Existing Contracts

Our approach focuses on two type of technical term contract:

1. The manual contract which have already been agreed, signed, and implemented in companies.
2. Contracts whose preliminary discussion about requirements and obligations have been completed, but have not yet been agreed and signed.

Existing contracts are scanned and provided to the input module which enables users to convert them into a format that can be stored in the database. Contracts from scanning in an optical or a facsimile treatment are stored in image formats.

A method of optical character recognition (OCR) is used to convert images into text format. The procedure is shown in Figure 2. When contracts received are originated from text editor, such as electronic documents, different text editors like lex parser are used to produce their content into text format. Then, neural network is used for training a module on these documents. After comprehending the contract the technical term contract is extracted from the text. Two extraction methods are employed:

- To extract relevant lexemes from the parsed document (digitization, rectification, mosaicing, etc.). Each lexeme is associated to specific GUI in the database server. The user is provided with GUI to update the factorized contract.
- To provide GUI to both the service provider and to the client to set the terms and conditions of technical contract. The structure of the organization is considered while setting down the terms and conditions. The lexeme extraction relies upon: 1) headings of various sections and subsections in contract document, 2) the frequency of technical term appearing in the document. If there are certain frequent terms which have slight differences then these terms are classified by using correlation analysis between the term itself and the closet match. The frequency of each lexeme is correlated with the closet lexeme/keyword by using Equation 1 (correlation analysis). Equation 2 describes the expansion of function $P(L_i, L_j)$ used in Equation 1. Where L_i is the frequency of lexeme and L_j is the frequency of closet match.

$$Corr(L_i, L_j) = \sum_{i=1}^{n} \frac{P(L_i, L_j)}{n} \quad (1)$$

$$\left[P(L_i, L_j) = \frac{V(L_i, L_j) - V(L_i)V(L_j)}{V(L_i^2) - V^2(L_j)\sqrt{V(L_i^2) - V^2(L_j)}} \right] (2)$$

After recognition of tokens from scanned documents, each lexeme is associated with a GUI which would take inputs from the user for the parts of scanned document which are unclear or ambiguous. If the concept which is extracted through parsing from the document is unclear then the input is taken from the user, and stored in the database. After taking input from the client, the same on static GUI is forwarded to consultant for validation as shown in Figure 4. The consultant is provided with limited editing facility on the GUI so that the user's input cannot be altered. Both the

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client and the consultant have their own database instances. These database instances are matched with the last input to store final copy in the shared database. Each mismatch is communicated to both ends for mutual agreement.

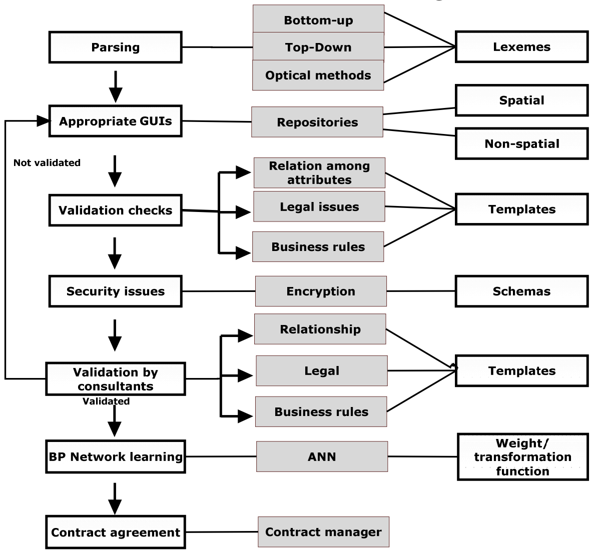

Fig. 3. Conversion of Existing Contracts

3.2. Agent based new contract creation

The creation module consists of GUI, validation control, graphic panel, and templates. Both consultants and clients input business rules and strategies through GUI which are stored in the shared database. These GUIs are designed in such a way that most of the inputs are bound to be numeric and date/time format instead of string input. The business rules are validated against each other and in case of conflict the concerned party is notified. The client enters application requirements for consultant to analyze which are communicated accordingly. The consultant provides list of services which the client requires. The services are offered with required time of completion and cost involved. Both clients and consultants can amend the lists of services by taking due care of business rules and obligations of both the parties.

