Harmony Search, Soft Computing and Applications

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Extended Abstracts

Editors
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Preface

International Conference on Harmony Search, Soft Computing and Applications (ICHSA) is a prestigious academic event, where both potential and young researches are met to discuss their knowledge and study. In 2020, the venue of the sixth edition of the event was Istanbul, Turkey. Unfortunately, we must organize the event online due to Covid-19 outbreak because of travel restrictions and health care. The conference is online organized with the support of Istanbul University – Cerrahpaşa.

The abstracts of the presented papers of ICHSA 2020 can be found in this book. The proposed studies include novel algorithms, advance modification of harmony search or other algorithms, hybrid algorithms, machine learning and artificial intelligence applications in science, engineering and management, structural optimization, soft computing applications in engineering.

We are sad to not meet face to face in Istanbul and not getting together in social events. We wish to meet everyone in another event in future health days. Also, we welcome everyone to Istanbul to see all the beauties of the city.

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Control of a jacket platform under wave load using ATMD and optimization by HSA

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Abstract. Jacket platforms are life bloods of oil-rich countries and one of the well-studied offshore structures subjected to environmental loads. In the Persian Gulf, wave loads are the dominant load in designing procedure. Vibration control of jacket platforms is always one of the important issues for demanding requirements such as production activity, safety and serviceability. Tuned Mass Damper (TMD) is one of the well-established control systems in this context. The present study investigates the dynamic behavior of the Ressalat platform located in the Persian Gulf under the wave loads. An Active Tuned Mass Damper (ATMD) is employed for vibration control, while taking the actuator saturation into account. A fuzzy controller is applied to calculate the control force. Moreover, the Harmony Search Algorithm (HSA) is examined to optimize the power of the actuator in the control system. Results obtained through this study indicate superior performance of the proposed ATMD in comparison to the TMD, leading to significant reduction in vibration of the Ressalat platform under studied wave loads.

Keywords: Jacket Platform, Tuned Mass Damper, Harmony Search Algorithm, Fuzzy Control, Wave Load.

1 Introduction

In recent decades, different control strategies (i.e., passive, active, semi active or hybrid) have been extensively employed to suppress the response of offshore structures (e.g., jacket platforms, tension leg platforms, spar structures, floating production storage, offloading vessels and riser structures) subjected to dynamic lateral loads [1, 2]. Jacket platforms are life bloods of oil-rich countries and one of the well-studied offshore structures subjected to environmental loads. Tuned Mass Damper (TMD) and Active Tuned Mass Damper (ATMD) are employed in this study to control the vibration of Ressalat platform located at a depth of 68 m from surface and exposed to the Persian Gulf’s sea waves.
2 Mathematical model of Ressalat platform with ATMD and optimization procedure

A simplified lumped mass linear model is adopted for the Ressalat platform [3]. The lumped characteristics (i.e., mass and stiffness) were calculated according to the properties of the real structure such that the simplified model exhibited the same natural periods of the detailed model as reported by Mohajer Nasab et al. [4]. The equivalent seven degrees of freedom system is shown in Fig. 1, where the platform deck is located in the 7th level. The equivalent mass and stiffness values are presented in Table 1, and the damping matrix of the structure is considered as the Rayleigh damping while assuming 2% damping ratio for the first and second modes. The period of first mode is 2.34 second.

Table 1. Specifications of the Ressalat platform

<table>
<thead>
<tr>
<th>Ressalat platform</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Level 6</th>
<th>Level 7</th>
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<td>Mass (ton)</td>
<td>106</td>
<td>129</td>
<td>116</td>
<td>105</td>
<td>92</td>
<td>63</td>
<td>1790</td>
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<tr>
<td>Stiffness (MN/m)</td>
<td>179</td>
<td>146</td>
<td>146</td>
<td>121</td>
<td>106</td>
<td>90</td>
<td>38</td>
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<tr>
<td>Volume (m$^3$)</td>
<td>134</td>
<td>134</td>
<td>117</td>
<td>113</td>
<td>103</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Cross-Sectional Area (m$^2$)</td>
<td>227</td>
<td>238</td>
<td>213</td>
<td>209</td>
<td>191</td>
<td>35</td>
<td>0</td>
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Random wave and constrained new-wave theories are utilized in generation of the wave records [3]. A wave with a 100-year return period was assumed, with significant wave height, peak spectral period, and peak level of 5.83 m, 7.10 s, and 4.77 m, respectively.

