ITISE 2018

International Conference on Time Series and Forecasting

PROCEEDINGS OF PAPERS

Volumen 1

ITISE 2018
International Conference on Time Series and Forecasting

Proceedings of Papers
19-21 September 2018
Granada (Spain)

Editors and Chairs
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I.S.B.N: 978-84-17293-57-4
Legal Deposit: Gr 1165-2018
Edit and Print: Godel Impresiones Digitales S.L.

Preface

We are proud to present the set of final accepted papers for the fourth edition of the ITISE 2018 conference "International work-conference on Time Series" held in Granada (Spain) during September, 19-21, 2018.

The ITISE 2018 (International work-conference on Time Series) seeks to provide a discussion forum for scientists, engineers, educators and students about the latest ideas and realizations in the foundations, theory, models and applications for interdisciplinary and multidisciplinary research encompassing disciplines of computer science, mathematics, statistics, forecaster, econometric, etc, in the field of time series analysis and forecasting.

The aims of ITISE 2018 is to create a friendly environment that could lead to the establishment or strengthening of scientific collaborations and exchanges among attendees, and therefore, ITISE 2018 solicits high-quality original research papers (including significant work-in-progress) on any aspect time series analysis and forecasting, in order to motivating the generation, and use of knowledge and new computational techniques and methods on forecasting in a wide range of fields.

The list of topics in the successive Call for Papers has also evolved, resulting in the following list for the present edition:

1. **Time Series Analysis and Forecasting**.
   - Nonparametric and functional methods
   - Vector processes
   - Probabilistic Approach to Modeling Macroeconomic Uncertainties
   - Uncertainties in forecasting processes
   - Nonstationarity
   - Forecasting with Many Models. Model integration
   - Forecasting theory and adjustment
   - Ensemble forecasting
   - Forecasting performance evaluation
   - Interval forecasting
   - Econometric models
   - Econometric Forecasting
   - Data preprocessing methods: Data decomposition, Seasonal adjustment, Singular spectrum analysis, Detrending methods, etc.
2. **Advanced method and on-Line Learning in time series**.
   - Adaptivity for stochastic models
   - On-line machine learning for forecasting
   - Aggregation of predictors
   - Hierarchical forecasting
   - Forecasting with Computational Intelligence
   - Time series analysis with computational intelligence

- Integration of system dynamics and forecasting models

3. **High Dimension and Complex/Big Data**.
   - Local Vs Global forecast
   - Techniques for dimension reduction
   - Multiscaling
   - Forecasting Complex/Big data

4. **Forecasting in real problem**.
   - Health forecasting
   - Telecommunication forecasting
   - Modelling and forecasting in power markets
   - Energy forecasting
   - Financial forecasting and risk analysis
   - Forecasting electricity load and prices
   - Forecasting and planning systems
   - Real time macroeconomic monitoring and forecasting
   - Applications in: energy, finance, transportation, networks, meteorology, health, research and environment, etc.

After a careful peer review and evaluation process (each submission was reviewed by at least 2, and on the average 3.2, program committee members or additional reviewer). In this proceedings we are presetting the abstract of the contribution to be presented during ITISE-2018 (accepted for oral, poster or virtual presentation,according to the recommendations of reviewers and the authors' preferences).

In this edition of ITISE, we are honored to have the following invited speaker:

1. Prof. Dr. Peter M Robinson , Tooke Professor of Economic Science and Statistics Department of Economics, London School of Economics .
2. Prof Andrew C. Harvey, Emeritus Professor of Econometrics in the Faculty of Economics, University of Cambridge, and a Fellow of Corpus Christi College.
3. Prof. Salah Bourennane, Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, Marseille, France.
4. Dr Karsten Webel, Deutsche Bundesbank, Central Office, Directorate General Statistics Germany.
5. Prof. Dr. Robert Kunst, Professor of Economics at the University of Vienna and affiliated with the IHS (Institute for Advanced Studies) .
6. Prof. Dr. Uwe Hassler, Applied Econometrics and International Economic Policy. Goethe University Frankfurt .

