SPATIO-TEMPORAL MINING FOR EMI FORECASTING IN GIS-FME MODEL

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ABSTRACT

The growing interest for Electromagnetic Compatibility (EMC) has been the progressive miniaturization and sensitivity of electronic components and circuits, often operating in close proximity to relatively powerful sources of electromagnetic interference. Many power quality (PQ) problems are observed in reduction the Electromagnetic Interference (EMI) and try to have a large EMC. One of the greatest problems in power distribution system for control the EMI is the location of the source. These instructions presents a spatio-temporal pattern mining technique is used to forecast load forecasting temperature, and pressure for find the EMI source. After finding the location and magnitude of the EMI source, we use the finite element method (FEM) to calculate the electromagnetic fields. The results of the Comsol software (based on the FEM method) export to GIS and engineers plan the network. Also power system operator based on the report of the GIS-FME can dispatch the power to utilities. The Great Tehran utility is used to demonstrate the performance of the proposed method.

INTRODUCTION

The growing interest in the last decades for Electromagnetic Compatibility (EMC) has been the progressive miniaturization and sensitivity of electronic components and circuits, often operating in close proximity to relatively powerful sources of electromagnetic interference. In HV, MV, and LV electrical utilities much capacitive and inductive energy is present. During switching action, or load flow that's energy convert to electromagnetic waves. Also when the current is in the conductors and transformers, electromagnetic fields is there.

Electromagnetic Interference (EMI) can occur in any part of the EM spectrum from frequencies of 0 Hz (DC.) to 20 GHz or higher. Effects of EMI are noticed in many of electronic equipment which may act either as the source, or as the victim, or both, of EM radiation. Three entities are involved in the existence of electromagnetic interference, namely: Source, Victim, and Coupling Path. To facilitate system and subsystem designs, it is necessary to determine both the coupling performance and shielding effectiveness (SE) characteristics of equipment and connectors that interconnect various components, subassemblies, equipment, and subsystems.

The source of the EMI includes vehicle ignition, lightning, power transmission lines, and non-linear equipment. An increasing number of non-linear equipment is interconnected via the power distribution network. Many power quality (PQ) problems are observed in reduction the EMI and try to have a large EMC. One of the greatest problems in power distribution system for control the EMI is the location of the source. P, Q, I, and V in power system haven't static behavior. Their magnitudes and angle are dynamic. The dynamic behavior is leading to changing the position of the EMI source. The grid operator is responsible for the quality of the supplied voltage and the users of electrical power are responsible for the quality of consumed or produced current.

Correctly analyzed model for forecasting EMI source location is required to manage and plan a power distribution system to have standard PQ. Location forecasting in the electrical supply industry helps decision making. Many variables can be considered. For instance, these include the temperatures, pressure, and load forecasting, and upgrading a utility.

A spatio-temporal pattern mining technique is used to forecast load forecasting temperature, and pressure for find the EMI source. It is applied every day and a geographic information database collected the data.The techniques of spatio-temporal mining can be applied for forecasting the EMI source location as follows:

Spatio-Temporal Forecasting and Trend Analysis
Spatio-temporal Association Rule Mining
Spatio-temporal Sequential Patterns Mining
Spatio-Temporal Cluster Characteristic and Discriminate Rule Mining

After finding the location and magnitude of the EMI source, we use the finite element method (FEM) to calculate the electromagnetic fields. Tehran's electrical power system is a large autonomous system with large number of customers. The customer's power & energy demand are increasing with high rates. This rate is felt on EMIs. This research tries to reduce the EMI in the city to have a standard quality (based on IEC/TR 61000-2-7). The results of the Comsol software (based on the FEM method) export to GIS and engineers plan the network based on this report. Also power system operator based on this report can dispatch the power to utilities. [1-10]

EMC-EMI

According to standards, manufacturers of electrical

devices are obliged to sufficiently protect their devices from electromagnetic disturbances. The manufacturers are obliged to ensure that these electrical devices produce very little electromagnetic disturbances to their surroundings. Each equipment manufacturer must adhere to the defined interference limits according to the standards to prevent disturbing the power network. The EMI/EMC Test Facility provides for protection of proprietary information and hardware throughout the test process. The Test Requester shall clearly mark all export controlled or proprietary hardware items and data provided with a notice of restriction on disclosure or usage.