Both the TMD and ATMD are assessed to control the vibration of the platform under defined wave loads. The assumed parameters for designing the TMD are presented in Table 2. A Fuzzy Logic Algorithm is applied for active control of the platform, with membership functions and relevant rules adopted from Shariatmadar et al. [5].

Harmony Search (HS) Algorithm is also implemented to optimize the amount of actuator power in active control. Reducing the maximum displacement of the deck during the vibration is considered as the objective function of the optimization problem.

Modeling and analyzing the uncontrolled and controlled structures are performed in MATLAB and SIMULINK soft wares. Additionally, the fluid-structure interaction, the effect of added mass due to accelerated motion of the body in the fluid, and the effect of actuator saturation are considered.
Table 2. Parameters for designing TMD

<table>
<thead>
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<th>Parameters</th>
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<tr>
<td>Structural Damping Ratio</td>
<td>2 %</td>
</tr>
<tr>
<td>Mass Ratio</td>
<td>3 %</td>
</tr>
<tr>
<td>Structural Circular Frequency</td>
<td>2.68 rad/s</td>
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<tr>
<td>Optimal Frequency Ratio</td>
<td>0.9639</td>
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<tr>
<td>Optimal Damping Ratio</td>
<td>0.106</td>
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3 Results and Discussion

The results presented in Fig. 2 indicate that the best response was obtained in less than 10 iterations by adjusting the parameters of the HS Algorithm appropriately.

A summary of various calculated normalized performance criteria (response of controlled to uncontrolled structure) for passive and active controlled platform, including normalized maximum displacement, velocity and acceleration of the deck level are shown in Fig. 3. In this figure, the blue and red colors represent the normalized structural response of passive and active controlled platform, respectively.

Passive control reduces the structural responses (displacement, velocity, and acceleration) by 7%, 7%, and 8%, respectively. Further reduction in structural response is observed with the active control, where the displacement, velocity, and acceleration values are reduced by 19%, 20%, and 26%, respectively. The results suggest that the vibration of the Ressalat platform is significantly reduced under studied wave loads, indicating superior performance of the proposed ATMD in comparison to the TMD.
Fig. 2. Convergence curves for the jacket platform

Fig. 3. Structural responses in different control modes

4 References


Performance of the whale optimization algorithm in space steel frame optimization problems

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Abstract. Frame optimization that contains highly nonlinear and irregular functions and discrete design variables is one of the most challenging optimization problems. Therefore, gradient-based optimization techniques cannot be successful in such problems. Metaheuristic techniques, especially population-based metaheuristic techniques, perform highly effective in solving the frame optimization problem. However, stochastic processes’ performances included in metaheuristic techniques vary based on problem. Accordingly, researches on the performance of novel metaheuristic techniques on challenging engineering problems continue. One of the novel metaheuristic techniques is the whale optimization algorithm (WOA) which is inspired by the bubble-net feeding behavior of humpback whales. The aim of this study is testing the performance of WOA for space steel frame optimization problems. For this purpose, WOA-based frame optimization program will be developed. Benchmark frame structures are selected to compare optimum solutions with literature results.

Keywords: Structural Optimization, Metaheuristics, Whale Optimization Algorithm, Steel Frames.

1 Introduction

Although Metaheuristic techniques quite effective to obtain solution of engineering design problems, their performances show different reactions time to time [1, 2]. According to the type of the problem, or the inputs of the optimization, the performance and thus the outputs can change. Therefore, the studies go on related to the performance of novel metaheuristic techniques, to overcome several engineering optimization difficulties. In this direction, recently one of the novel metaheuristic techniques is discovered. This is the whale optimization algorithm (WOA) which is nature-based and inspired by the bubble-net behavior of humpback whales. Since this up-to-date algorithm has advanced properties for solving such problems, we wonder the performance of this algorithm for frame optimization. Consequently, the main goal of this study is actually examining the performance of WOA for space steel frame optimization problems. In order to test the performance, a computer script which is based on WOA will established with an application of frame structure optimization. Measures will be selected from the
frame structures for the application and the results will be compared by the results produced in earlier related studies. Further, the discussions will be made on the outcomes of this research. Next, size optimization techniques will be explained utilizing steel frames. After that, the novel algorithm WOA will be detailed for our study, then a design example will be indicated with its main results explored. Last but not least, a conclusion will be presented.