During ITISE 2018 several Special Sessions will be carried out. Special Sessions will be a very useful tool in order to complement the regular program with new and emerging topics of particular interest for the participating community. From the organization of ITISE, we would like to thank deeply the great work that the organizers of Special Sessions do. Thank you very much for your great effort and interest.

Special Sessions that emphasize on multi-disciplinary and transversal aspects, as well as cutting-edge topics are especially encouraged and welcome. and in this edition of ITISE 2018 are the following:

1. *Forecasting Evolution*, Prof. Philip Gerrish, School of Biology, Georgia Institute of Technology, 310 Ferst Dr, Atlanta, GA 30332 .

2. *Forecasting Climate Weather and Operation Impact on Reliability, Safety and Resilience of Critical Infrastructures*, Prof. Krzysztof Kolowrocki, Gdynia Maritime University, Poland, and Prof. Joanna Soszynska-Budny, Gdynia Maritime University, Poland

3. *Applications of time series for hydro-climatic data*, Prof. Bruno Remillardi, Professor at HEC Montral. Consultant at the National Bank of Canada and Prof. Bouchra R. Nasri .

4. *Times series analysis in geosciences*, Prof. Eulogio Pardo-Igzquiza, Professor at Instituto Geolgico y Minero de Espaa (IGME) and Prof. Francisco Javier Rodrguez-Tovar, Depart. Estratigrafa y Paleontologa, University of Granada, Spain.

5. *Forecasting in High Dimension and Complex/Big Data* , Prof. Dr. Luis Javier Herrera and Prof. Dr. Ignacio Rojas , Dep. Computer Architecture and Computer Technology, University of Granada, Spain

6. *Quantum Computing*, Prof. Peter Gloesekoetter, Fachbereich Elektrotechnik und Informatik, Stegerwaldstrae 39, 48565 Steinfurt, Germany. and Dr. Bernd Burchard, Elmos Semiconductor AG, Germany.

7. *Computational Intelligence methods for Time Series*, Prof. Dr. Hctor Pomares , Dep. Computer Architecture and Computer Technology, University of Granada, Spain and Prof. Dr. German Gutierrez , Dep. Computer Science, E.P.S. University Carlos III of Madrid, Spain

8. *Structural Time Series Models*, Prof. Dr. Fernando Rojas , Dep. Computer Architecture and Computer Technology, University of Granada, Spain

9. *Recent Developments on Time-Series Modelling*, Prof. Dr. Olga Valenzuela, Applied Mathematics, University of Granada, Spain

10. *Expert Systems with Time Series - Data*, Prof. Dr. Kalle Saastamoinen , Department of Military Technology, National Defence University,Helsinki, Finland

11. *Spatio-temporal brain dynamics in attention tasks*, Prof. Dr. Juan Manuel Grriz , University of Granada, Spain, and Prof. Dr. Pedro A. Valdes-Sosa , Cuban Neurosciences Center and Prof. Dr. Csar Germn Castellanos Dominguez , Universidad Nacional de Colombia

This new edition of ITISE was organized at the Universidad de Granada, with the help of the Spanish Chapter of the IEEE Computational Intelligence Society and Spanish Network Time

Series (RESET). We wish to thank to our main sponsor the institutions Faculty of Science, Dept. Computer Architecture & Computer Technology and CITIC-UGR from the University of Granada for their support. We wish also to thank to the Dr. Veronika Rosteck and Dr. Eva Hiripi, Springer, Associate Editor, for their interest in the future editing a book series of Springer from the best papers of ITISE 2018.

We would also like to express our gratitude to the members of the different committees and to the reviewer for their support, collaboration and good work.

September, 2018
Granada

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Data Mining Applied for Performance Index Prediction in Highway Long Segment Maintenance Contract

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Abstract. The dynamics of the national road service level in Indonesia was quite high. There is a significant difference between segments and different areas, even within the same area there is a different variation of level service. These conditions encourage the Directorate General Highway to make up a new concept, by doing a long segment contract that handles national road in a single integrated contract. However, the limited budget and the poor handling of distribution pattern will cause a bad implementation of a long segment contract. Two-objective optimization models consider maximum Performance Index and minimum maintenance cost. The study was conducted on the entire national road network in the Jakarta Metropolitan 1 are paved with the flexible pavement. In the proposed approach, data mining models are used to predicting the performance index over a given period of time. Preventive maintenance is chosen in this study. Multi-objective optimization models were developed based on the Simplex Method. The limited budget and effective targets are the two constraints in the developed models. Based on the R-Tools result, the optimal solutions of the two objective functions are Obtained. From the optimal solutions represented by index performance and cost, an agency more Easily Obtain the information of the maintenance planning. The result of the proposed development models can provide the optimal budget distribution for each segment in a long segment contract.