A Distribution System is exemplified in Fig.1. Applying the concept of fixed installation, there is principally no difference between electrical networks or connected equipment in terms of electromagnetic disturbances. Both networks and connected equipment can emit electromagnetic disturbances and immunity is similarly relevant in this context.

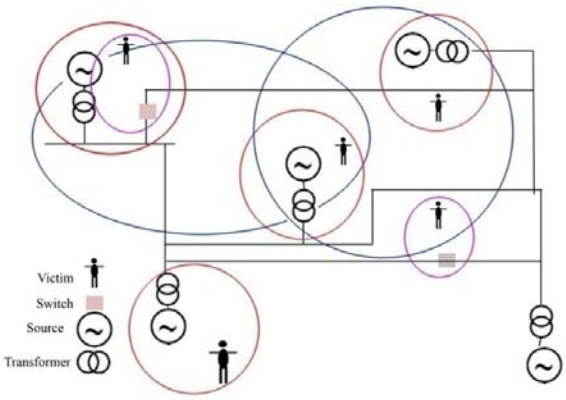

Fig. 1. Distribution system and electromagnetic interference

Finding the source of the EMI, on the city is the greatest problem. To facilitate system and subsystem designs, it is necessary to determine both the coupling performance and shielding effectiveness (SE) characteristics of equipment and connectors that interconnect various components, subassemblies, equipment, and systems.

EMI shielding is an important application when it comes to modelling power distribution systems. Thus, it is necessary to review the status of EMI modelling and shield design of the modelled power device thoroughly. Algorithm that we used for this study presented in Fig. 3.

The work of G. Vasilescu [11] is suitable in formulating SE at distribution system. For a given external source, the shielding effectiveness is the ratio of electric or magnetic field strength at a point, before and after the placement of the shield in question. Denoted by SE, this figure of merit is calculated with the expression:

$$SE = 10\log\frac{P_i}{P_t}[dB] \qquad (1)$$

Where Pi is the incident power density of the electromagnetic wave (measured at the point of observation, before shielding);

Pt is the transmitted power density of the electromagnetic wave (measured at the same point, after shield is in place). Expression (1) holds for near- or far-field conditions, and can be used at distribution system.

SPATIO-TEMPORAL MINING MODEL OF THE DISTRIBUTION NETWORK

A spatio-temporal object can be defined as an object that has at least one spatial and one temporal property. The spatial properties are location and geometry of the object. The temporal property is timestamp or time interval for which the object is valid. The significance of spatiotemporal data analysis and mining is growing with the increasing availability and awareness of huge amount of geographic and spatiotemporal datasets in many important application.

To modelling a network in GIS, modelling any groups of equipment based on the structure and action of it in to point, line or polygon model. A geometric network is associated with a logical network, which is a pure network graph consisting of edges and junction elements. Referencing the line-network-oriented thinking, expert experience is summarized as reasoning strategy which is described as routing rule. Using these rules, the diagram built in above section will become regular and readable [3].

The tools and algorithms in the GIS software are descriptive in network; they help summarize the salient characteristics of a spatial distribution.

They are useful for answering questions like:

- Which part of the site is most dangers?
- Where is the peak centre?
- Which equipment has the broadest domain?

The options available for modelling spatial relationships include inverse distance, fixed distance, polygon contiguity, k nearest neighbours, Delaunay triangulation, peak time and source distance.

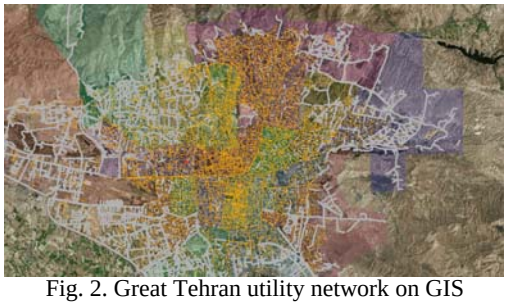

Fig. 2. Great Tehran utility network on GIS

Fig. 3. Transformers and capacity of them on GIS

The application and software that we have to communicate with GIS are: SCADA[1] (for the latest network changes online), Billing (for demand), and database of the power market (for online load flow).