2 Size Optimization of Steel Frames

Ideal optimization plan of steel space structures involves picking optimum pieces for its members from accessible steel segments rundown to fulfill the workableness, strength and geometric necessities expressed in the codes for design. Meanwhile, the structure is built inexpensively. For the most part, the optimization issues for enhancement have triple sections which are objective functions, structure factors as design variables and requirements as constraints. The scientific model of the design optimization issues reliant on the steel configuration code is considered by formulae and explained as follows.

\[
\text{Minimize } W(X) = \sum_{i=1}^{N_G} m_i \cdot \left( \sum_{j=1}^{n_i} l_j \right)
\]

Subject to

\[
g_s(X), g_d(X), g_{td}(X), g_{id}(X), g_{di}(X), g_{ce}(X), g_{bc}(X) \leq 0;
\]

where \( W \) represents the weight of structure, \( m_i \) is the unit weight of steel segment associated with the \( i^{th} \) group, \( n_i \) corresponds to the total member number for the group \( i \), \( N_G \) conforms to the total number of design sets, \( l_j \) signifies the length of \( j^{th} \) section in group \( i \), and \( X=[X_1, X_2, X_3, ..., X_{N_G}] \) denotes the sequence number vector for steel members picked for design clusters using standards characterized as the design variable of the size optimization. \( g_s(X), g_d(X), g_{td}(X), g_{id}(X), g_{di}(X), g_{ce}(X) \) and \( g_{bc}(X) \) terms respectively represent strength, deflection, top-story drift, inter-story drift, joint displacement, column to column geometric and beam to column geometric constraint functions.

3 Whale Optimization Algorithm

Whales are known as intelligent mammals. Among the kinds of whales, the humpback whales have unique behavior of hunting of prey. This special foraging behavior is called bubble-net feeding method [3].

Humpback whales mostly prefer to hunt krill and herds of small fishes close to the surface. It is observed that the humpback whales hunt in groups. They can detect how far the prey from herself and surround it. The leading whale dives and moves up with a circular or ‘9’-shaped path in approximately 10-15-meter-deep and starts to create several various sized bubbles [4]. All created bubbles rise to the surface at the same
time by forming a cylindrical or tubular bubble network. This spiral bubble net makes the prey collect toward the center of the net. So, the group of humpback whales reach to the prey by following this spiral path and swallow the prey in the net [5].

In 2016, Mirjalili and Lewis [6] proposed a sole objective algorithm which is a stochastic population based, nature inspired algorithm WOA inspired by the spiral bubble-net predation method of the humpback whales to catch their preys. Three typical behaviors of the humpback whales are used to model WOA mathematically.

The pseudo-code of the WOA algorithm is given below [6]:

Initialize the whales population $X_i$ ($i = 1, 2, ..., n$)
Calculate the fitness of each search agent $X^*$ = the best search agent
while ($t < $ maximum number of iterations)
    for each search agent
        Update $a$, $A$, $C$, $l$, and $p$
        if $1$ ($p < 0.5$)
            if $2$ ($|A| < 1$)
                Update the position of the current search agent by (13)
            else if $2$ ($|A| \geq 1$)
                Select a random search agent ($X_{rand}$)
                Update the position of the current search agent by (21)
            end if $2$
        else if $1$ ($p \geq 0.5$)
            Update the position of the current search by (17)
        end if $1$
    end for
    Check if any search agent goes beyond the search space and amend it
    Calculate the fitness of each search agent
    Update $X^*$ if there is a better solution
    $t = t + 1$
end while
return $X^*$

4 Design Example

Five story steel space frame which is taken from previous studies in the literature, having 105 members and 54 joints grouped into 11 independent design variables, is considered as the design example [7-8]. The steel frame is optimized 50 times using the WOA with various seed values. According to results, the lightest weight obtained is 258.416 kN which is derived by SJSSSO algorithm. The estimated weight by WOA is 1.44% more than the lightest weight attained from previous studies which have the same design circumstances. The WOA has the second-best performance among given algorithms by an optimum weight of 262.13 kN. Also, since maximum strength ratio has a value of 0.960 which is close to 1.00, it can be said that third load combination has a major role on design process.
5 Conclusion

Research are carried on which focus on the performances of up-to-date metaheuristic practices to solve a lot of puzzling engineering problems. One of them introduced recently, named WOA, is basically inspired by the hunting behavior characteristics of humpback whales. In this direction, this study examined the performance of WOA for a popular civil engineering problem of space steel frame optimization. For this reason, a WOA-cased frame optimization program was established. Accordingly, an application of benchmark frame structures was analyzed considering the measures selected from the frame structures. Then, a detailed comparison has been made for the optimum solutions inspecting the results possessed by the related studies previously. The same design circumstances as used in the earlier studies of the particular frame structure were used in our analysis. Although the outputs indicate that the lightest optimum structure weight was derived by the SJSSSO algorithm, the estimated optimum weight by WOA is only 1.44% more than the lightest weight. In this case, the methodology of WOA provided the second-best performance with an optimum weight of 262.13 kN compared to the other algorithms applied for the particular frame structure. Additionally, the maximum strength ratio derived by WOA has the value of 0.960. Therefore, the third load combination with WOA plays an important role for the design process.