The proposed agent takes the list of services from the shared database and orients them according to the business rules and constraints of the client. For example, the consultant has offered to use pirated copy of some products. The agent removes the option as it contradicts with the business rules of the client. The agent further provides interface for each service to take detailed client requirements. Both stakeholders select a list of performance indicators and the method for measurement of indicators. For example, the acceptable performance indicators for digitization are number of maps (quantitative and time bound), number of engineering designs (quantitative and time bound), scale of engineering designs (qualitative and time bound), color schemes (qualitative), legends (qualitative), engineering codes for design of drawing (qualitative and specific), and interface implications. Predefined list of performance indicators is provided to both parties; however the party has the option to define newer ones. The agent is again responsible to advise both parties about conflict in performance indicators.

Both parties mutually agree on deadlines and penalties cost against violation of schedules. The agent provides addendum to list down the discrepancies which can occur both at consultant and client's end. Penalty costs are also included in addendum. The agent evaluates the penalty value on the basis of volume of discrepancy. In the next step, the client defines its needs of accuracy and security. The consultant can offer additional security services for example, tracking the changes through web browser. The companies usually demand critical accuracy depending upon the application domain. For example, pipeline industry while building GIS for laid pipelines cannot compromise on the accuracy values because the underground pipeline is tracked by the GIS. In case of inaccurate computations the company can face lot of losses in manpower and cost. Another class of companies cannot sacrifice privacy of data e.g. state intelligence agencies. These issues are dealt in security and accuracy module of intelligent contract management application. According to the framework the contracts have been stored in the database both at client and consultant's end and after necessary comparisons they are stored in the shared database. The next step is to prepare an artificial neural network which helps the agent to learn all the rules and terms of contract and track the performance as well as compliance of contracted terms and conditions. Back propagation neural network (BNN), because of its feed forward and backward pass, is the ideal option to train agent for such cases.

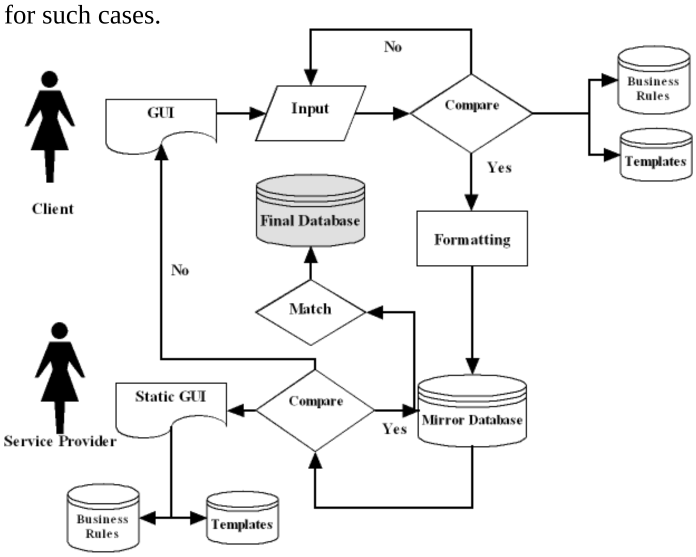

Fig. 4. Contract Creation

IV. Backpropagation Artificial Neural Network

Artificial neural network is used to train a system on facts and rules. It has layered architecture which works on principle of weight and transfer function [Milosevic et. al, 1995]. BNN is a multi-layered network that contains multiple layers within hidden layer. The back-propagation algorithm is a supervised learning algorithm that does not change network structure or activation functions of nodes, but only adjust weights in the system [Massey, 2003]. BNN learning stages contain two phases, i.e. forward pass and backward pass [Amy et.al, 2005].

$$(NI) = \sum_{i,j=1}^{n} W_{ij} X_i \tag{3}$$

$$Out_k = f\left(\sum_{j=1}^{n} W_{jk} H_j\right) = f\left(\sum_{j=1}^{n} W_{jk} f\left(\sum_{i=1}^{n} W_{ij} X_j\right)\right) \tag{4}$$

Where W_{ij} is the adjusted weight and H is output of particular node.

The forward pass calculates net input of every node (Equation 3) to generate output using activation function. The net input from input layer to the hidden layer and output at output layer is calculated in the Equation 3 and 4 respectively.