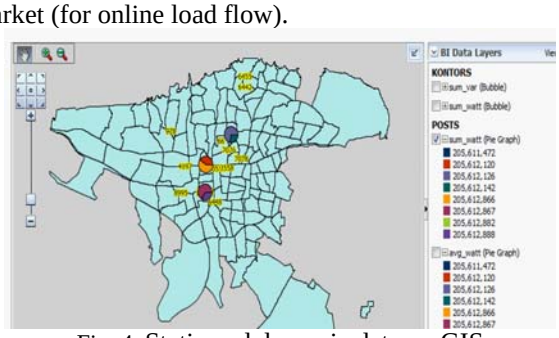

Fig. 4. Static and dynamic data on GIS

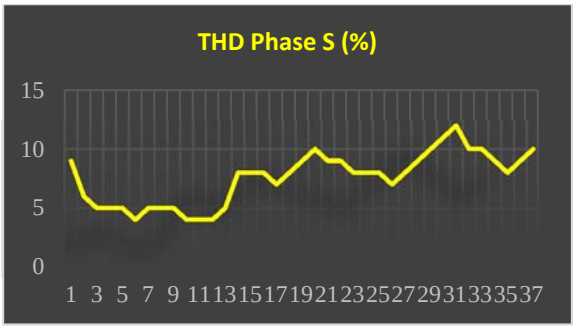

Fig. 5. THD of the utility on the GIS

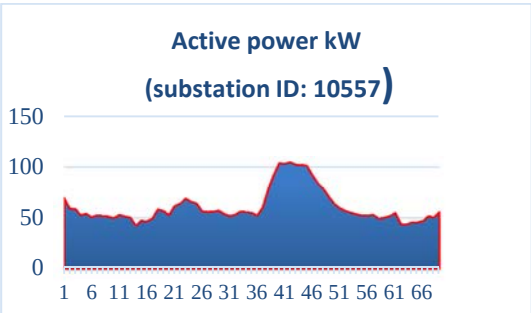

Fig. 6. Active power for substations on online GIS database

A lot of data we need to have the best decision about the utility condition. These part picture shows some of this data (Static data, Dynamic data, THD data, and Load flow data).

Extraction of EMI source and spatio-temporal information

Load pattern data are derived every 5 minutes for the transformer and lines. This is measured by a wireless load measuring system. Every data that we need to calculate the magnitude of the electromagnetic wave, are measured.
The customer information relation and voltage transformer information relation from a database of the GIS-FME system are used to extract of the following data: transformer ID, load local property, total capability of each transformer, and sum of the transformer power load. The extracted power load record is restructured as a daily vector representation using the formulation. *Eq. 2* (Emi_d) is defined as the average of the distances between each input vector assigned to the cluster and its center for evaluate the EMI magnitude.

$$Emi\_d = \sqrt{\frac{1}{k}\sum_{k=1}^{k} d^2(r_k, C_k)} \qquad (2)$$

These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and decision strategies. GIS provides adequate spatial platform for system representation and manipulation, since network models and databases can be accessed and modified to perform system analysis. Many GIS contain the Cliff–Ord routines that allow for the calculation of spatial autocorrelation.[12-14]