Keywords: Data Mining, Long Segment, Preventive Maintenance, Performance Index

1 Introduction

The road network is planned, constructed and maintained to facilitate transportation with safe, comfortable, and efficient. To realize these goals, within a recent decade's pavement management system continues to be developed. For example, the United States developed a pavement management system through the American Association of State Highway Officials (AASHO) in the late of 1950s [1]. At that time not only, the

adfa, p. 1, 2011.

developed countries are to develop a pavement management system. Through the help of the World Bank, pavement management systems in the developing countries still continues to be improved by developing the Highway Development and Management (HDM) since 1966. On the development progress, HDM calibrated according to the conditions and standards that apply in each country. Since 1994 until now HDM-4 was developed to respond to the global demands in the road sector which are complex, including pathway safety, environment, and energy, beside to the management aspect [2].

Over time, the purpose of a pavement management system continues to branch out. At the first stage, the government as the organizer of the road continues to increase the functional capacity of the pathway. But currently beside to increase the capacity of the pathway, pathway organizers must meet the higher expectations of road users in the form of comfort, convenience, and security. Related to the organizers of the main road and all stake holders should continue to develop themselves to maintain, expand and improve the performance of the network system of the existing road. One step to achieving this purpose need a better management system so all the existing resources can be optimized. Through the current approaches was assisted by modern mathematics and computer technology, the budget allocation as one of the resources for the improvement of the road pavement management system that can be implemented more efficiently [3].

Pavement management system is done in sustainable, begin from design, planning, construction, operation, maintenance, to control. All stages in the cycle of pavement management system have a role that all was important. Stages of pavement management system have a significant effect in maintaining the performance of the road if done continuously over a long period [4]. It is influenced by the nature and character of the road pavement structure can be patterned with different approaches of data and other historical records.

In its development through the process of testing implementations, Directorate General of Highway (DGH) Indonesia to implement the Long Segment Maintenance Contracts (LSMC) in 2015 as a way to improve the standard of maintenance and replacing the self-management approach based on direct labor applied. These contracts include elements of compensation results is fundamental in the approach of Performance Based Maintenance Contract (PBMC) but the duration is shorter. Therefore, some of the difficulties associated with the contract form like PBMC can be avoided. It is expected with this LSMC, pavement management system in Indonesia is getting better. The performance of the main road became the main parameter in measuring the sustainability of LSMC requires a special attention.

Performance may be reduced in proportion to the increasing age of the pavement and the traffic load [5]. In general, the age of the pavement is determined based on the cumulative equivalent standard axle (CESA) is expected across the road pavement, it was calculated from the start of the road pavement constructed, operated until the pavement is categorized as damaged (end ages of the plan). The decline in overall road performance of the function increase traffic volume and traffic load, changes of environmental conditions, as well as other conditions [6].

Basically, the road pavement structural function can decrease with age. However, the function of pavement on the road network often suffer a structural damage prior to the age of the plan is achieved, due to various conditions during the operation. One of the phenomena that is common in developing countries is overloaded [7]. The condition occurs continuously without can be prevented. Due to limited modes of transport as well as the purpose of minimizing the transport cost that caused the road damage occurs sooner.

Before the damage reaches a lower layer, an indication of damage initiated by surface damage. The level of flatness and surface roughness change with road performance. The roughness of road is an important indicator because it directly affects the driver and the vehicle. The number or index flatness related to the amplitude and frequency distortion pavement, the suspension characteristics of the vehicle, and the vehicle speed. The condition of the road that is not a good flatness can reduce speed, causing potential damage to the vehicle, increasing the operating costs, and increase exhaust emissions [6].