References

Multi-Objective Optimization of the Reinforced Concrete Beam

Zhang, Zhi-Yu\textsuperscript{1} Zulkarnaen Gifari\textsuperscript{2} Ju, Young-Kyu\textsuperscript{3}\* Kim, Joong-Hoon\textsuperscript{4}\*
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Abstract. This paper introduces two kinds of Multi-objective optimization algorithms. The optimal values are determined through Multi-objective functions and various equality and inequality constraints. The optimal value results of the two algorithms with different parameters are discussed. A simplified optimization case of Reinforced Concrete Beam was discussed that minimizes the total cost of reinforced concrete beams while complying with all strength and serviceability requirements for a given level of the applied load. This paper focuses on the differences between Multi-objective Harmony Search Algorithm (MOHSA) and Multi-objective Genetic Algorithm (MOGA) for reinforced concrete beam design subjected to a specified set of constraints by considering aspects of the Harmony Memory Considering Rate (HMCR) parameters in HSA and Population Mutation (Pm) parameters in GA. Through HSA and GA for RC beam problem, with same reference strength, the result using GA has lower cost than using HSA.

Keywords: Reinforced Concrete Beam, Multi-objective Optimization, Harmony Search Algorithm, Genetic Algorithm

1 Introduction

1.1 Background

For the optimization design of reinforced concrete, the design method is to propose a design plan, and through mathematical analysis, to verify whether the requirements of the problem are satisfied.

The design of reinforced concrete beams is usually an iterative process. Firstly, the designer will assume the weight of the beam, determine the section of the beam, and then determine the resistance moment of the part in order to check whether it is suitable for a given applied bending moment. Repeat the process until finding the most
suitable section. Due to the weight of the beam, the resistance moment of the section and the applied bending moment cannot satisfy the requirements in this process, and the above problems also exist in many practical cases. However, this paper discussed the differences between Multi-objective Optimization HSA and Multi-objective Optimization GA for reinforced concrete beams by considering aspects of the HMCR parameters in HSA and Pm parameters in GA.

1.2 Multi-Objective Optimization

Multi-objective optimization problems show that the actual optimization problem involves not only optimizing one objective but simultaneously optimizing several conflicting objectives, include multiple objective functions to be optimized simultaneously and various equality and inequality constraints.

Generally, Multi-objective optimization problems include multiple objective functions to be optimized simultaneously and various equality and inequality constraints. This can be generally formulated as:

\[
\begin{align*}
\text{Min } & f_i(x) \quad i=1,2,3,4,\ldots,N \\
\text{S.t. } & g_j(x)=0 \quad j=1,2,3,4,\ldots,M \\
\quad & h_k(x)\leq0 \quad k=1,2,3,4,\ldots,K
\end{align*}
\]

(Adopted from S. Sivasubramani 2011)

Where N, M and K are, respectively, the number of objective functions, the number of equality constraints and the number of inequality constraints. And \( f_i \) is \( i \)th objective function, \( x \) is a variable representing the objective function.

2 Methodology

2.1 Case Study

Fig. 1. Illustration of RC beam

(Adopted from Hossain M 1989)

An optimization case that minimizes the total cost of reinforced concrete beams while achieving maximum strength, the illustration of RC beam shows in Figure 1.

As shown in Figure 1, the beam span is \( L \) (m), and the load including the beam weight is \( q \) (kN/m). The purpose of the design is to confirm the cross-sectional area of the reinforcement (As), the width of the beam (d), the depth of the beam (h), and the compressive strength of the concrete (fc).
The basic assumptions for the design of reinforced concrete are as following:
1. The yield stress of the reinforcing steel is Constant (355MPa).
2. The average compressive stress in the concrete is 0.85\(f_c\).
3. The effective depth is assumed to be \(d_e=0.8h\)
4. The bounds of the variables are \(100 \leq b \leq 600\text{mm}, 150 \leq h \leq 1200\text{mm}, 20 \leq f_c \leq 80\text{ MPa}\).