In backward pass, the output is passed back to previous hidden layer by adjusting weights on the basis of error. The weight adjustment is determined by Equation 5.

$$\Delta W_{jk} = -\xi \frac{dE}{dW_{jk}} \quad (5)$$

Where ξ is the constant adjustment value.

In this paper, Back propagation technique is used for learning of contractual terms and conditions. A training sample is presented to BNN. The desired output of the sample is calculated by calculating the OUT_k value. The output is compared by the desired value and the error is computed. Scaling factor is measured to determine that what adjustments should be made to get desired output. The local error (scaling factor) is evaluated on the previous layer with specially considering the neurons with higher weights. The procedure is repeated until the error become negligible.

V. Case Study

Gas pipeline industry's GIS is taken as case study. The company has larger distribution network within cities. The project of GIS development of the company is in progress with the consultancy services of GIS consultants. The engineering drawings of the company are converted in cartographic formats and distribution network of one city is converted in 580 engineering design sheets. The documents of contract are scanned and parsed into tokens. 62 out of 80 tokens have been converted to meaningful lexemes while the rest were misinterpreted. The spatial database server which was already hosting GIS application was used as shared database server between service provider and client. The determinant value of few correlation matrices of lexemes are presented in Table 1.

Table 1. Few Lexemes with determinant value of correlation matrix

Lexemes	*Determinant of correlation matrix*	*Lexemes*	*Determinant of correlation matrix*
Geo-coding	4	Raster	2
Mosaicing	4	Coordinates	4
Rectification	5	Dimensions	2
Vector	3	Digitize	4

After extraction of lexemes from contract documents each lexeme is attached with GUI. The user is provided with GUI for verification of interpretation of lexemes as well as for extraction of that information which is not derivable from lexemes. The GUIs and graphical panels embedded in the system are digitization rules and codes, digitization performance indicators, database attributes/relationships, database resources, GUI formats and fields, rectification scale and projections, GPS data collection, satellite image procurement, and implementation.
The database is stored and shared with consultant. Terms and conditions of the contract are agreed by both parties and finally the database becomes a repository. BPNN is trained onto the data sets for managing future complications of contract. The inputs given for training are as in Table 2. Number of good forecasts is much higher than those of bad forecasts which keep on improving by increasing the number of samples. The tolerance of network increased in test set showing that the rate of correct prediction increases after sufficient training.

Table 2. Training Iterations on forecasts

	Training Set	*Test Set*
Iteration trained	4252	N/A
No of rows	414	85
Tolerance	0.1	0.3
No of good forecasts	309	75
No of bad forecasts	105	10
Average MSE	0.1959	16.482

After the completion of training, BNN is provided with 500 inputs. Figure 5 shows the graph between rate of error and number of iterations. In the beginning, when the network was trained on limited samples the difference between desired output and current output was increasing. After sufficient training, consistency is observed in the rate of error.

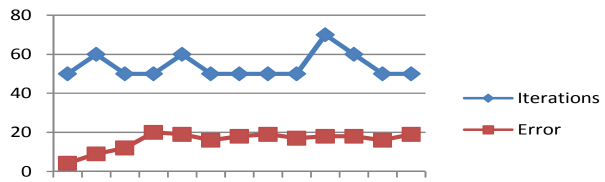

Fig 5. Training Error

VI. Conclusion and Future Work

The study provided a mechanism to automate complex activities in contracts. The work has mainly contributed in, (1). Automation of signed contracts (2). Creation of new automated contracts (3). Intelligent performance measurement on the basis of compliance with terms and contract conditions. The approach is time and space efficient because the framework will eliminate manual mechanism as well as file system by incorporating integerable shared database. The solution will provide consistent contract management. The performance indicators will be considered as performance standards between the client and service provider hence resulting in commonality among standards across the domains. The validation of databases twice at

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local and shared level ensure the authenticity and security of all the transactions. The compliance with contracts is efficiently monitored not only in accuracy but also in time and space management. The system does also have the learning capability and the facts of knowledge base keep on updating by the inclusions of new inferences.

The cost of contract creation and management will obviously increase but such investment can be considered "Long run investment".

As a future work we plan to include service and resource terms of contract in order to provide a whole functional contract system. The source of communication between client and consultant is a shared database which cannot be relied in the contracts where frequent communication is required. Similarly, communication software between client and consultant can be extended by using any of the existing mechanism of message passing.

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