The decline in road performance did not take place in real time, but gradually follow a function of time and a time series. The speed and shape changes in performance have certain patterns and trends. The collection of large amounts of data, it is necessary to be able to produce a good pattern and continuous [8]. Approach to new techniques and the use of the latest technology is necessary so that a set of data that has been collected through measurement Performance Index (PI) can be utilized in a structured and scalable to support pavement management system better roads through the interpretation and prediction of accurate data.

2 Study Literature

2.1 Long Segment Maintenance Contract

One of the difficulties divert the implementation of routine maintenance to the private sector in the short term is the lack of capacity of road contractors to handle the new load work. To support the contractor to take over the routine maintenance tasks, since the beginning of the LSMC was designed to reduce the risks and the financial exposure for the contractor to limit the term of the contract becomes one to three years; handling and great improvement work is determined by the DGH; using low-risk pricing structure with a combination of lump sum payments and the payments that adjust as PI for routine maintenance (similar to PBMC) and a payment schedule based on the rates for major maintenance work.

This LSMC is a milestone for achieving steady PBMC, by the way doing a new approach to the management of pavement without prejudice to the responsibility of the organizers of the road but changed the focus of the responsibilities organizers of the road radically. In a performance-based contract, the organizers do not need to set any details on how the contractor to achieve the desired results. The Road organizers will be required to be able to define the problem clearly, develop a methodology for determining acceptable performance indicators and measured in accordance with the mission of the organizers of the road, as well as developing objective performance evaluation system. Determination of performance indicators not only require engineering expertise micro multi fields but also can path the achievement of realistic macro indicators such as implied in the mission of the organizers of the road. The large projects with strong competition, long duration and extension periods, long outsourced road sections that incorporate crack sealing, pothole repair, illumination repair/maintenance, and mowing activities, favor outsourcing under PBC [9].

LMSC requires a culture shift service provider. Technical capability and innovation service providers in order to be competitive. The pattern of construction services business will also change with the increasing integration of the stages of design, construction, operation and maintenance. LSMC also requires a change in the culture of service users, given that most risks can occur due to the behavior of service users. Many assumptions used in the design of roads and bridges being care through various traffic regulation on road transport. One important example is the traffic loading. Disobedience of road users on the rules on Heaviest Loads axis (HLA) will cause uncertainty in the design of the structural strength. As a result, the reliability of the design will be decreased which leads to the risk of premature failure. This kind of risk is borne by the contractor if it would cause a sizable premium and a burden on the budget. This would complicate the handling strategy and budgeting road, given the uncontrolled rule violations have an uncertainty broad space due to loss of control boundaries.

One of the main objectives of this LMSC is the ongoing maintenance activities in order to maintain the conditions, the capacity of the road network services that have been built so that it can meet the needs of users as well as users of the road. Through the work of maintaining the condition of existing roads to be kept in a steady state. Thus, the minimum level of service in accordance with the Minimum Service Standards, also the design life of the road can be met as well as the performance of the road will be restored to the initial condition at the time of construction. In order to maintain the service road, streamline maintenance of roads and ensuring the maintenance costs, we need a contract innovation such as performance-based contract, the expected implementation constraints that would be solved.

2.2 Artificial Intelligence

Interpretation and prediction data is one of the important things in a pavement management system. Big sets of data into information without meaning only if no interpretation and the right and accurately prediction. In connection with this, we need a model that can provide a good approach to the process of interpretation. Data mining (DM) is a widely used approach to the interpretation of data in various disciplines. Through an approach to artificial intelligence (AI), DM has a huge potential to assist in the interpretation and prediction [10]. Utilization of AI in a group of civil engineering science has been done by Terzi [11] to compile a predictive model pavement serviceability index (PSI) and surface distress index (SDI). Furthermore, Zhou [12] to develop models of geographic information system (GIS) road maintenance; the development of predictive models of jet grouting [13]. In literature searches were performed, until now the approach to AI and DM techniques have not been developed for predictive modeling PI on LSMC.