### 2.2 Objective Function

According to the price of Concrete and steel, defined the first Objective function and the structure should satisfy the ACI building code with a bending strength to defined the second Objective function.

\[
\text{Min: } f(As,b,h,fc)=0.0059*As + (1.0971*f_c + 56.891)*b*h/10^6
\]

\[
\text{Max: } 1/M(u)=1/0.9*As*fy*(d - a/2)/10^6
\]

The First Constraint is that the depth to width ratio of the beam is restricted to be less than, or equal, to 4.

\[g(x)=h/b-4\leq0\]

**Defined the Parameters of HSA and GA.** Compare the output codes by changing the HMCR parameter in the HSA, and Pm in the GA to compare the output data. The HSA parameters need to be defined:
1. Harmony memory size \(HMS=50\).
2. Harmony memory considering rate \(HMCR=0.7,0.8,0.9\).
3. Pitch adjusting rate \(PAR=0.2\).
4. Bandwidth \(BW=1\).
5. Maximum pareto size \(Ps=20\).
6. Maximum iteration \(MaxIter=1000\).

The HSA first generates \(M\) initial solutions and puts them into the harmony memory HM, where HMCR is the probability of selecting a harmony from the HM.

The GA parameters also need to be defined:
1. Population Size \(Ps=50\).
2. Population Crossover \(Pc=0.8\).
3. Population Mutation \(Pm=0.1 & 0.2\).
4. Maximum iteration \(MaxIter=1000\).

The mutation in GA is an auxiliary method to generate new individuals. It determines the local search ability of GA while maintaining the diversity of the population.

### 3 Result and Conclusion

#### 3.1 Result of Coding

Coding for the problem using MATLAB and obtain multiple sets of data by modifying parameters of HSA and GA.
Find the Optimization Point with the MOHSA and MOGA from the Fig 2. In the MOHSA the Beam size is that B=365mm, H=1116mm, fc=53MPa and Price=$104 and in the MOGA is that B=356, H=1118, fc=53MPa and Price=$99.

3.2 Conclusion

This paper focuses on the optimized design RC beam using MOHSA and MOGA by changing the parameters of HMCR and Pm. According to data comparison, with the same reference strength, the result using GA has a 5% lower cost than using HSA.

References

Wear Particles Classification using Shape Features

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Abstract. Wear debris provides important information about the machine condition that can be used to prevent the loss of expensive machinery. This information is crucial as it depicts the condition of the machines and can be used to predict early failure of the machinery which can prevent a major loss to the industry. Wear debris or particles produced in different parts of machine vary in shape, size, color, and texture. Human experts are extremely efficient in recognizing such objects however, wear judgments are occasionally based on their specific perceptions. The goal is to look beyond the personal opinions and bring consistency in judging and recognizing wear particles. This study focus on the identification of wear particles by using shape based features. Different shape features of Histogram of Oriented Gradients (HOG), Rotation Scale Translation (RST) invariant features, solidity, rectangularity, and thinness ratio, are extracted and used to train various classification models. The performance of the classifiers are compared to one another and the classification of debris is analyzed.

Keywords: Wear Debris, Particles Classification, Shape-Based Features, Histogram of Oriented Gradients, RST Invariant Features.

1 Introduction

Computer vision is one of the emerging fields that is influencing the automation industry since last few decades. Analysis of wear particles is one of the prime application areas of visual inspection systems that can provide essential information of machines condition. Manual analysis of wear debris is very time consuming and tedious, therefore, automated analysis is very useful for the experts to make key decisions in time. Wear particles are classified in many types however, automated classification of only six types of cutting, fatigue, fiber, severe sliding, non-metallic, and water are discussed. The aim of this paper is to identify particles by using only shape features.

2 Related Work

Several methods exist in literature to analyze and recognize the wear debris. Peng et al. have used deep neural network to identify fatigue, oxide, and spherical wear particles considering the case of overlapping particles. They have used transfer learning approach by using Inception-v3 model to extract features and classify the particles.
Li et al. have trained a single layered feed forward neural network by using Extreme Learning Machine technique to classify the wear particles based upon the shape, texture and color features [2]. Peng et al. have proposed a hybrid search-tree discriminant technique to discriminate oxide, fatigue, sliding, cutting and spherical wear particles [3]. Wu et al. have proposed an online fluid monitoring scheme for particles analysis [4]. Laghari et al. have proposed the Fourier descriptors based technique for the analysis of particles profile [5]. Laghari et al. have used the shape and edge details of the wear particles to devise an interactive image analysis system [6]. Yuan et al. proposed a radial concave deviation based method to determine feature parameters that are relevant to the size and shape of the wear particles [7].