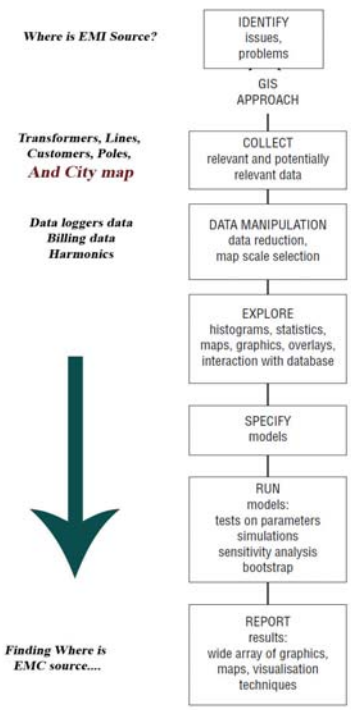

Fig. 7. GIS approaches to spatial statistics analysis for EMC source finding

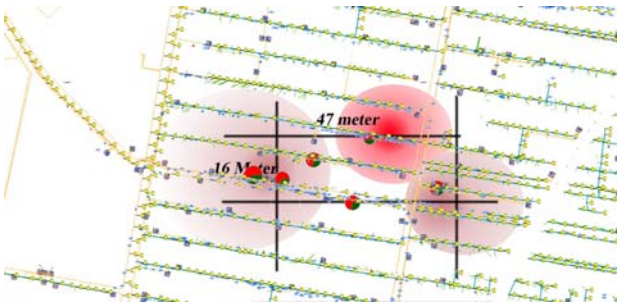

Fig. 8. High THD in the utility network

1 Supervisory Control And Data Acquisition

FME solution for calculate the EMI magnitude

FEM is a differential method working in the frequency domain. The entire domain is discretized into cells. Cell sizes can be chosen according to the fast or slow variations of fields around some parts of the simulation domain. In particular, much larger cells can be used far away from sources or conductors or non-homogeneous media. Because the entire domain is discretized and non-uniform cell sizes can be used, this method is ideal for highly inhomogeneous materials. For numerical calculations, the FEM-tool COMSOL Multiphysics is used. This network has been studied in various electromagnetic modes. Also we use gauss meter to measure the magnetic and electric fields in network and simulation results are also compared. Steps for simulation is presented by Fig. 9:

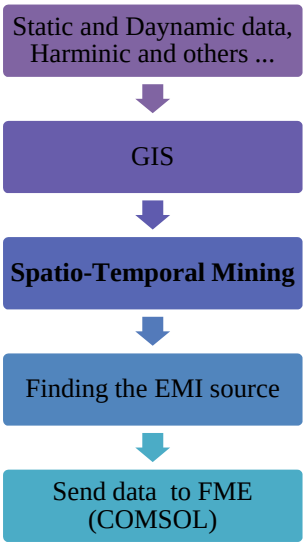

Fig. 9. Algorithm for study the electromagnetic compatibility

The total SE depends upon the absorption losses *A* and the reflection losses *R* in the following way:

$$SE = A + R + B \text{ [dB]} \quad (3)$$

B being is a term related to re-reflection (it is always negative). A, R, and B expressions exist on [11].