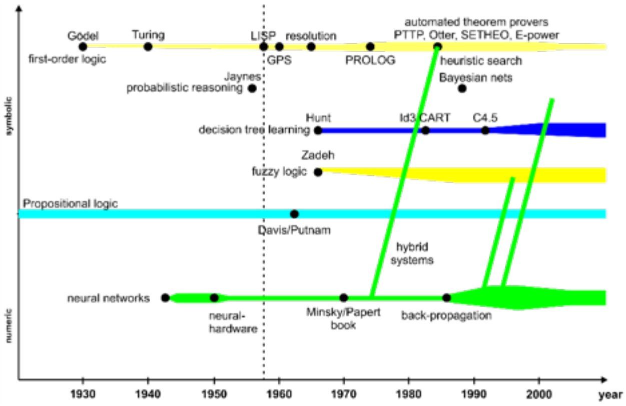


Fig. 1. Development of Artificial Intelligence [13]

Soft computing method performed by imitating the processes that found in nature, such as brain and natural selection [14]. Soft computing techniques allow the processing of data with uncertainly, imprecise and ambiguous. In the early mid-1960s, a new branch of computer science began to attract the attention of much of scientists. This new branch, known as AI, can be defined for the study of how to make computers able to push the quality of people jobs to get better. To achieve these objectives, the computer developed by imitating human behavior. In 1970 AI is more focused on the development of expert systems are designed to support decision-making through opinions of experts computed. Then, in the 1990s there was a shift of AI development, that is studying the various issues directly from the data [15]. Until now AI continues to grow and includes several methods and solutions across a science. In figure 1 we can see the development of AI in various areas of science. AI development began in 1970 is growing, characterized by the melting of numeric and symbolic approaches are complementary.

The development of the information technology industry is very fast, scientific data collection was growing rapidly. Databases in large size is not a problem if it can take advantage of computer technology with a range of major applications and supporters. All data has been collected and stored in a database that can either be a very valuable knowledge that can be used to support making decision and optimization of an action. Classical statistics have limitations to doing the data analysis with a large number or when the function of the complex relationship between the variable data. To overcome these limitations, need to develop tools of computer-based data analysis with greater capabilities and automatic [16]. This field is formally defined as knowledge discovery from databases (KDD). Wang [17] mentions in its development is increasingly recognized by the term KDD DM. Furthermore, in this dissertation, DM terminology is often used as a synonym of KDD.

2.3 Data Mining

Understanding of scientific fields plays an important role in the success of designing algorithms DM. The database was only a set of data without meaning if it is not done with the right algorithm approach [18]. Furthermore, Fu also said that the results of a review conducted in the last few years, the ability of DM growing in a particular domain and depends on the number of researchers who continuously develop specific algorithms. In the simple case, science can help identify the right features for modeling the underlying data compilation and database Scientific knowledge can also help design the business objectives that can be achieved using in-depth analysis of the data base.

One of the steps in developing the model prediction performance of the road pavement management system is processing the road condition data in a process to establish a data mining KDD poverty. DM is combined logically with the knowledge of the data, and statistical analyzes were developed in the knowledge business or a process that uses statistical techniques, mathematics, artificial intelligence, imitation and machine-learning to extract and identify useful information to the associated knowledge of a variety of large databases, In the stages of KDD, DM algorithm equipped with the dataset that used for learing-phase, to be developed into a data-driven models. The model can be described as the relationship between inputs and outputs, which can provide useful information. DM operation in developing the model hereinafter referred to DM task.

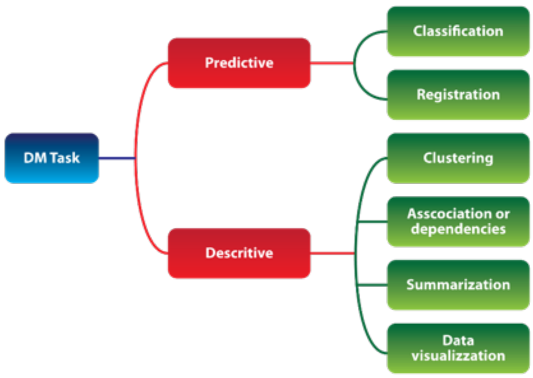


Fig. 2. DM Task

DM task is based on the ability of DM in solving various problems with interpretation and other statistical operations on the data [19]. Depending on the type of pattern is found, DM task usually classified into two categories, predictive and descriptive. Predictive Approach doing inference on the data to predict the values of the unknown variables of output, considering the known values of the input variables [20]. While the descriptive approach to characterize and summarize the general nature of the data in order to improve understanding and provision of information. The ability of DM task depends on the ability for users to do initial identification of a problem and goal completion.