3 Methodology

Object segmentation is the first step to extract its features, therefore, it is required to segment the particles in the images. Global thresholding is used to segment these particles from the background and noise is removed by means of area based filtering. The next step involves computing the features of the particles. These features include RST invariant features based on central moments, aspect ratio, circularity, Euler number, solidity, and HOG. RST invariant features are selected because they are one of the notable descriptors to characterize and describe the shape of an object. To compute the RST invariant features, it is required to calculate the central moments which are computed as:

$$
\mu_{ij} = \sum_x \sum_y (x-x')^i (y-y')^j I(x, y)
$$

where, x and y represents the coordinates of the pixel, and I(x, y) represents the intensity of the pixel. The central moments of the image are only translation invariant. They are also required to be made rotation and scale invariant. The scale invariance can be achieved as below.

$$
\eta_{ij} = \mu_{ij} / \mu_{00}^{(1 + i+j)/2}
$$

After achieving the scale invariance, central moments can be made rotation invariant by using the equations in [8]. The next task involves calculating the shape features like aspect ratio, Euler number, etc. To calculate aspect ratio of the particle, minor and major axis length is computed, and their ratio is used as the aspect ratio. Circularity is calculated as: circularity = \((4 \pi \times \text{area}) / (\text{perimeter}^2)\). Euler number is found by estimating the number of holes in the particle and subtracting the hole count from value one. The solidity is computed as the ratio of area of the particle and convex area of the particle.

HOG features are based upon local intensity gradient orientation which make them a good shape descriptor. Before computing HOG features, segmented particles are aligned on the major axis to avoid the effect of rotation. After aligning particles, image gradients are computed in the horizontal and vertical directions. Then, magnitude and phase of the gradients are calculated and HOG descriptor is computed using default parameters i.e. blocks size of 16 x16, cell size of 8 x 8 cells and nine evenly spaced unsigned bins.
After computing features of the particles, a multiclass Error-Correcting Output Codes (ECOC) model is trained by using linear SVM, k-Nearest Neighbors and pseudo linear Discriminant Analysis (DA) binary learners. SVM is used due to the optimal margin gap between the separating hyperplanes that give more robustness against outliers. Similarly, kNN can provide good accuracy as it groups similar objects quite well. The separability measure is also good for discriminant analysis based classifier. The coding scheme used for ECOC model is one vs one and the multiclass ECOC model predicts the output class as:

\[ k' = \arg\min_k \left( \frac{\sum_{l=1}^{L} |m_{kl}| g(m_{kl}, s_l))}{\sum_{l=1}^{L} |m_{kl}|} \right) \]

For linear SVM learners, ECOC model uses Hinge loss function whereas quadratic loss function is used for kNN and pseudo linear DA learners.

\[
\text{Hinge loss} = \max (0, 1 - y_is_i)
\]
\[
\text{Quadratic loss} = \frac{(1 - y_i (2s_i - 1))^2}{2}
\]

4 Experimentation Results

The software tools used for the experimentation are Matlab 2015a, and Computer Vision and Image Processing (CVIP) tools.

4.1 Dataset

The dataset used in this paper contains six types of wear particles including cutting, severe sliding, fatigue, fiber, nonmetallic and water particles.

4.2 Testing Procedure

Different combinations of features and classifiers are used to test the results of the proposed method. The performance of five feature sets and classifiers is evaluated by using cross validation accuracy. After making five feature sets, three models of multiclass ECOC classifiers are trained by using linear SVM, kNN and pseudo linear DA binary learners, respectively. The trained models are cross validated by using ten-fold cross validation. Then, k-fold loss is estimated from the cross validated model. The accuracy of each model is obtained by subtracting the k-fold loss from a value one and the results are shown in Table 1.