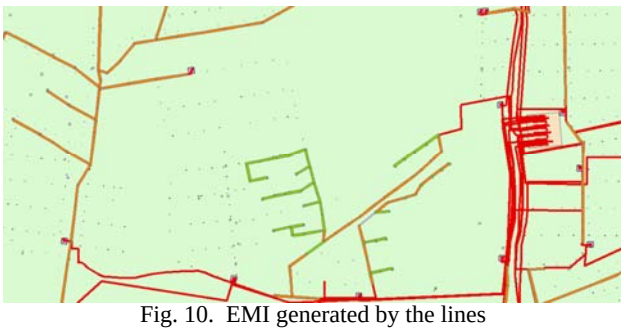

Fig. 10. EMI generated by the lines

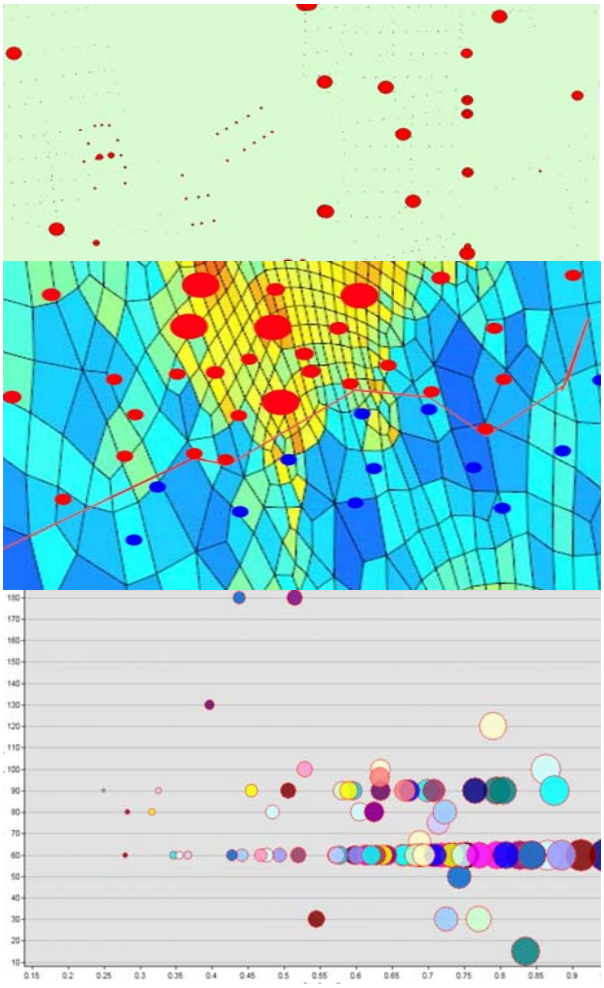

Fig. 11. Simulation the EMI source on FME software (COMSOL)

CONCLUSIONS

It is very important to forecast "*Where is the EMI source*" for electric utilities in a competitive environment created by the electric industry. In this paper, the proposed main mining tasks include clustering method and spatio-temporal mining technique. The proposed classification method discovers electric EMI source in multiple time granularities and different localities. As a result, spatio-temporal mining based classification. In this article, a two-dimensional finite element model for both the EMC and EMI solutions inside a power distribution system has been presented. Also, Spatio-Temporal application of technology in power distribution network was introduced and communication between GIS and software in Power Company was defined.

When we have a large network that has EMI source, can't find the location without software algorithms. This article jointed three software with smart algorithm to finding the location of the EMI source. After finding that, we can decision on the EMC.

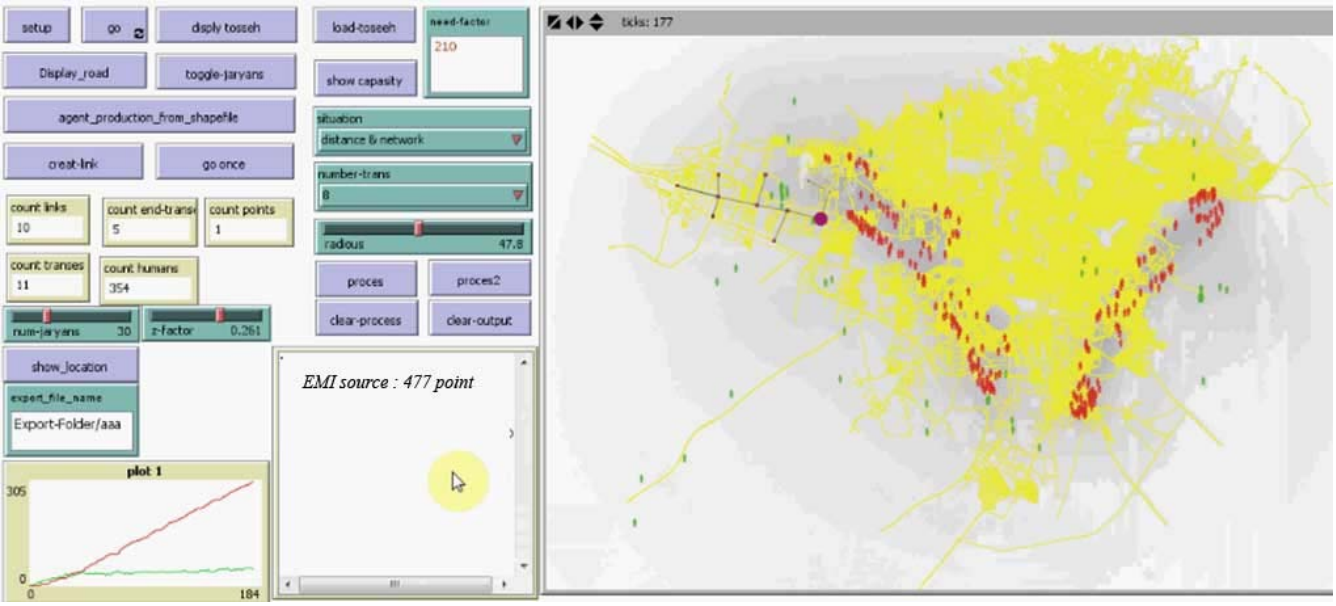

Fig. 11. Spatial- Statistic analyzing the source of the EMI

Acknowledgments

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