DM classification task is one of the most frequently to used and have the purpose of finding a model that can classify data into each class. Trained model must be able to classify the data into groups based on the attributes of certain data [21]. The model used for classifying usually constructed using a set of supervised learning. Figure 1 summarizes the DM task that is used today. Various task developed in DM largely based statistical approach applicable in general, so it is easy to understand description. Some DM algorithms are mostly used in the classification task on a decision tree, neural networks and support vector machines. The model ability to perform his function to classify with classification metric [22].

2.4 Pavement Maintenance Optimization

Optimization approach in a pavement management system is needed to optimize the limited resources to meet the needs of road pavement maintenance that continues to grow. In a simple understanding, optimization involves a variety of resources to maximize or minimize the objective function of several binary, integer decision variables considering the inequality constraints. Modeling results generated through engine modifications iteration still need improvement so that the number of input variables formed by fuzzy approach is more accurate. Model optimization is not only used in the maintenance of pavement but is also used to get the optimal planning, one of the models that exist today is the integration of genetic algorithm with a geographic information system the way to get the alignment is optimal [23] and [24].

An obstacle to the single-objective function is rare in road pavement management problems. In a pavement management system is precisely the various objectives and constraints to be resolved at the same time. The objective can be achieved more than one and contradictory, so it needs to be optimized simultaneously or by minimizing some objective function. Single-objective optimization approach, the idea of optimization with the goal of minimizing or maximizing a certain objective value [25]. While the approach of Multi-Objective Optimization (MOO) is consists of two or more objective that needs to be optimized. In development MOO approach is more developed, due to various constraints and objectives more dynamic. MOO approach can be used to perform flexible pavement optimization with overload and can be developed with a variety of the others approaches [26].

3 Methodology

The basic principle of LSMC is to maintain the serviceability level of the pavement with the available resources and budget. To obtain a good result, the policy maker efficiently utilizes the existing resources, by optimizing the equipment, materials, personnel, methods, and costs. Moreover, policy maker can also plan a cost-effective and efficient method by considering the priorities and the schedule of routine maintenance, major rehabilitation and or reconstruction. But when faced with the extensive national road network and its constraints, this method of optimizing is considered as a difficult task. A systematic and well-concept effort is needed so that business-process maintenance management can run smoothly and measurable. The systematic process can be started with the identification of the problem, pavement performance prediction, deterministic formulation, and optimization process itself.

3.1 Performance Index Prediction

One of the basic issue in pavement management system is the development of performance or deterioration prediction models. Several performance prediction models have been proposed over the years, some of which are simple and others more complex. The success of a maintenance management process in LSMC depends on the performance prediction, executed by the system. To enhance the performance of PMS, successful prediction of pavement performance is of primary importance. The researcher will conduct the PI prediction models based on Support Vector Machines (SVM), which are empirical (data-driven) methods, while the occurrence of the fatigue cracking was predicted by a mechanistic-empirical procedure. SVM is one of them popular method approach in Data Mining (DM). DM aims at the extraction of useful knowledge from raw data and it is receiving an increasing attention by the both the research community and industry. Indeed, many case studies suggest that companies are increasingly investigating the potential of DM technology to deliver competitive advantage [27]. The success of the development of the IRI model can be used to use the existing data to support the management of the road network with the Pavement Management System in the road network of West Java [26]. Then, with SVM approach, IRI prediction is implemented to separate the road networks which affected by the normal load and overload. The model shows a great influence of the truck overloads identified on the road network evaluated [26]. DM in R-Project for statistical computing (R-Tools) is an open-source computational environment and high-level language that integrates powerful statistical and graphical features for data. R-Tools adopts a very flexible and object-oriented design [10]. The tool can be easily extended by the creation of packages. PI prediction model was developed from *rminer* library with the inclusion of several variables such as crack, pothole, and rutting.