<table>
<thead>
<tr>
<th>Feature Set</th>
<th>Accuracy %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Linear SVM</td>
</tr>
<tr>
<td>RST Invariant features</td>
<td>22.2</td>
</tr>
<tr>
<td>HOG</td>
<td>22.2</td>
</tr>
<tr>
<td>Shape parameters</td>
<td>94.4</td>
</tr>
<tr>
<td>Shape parameters + RST features</td>
<td>83.3</td>
</tr>
<tr>
<td>Shape parameters + HOG</td>
<td>27.8</td>
</tr>
</tbody>
</table>
The Table shows that ECOC model trained by using third feature set (shape parameters only) and fourth feature set (shape parameters plus RST features) have good accuracy whereas other feature sets have very low accuracy results. This is due to the fact that wear particles have many variations in the shape within the same class that is affecting the local features like HOG. Conversely, shape parameters are depicting the overall trend of the shape i.e. elongation, convexity, number of holes, etc. Therefore, shape parameters are better in classifying the wear particles.

On the other hand, linear SVM and kNN have almost similar results whereas models based on linear DA learners have very low accuracy. The reason may be that linear DA assumes that all the groups are identically distributed and use all the data to estimate the covariance matrices that can be prone to outliers. In contrast, SVM and kNN do not make any assumptions about the data and give relatively better accuracy.

5 Conclusion

In this paper, automated classification of six types of wear particles is presented. It is observed that shape parameters are essential to categorize wear debris. It is also observed that shape features that are based on local intensity gradients do not perform well with wear debris classification.

References

Smart Academic Guidance for Institutional Students

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Abstract. Smart time conflict solvers and event time managers are some of the essential tools for educational institutions that can help students to attend events which might conflict with the lecture or other activity timings to gain advantage of the opportunities enriching their professional benefits. Generally, a university timetable has certain time conflicts that remain undiscovered until the time of students’ registration. Therefore, a smart and innovative approach in terms of a software package is implemented and described in this paper. The developed software uses smart and efficient searching methods for achieving an optimum time match between any group of students and under any specified constraints. Consequently, the devised event organizer can find an optimum time to allocate for the event by finding the best time at which the majority of the intended people are free for the event. In addition, students who struggle with time conflicts between two or more courses can also find the most suitable times in which their time conflicts are resolved. The software searches for classes by locating the time and courses intersections between all the students who are related to such conflicts. These time conflict processes are difficult to handle manually and may be prone to errors.

Keywords: Time Conflict Solver, Software Package, Educational Institution, Time Table, Event Management.

1 Introduction

Timetabling is an essential process for an educational organization, particularly in universities and institutions, due to the scheduling of large number of time-based events and lectures to be planned between large numbers of participants. Usually, the university or organization resorts to external services to handle such issues. One such online service is DegreeWorks that is currently in use by the United Arab Emirates University (UAEU). This web based service allows academic advisors and students to make study plans and add their required courses for all graduating semesters. This also ensures the course planners to indicate the exact number of students who will register each course in all planned semesters. However, it does not provide an automated scheduling and class time conflict solver. Hence, a student has to resolve time conflicts manually, which is both time-consuming and difficult to do [1].

Jadawil is another service that is currently being used by UAEU students. It is a website developed by an Electrical Engineering alumnus. It provides a reasonable number of
suitable time arrangements for any given set of courses. This is useful when there are many course selection choices for a student and it will also help in deciding which set of courses to consider. However, it does not relate the students’ data to one another and neither does it provide solutions to the time conflicts for the events. Hence, the students are not that much benefitted from this kind of service [2].

A third tool in use for event time scheduling by the University is Google Forms. It is a service that allows for the collection of data from the participants. Data collection is performed by sending a form link in which they are asked to register for a certain event or workshop by specifying their available times. After the data is collected, the activities department manually finds out appropriate time slots to suit the majority of students [3].

Although this process seems logical, it has many flaws. Primarily, asking the students to click on a link to fill in the necessary information greatly decreases the potential number of interested students. Moreover, in the case of large numbers of students’ registrations, the organizers find it difficult to choose ideal times based on the vast amount of data provided because it becomes too laborious.

Alternately, a random time of around 12:00 pm is chosen. This time selection is particularly the busiest in terms of the maximum number of lectures happening at the university. A more frequent scenario for the students is that multiple events or seminars may overlap with college lectures that cannot be avoided. As a result, the students may omit the chance to attend many interesting seminars and events that could benefit them in their professional life and career.