3.2 Deterministic Formulations.

This study has a multi-objective, namely maximizing level of service as measured by the PI and minimize the cost of maintenance. Further, the model developed by including the variables of overload and life cycle cost in a multi-year budget.

3.3 Performance Index Maximization and Maintenance Cost Minimization

As described in pavement condition section, a smaller value of PI is indicated better road performance, as written in (Eq. 1). In addition to maximizing serviceability level road with a target value of PI biggest, the agency also should minimize the budget that will be used for maintenance costs. In the (Eq. 2), it is described that the budget used for the maintenance of any treatment depends on the unit cost multiplied by the length of the segment roads.

$$\text{Maximize:}\left(\frac{1}{\sum_{i=1}^{n} d_i}\right) * \sum_{i=1}^{n}(d_i * \sum_{t=1}^{m} PI_{it}^{1} * x_{it}) \geq \ average_{PI} \quad (1)$$

$$\text{Minimize: } \sum_{i=1}^{n} 0 \sum_{t=1}^{m} C_{it} * x_{it} \leq B \quad (2)$$

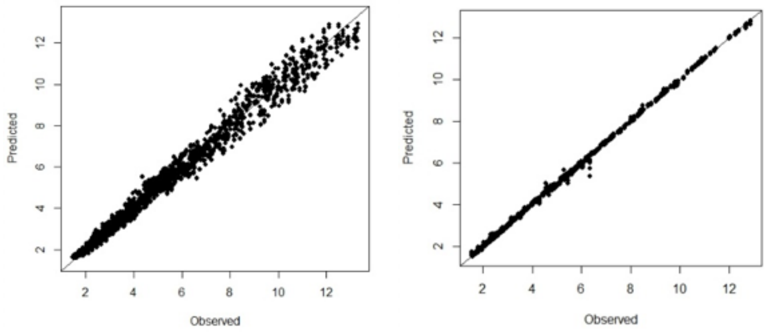
Where
d_i= distance weight parameter to pavement segment i
n= total number of pavement segment of the network
m= total number of pavement management treatment options
t= type of treatment options
PI_{it}^{1}= PI value one year later for treatment t applied to pavement segment i
x_{it}= if treatment t selected to pavement segment i
$average_{PI}$= predefined pavement network average PI level
c_{it}= cost parameter of treatment t selected to pavement segment i
B= budget level for pavement LSMC

4 Experiment and Discussion

As the case study, the national road network in the Metropolitan 1 Jakarta – Indonesia is selected. The road network in Metropolitan 1 has a fairly complete characteristic. The northern part is characterized by the presence of the northern corridor of Java Island that serves as the main transportation lines and this corridor is passed by all types of vehicles. West Java's northern coast line connecting the port city of Jakarta with other cities in Java such as Cirebon, Semarang and Surabaya. In addition, there is south corridor marked by big city transportation character.

4.1 PI Prediction Model

Using DM with SVM model will result in predictive PI value obtained for each road segment on the national road network in Metropolitan 1 Jakarta. In this work, we used the rminer package of the R tool to train the SVM model. For each model, a total of 1.000 runs of a 20 cross validation procedure were applied. The predictive results (measured over unseen data) are shown in terms of observed versus predicted scatterplots. In such scatterplots, the better the predictions, the closer they are to the diagonal line (perfect model). Figure 3 the scatterplots of PI predictive models, revealing a good fit.



a. Learning b. validation stage

Fig. 3. Target PI values versus SVM PI outputs

Figure 3 (a) is some scatterplots showing the results of the learning stage modelling learning stage with total amount of 1100 data, and Figure 3 (b) is an iteration for validation stage. The computed regression error metrics, in terms of the Mean Absolute Deviation (MAD) 0.62 ± 0.01, Root Mean Squared Error (RMSE) 0.72 ± 0.02 and coefficient of determination (R2) 0.89 ± 0.02. The lower the MAD and RMSE values, the better the predictive model, while a perfect model should have an R2 value close to 1.0. The results are presented in terms of the average of the runs and with the respective 95% confidence intervals according to a t-student distribution. Analyzing the results it is clear that a good fit was achieved by the SVMs model.