2 Related Work

Le Kang and George M. White proposed an approach based on logic programming to resolve the constraints in timetabling [4]. Victor A. Bandadym discussed the problems related to academic timetabling and proposed a classification for timetabling requirements, solution methods, mathematical models, data representation and interface design [5]. Elmohamed et al. compared the annealing techniques to tackle the problem of academic class scheduling and concluded that best results were obtained by using simulated annealing with adaptive cooling and reheating as a function of cost [6]. S. M. Selim proposed the modified Almond’s algorithm to construct the university faculty timetable [7]. S. Kadry and B. Ghazal described a solution for exam scheduling by using Maximal Independent Set, Multi Criteria and Heuristic Graph [8]. V. J. Kadam and S. S. Yadav briefly described the problems related to academic timetable scheduling in [9].

3 Methodology and Framework

3.1 Bitwise AND Operation Implementation for Student Data storage

Database management is important to any software that has multiple fields of data as well as the way the database is organized, and the significance of the data type to the
operation of the software. The main challenge in this project was to figure out how the
students free times and schedules were saved and optimized such that it needed the least
number of processes to visualize or compare to other free times.
The process starts by dividing the 24 hours day to 30 minutes time slots resulting in 48
time slots array to represent different time periods within a day. Starting from the left
most digit or time slot, this array of times are filled with ‘1’ s or ‘0’ s depending on the
intended task. For storing student’s free times, a ‘1’ represents a free time slot while a
‘0’ corresponds to a busy or scheduled time slot. The leftmost slot corresponds to 00:00,
the next one corresponds to 00:30 and so on. For instance, if only the leftmost time slot
is filled with one, and the rest are filled with zeros, the student is said to be free from
00:00 to 00:30 (12:00 am to 12:30 am).
The next step is to convert this array of ones and zeros to integer number however, the
integer number accepts at most a 32-bit binary number. Therefore, the morning period
of a 24 hour whole day is divided to start at 00:00 and end up at 12:00, and corresponds
to the time slots from the leftmost slot up to the 24th time slot (moving from left to
right). The Evening period starts at 12:00 noon and ends up at 00:00. Notice that starting
at 8:00 morning (leftmost slot) is more convenient however, it is found that starting at
00:00 makes the process of converting the user input representing the free time to binary
number easier. The conversion process takes place as following:
1. Get the start time and end time from the user. The format is (hour: minutes).
2. The first time slot corresponds to 00:00, from array point of view, the index is zero.
   So, if starting hour is multiplied by two, the exact start index is known in the times
   array. So, for any starting hour with minutes = 00. The start index = start hour * 2.
   Alternatively, if the minutes is between 1 and 30, then it is assumed that the student
   is unavailable for this time slot. A ‘1’ is added to the calculated start index, and the
   start index = start hour * 2 + 1. If the starting minutes is somewhat between 31 and
   59. Then, a 2 is added to start time so the next hour is taken as a starting point.
3. For the end time index, it is the same except that a ‘1’ is subtracted from the calcu-
   lated index. For instance, if the student decides that the end time is 10:48, then the
   actual end time to the system is 10:30, because an assumption is made from the
   beginning that the student is either available or unavailable for the whole time slot
   (30 minutes).

3.2 Student Information Interface

The second phase involves designing a simple graphical user interface (GUI) so that
student data can be entered in a more convenient way. The software takes the student
name, ID, email address, mobile number, college, and department. The same GUI is
used to get instructor data. The data set to be used to prove the concept consists of nine
courses which are Calculus I, ESPUI, Chemistry, Physics, Biology, Finance, Economics,
Marketing, and Supply Chain. There are five instructors, and their names, courses
and classes times. There are 15 students, and their names and courses. The GUI is de-
veloped keeping in mind, that the student free times are stored in the system; other
times are assumed to be occupied either by courses or other activities.
4 Applications to Real World Problems

4.1 Event Organization

All over the world, universities organize several events across the academic year which are mainly students-based events with students as the major audience or attendants. As mentioned earlier, the university uses Google form to ask the students for their available times, and then a manual matching process takes place. This manual process can be automated in such a way that an optimal event timing can be found; hence attendance to the events are maximized. The algorithm to do this automatic matching is as follow:

1. Identify the group of students to find the best time match for them.
2. Specify the time constraints for the search (starting time and ending time and day).
3. Apply the filter.

The software retrieves all the specified student’s free times, and do a bitwise operation with the integer number resulted from the conversion of the specified period for search.

"SELECT * FROM StudentInformation WHERE SundayMorning & " + Specified-TimePeriod + " > 0 AND College = " + college + " AND JobTitle = 'Student'".

This statement returns the students who are free in the specified time. Only one statement is needed to find out the results quickly and accurately. This algorithm can be applied to any time matching process. The only remaining thing is to add more constraints to find out the best time for any given set of students.

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