4.2 The Developed Optimization Model

Stochastic Optimization approach can be used to determine the model of Pareto Solution to obtain the optimization of PI value and the maintenance costs. The post-optimization decision making, or the methods used to choose the final solution are also illustrated by the model application. In this research, the optimization is conducted for various maintenance scenarios. The optimal maintenance programs are selected by using the Pareto approach. Pareto approach is an approach to choosing the pattern of maintenance with the closest distance to the axis 0 (Fig. 4).

In the optimization phase, the maintenance scenario is performed by iteration, utilizing the tools provided by the R-Tools by performing simulations tiered generation. Maintenance Scenario is conducted gradually refers to the DGH standard scenario, in sequence and then combined to achieve the optimum point is called the Pareto optimality and the shortest normalized distance.

In this optimization stages, the scenario maintenance is performed by iterating utilizing the tools provided by R-tools by conducting simulation tiered generation. Scenario maintenance done gradually consecutively then combined to achieve the optimum point is called Pareto optimality. The pattern of Pareto optimization approach is done by transformation with the first generation. This is consistent with Pareto's theory, that a small percentage (20%) of the causes of the problems giving a potential settlement of the majority (80%) issues. In the optimization of road maintenance, known indicator value is the IRI. Expected by selecting the maintenance scenario that became a group-based index of Pareto, the pattern of maintenance costs being able to read the movement of the overall value of PI.

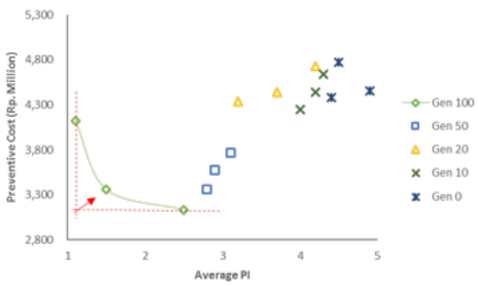


Fig. 4. Pareto Optimality

To simplify the optimization scenario in this research approach road conditions with 4 types of handling LSMC. Maintenance chose to achieve the best PI and use the available budget. With Pareto approach provided by optimx on R, obtained pattern maintenance activities of each segment and the prediction value predicted PI on each segment. Estimated value of PI obtained in LSMC period before (original) and after optimization (Opt1, Opt2, Opt3) can be seen in figure 5.

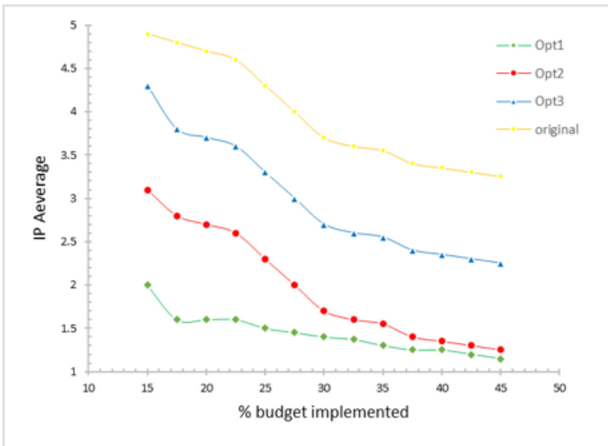


Fig. 5. PI optimization

Simulations carried out by iterating dynamically linked with the performance prediction model part way through iteration SVM models. The second main part is mutually connected and controlled with the subject equation (1) and (2). PI value to be come to a target in the simulation is the average value of PI most optimal road network with due regard to the minimum limit value PI on each segment. Iteration models show that the necessary steps to achieve this jump.

5 Conclusion

This study developed a model of multi-objective optimization in LSCM to generate an optimal scenario of pavement maintenance. A two-objective optimization model considers maximum PI and minimum maintenance cost. Both of these objectives are considered to be achieved simultaneously. Constraints faced is road deterioration that can accelerate the decline in the level of PI. Through the DM approach to obtain predicted PI, maintenance optimization is then performed by maintenance type that is received in each group of highway networks. The results showed the load factor group with preventive pavement maintenance scenario produces the most optimal financing.

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