Research Highlight 1: The Heuristic Algorithm of Stacking Layer for the Three-Dimensional Packing of Fixed-Size Cargoes, by Dr. LIU Wangsheng (Track Leader: Associate Professor LEE Loo Hay)

Introduction

With the Standardization and normalization of the logistics and distribution services, especially the wide use of large tonnage container ships, in order to improve the loading efficiency, more and more standardized packaging has been used. Therefore, the research of fix-size loading is an urgent issue. However, in previous researches, loading problem with different sizes is explored more. There has been little research focus on the fix-size loading problem. The algorithms proposed for different size are very complicated, and not suitable for the fix-size loading problem. The algorithms for fix-size above only considers maximizing the volume of cargo accommodated, the arrangement is usually irregular or instable, and is not good for loading and unloading. Practical loading needs consideration of the stability and convenience for loading and unloading. From the intuition that objects should be kept even and stable, this paper propose an Heuristic Algorithm of Stacking Layer for the Three-Dimensional Packing of Fixed-Size Cargoes, which is convenient and stable for loading and unloading.

Problem Definition

The fix-size of object is a box, so the problem can be described as: given a infinite set of boxes with fix-size, try to find the best loading method to a container with known size, to maximize the efficiency of the loading space utilization (or the total volume of cargo), with the consideration of the convenience and stability of loading and unloading. There are several assumptions in this following discussion:

(1) the box size is less than the container size;
(2) boxes can be arbitrary rotated and arranged in the container; and
(3) the boxes can be stacked.

Stacking Layer Method

- **Concept of stacking layer method**

  Stacking layer method simulates the idea that each layer is ensured to be more "straight" during the real packing process. Each pile is packed along the same direction, and each layer cannot be filled until the previous layer is fully filled. Each layer must be smooth and tidy. There are two categories according to the direction when packing: the parallel layer stacking and vertical layer stacking. Parallel layer stacking keeps each layer of the cargo paralleled with the compartment door. And vertical layer stacking keeps each layer vertical to the compartment door. The vertical layer stacking method in the paper specifically means that the stacking is along the direction of the compartment height.

  The compartment door of the truck is usually set in three ways:

  (1) in the rear compartment;
  (2) in the side;
  (3) two doors both in the rear and the side.

  Vertical layer stacking is preferred for the stability of the load because the load-bearing surface holds the whole bottom of the compartment. And for the parallel layer stacking, each layer bears a much smaller area that only a small strip of the bottom of the compartment is taken. But for (1) and (2), workers need to load and unload the cargos layer by layer since there is only one door and step on the cargos when working on the layers far away from the door. Loading and unloading cannot be done if there is not enough space in the compartment. Therefore,

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Stacking Layer Method

in order to facilitate loading and unloading easily, parallel layer stacking method is more appropriate. The layer farthest from the door can be filled first, which means the filling is from inside out. And the cargos can be unloaded from outside layer by layer during the distribution. Because there are two doors in (3), it is much easier when loading and unloading. The layers far away from the back door can be load and unloaded through the side door, so vertical layer stacking method is preferred.

- **Steps of stacking layer method**

Based on the earlier packing algorithms, a two-step solving algorithm for stacking layer method is introduced in this paper. First, a triangular combinatorial optimization along a certain direction of the compartment is operated. Then the layout is further optimized. Solving the first step is similar to the one-dimensional cutting stock problem. The length, width and height of the compartment is ordered from largest to smallest, denoted as s_1、s_2 and s_3 ($s_1 \geqq s_2 \geqq s_3$). The loading direction of each layer is denoted as z (stands for the length or width or height of the compartment). We seek for the linear combination of s_1、s_2 and s_3 that minimizes the remaining space along the loading direction. The objective function is

$$Min\ FZ = Z - (a \times s_1 + b \times s_2 + c \times s_3) \quad (1)$$

which subjects to the constraints condition of $0 \le a \le \lfloor z/s_1 \rfloor$, $0 \le b \le \lfloor z/s_2 \rfloor$, $0 \le c \le \lfloor z/s_3 \rfloor$ (a, b, c are integers), where FZ is the remaining space and "$\lfloor\ \rfloor$"means to round down.

Step two is actually a layout problem that the layout space is located in (x, y) and the objective rectangular to be filled is (s_m, s_n). Suppose $s_m \geq s_n$, there are four types of stacking models illustrated in Fig. 1. The black filler represents the remained gap.

In fact, the former three stacking models are the special case of the fourth packing model. When $x_2 \sim x_4, y_2 \sim y_4$, or x_1、x_2、x_4, y_1、y_2、y_4 or x_2、x_4, y_2、y_4 are all zeros, it becomes to stacking model 1; when x_1、x_3、x_4, y_1、y_3、y_4 or x_1、x_2、x_3, y_1、y_2、y_3 or x_1、x_3, y_1、y_3 are all zeros, it becomes to stacking model 2; when x_3、x_4, y_3、y_4 or x_1、x_2, y_1、y_2 are all zeros, it becomes stacking model 3. So the stacking method can be summarized as: find the parameters in packing model 4 $x_1 \sim x_4, y_1 \sim y_4$ to minimize the remaining space and maximum the number of rectangles embedded whose edges are donated as s_m and s_n. Stacking method 4 combines the length of side edge to fill the space, which is equivalent to variety stacking models and mutation models. The stacking model is a mutation model of stacking method 4, which is similar to this paper. y_2 is not bind to $s_n \times y_1$ and x_3 is not bind to $s_n \times x_2$. But they are bind to each other in this paper, which is more consistent to the idea that people maintain the stability, tidily and smooth in the actual loading.

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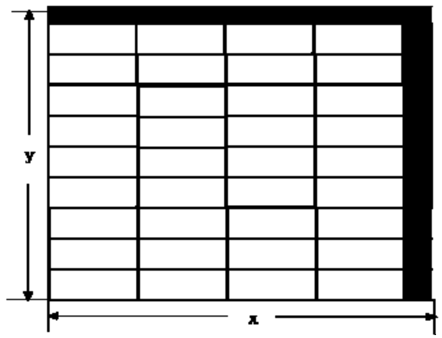
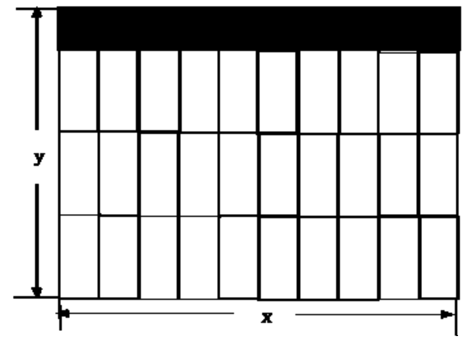
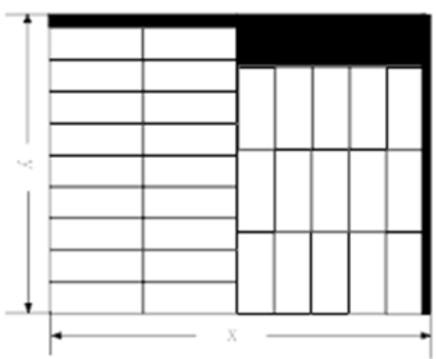
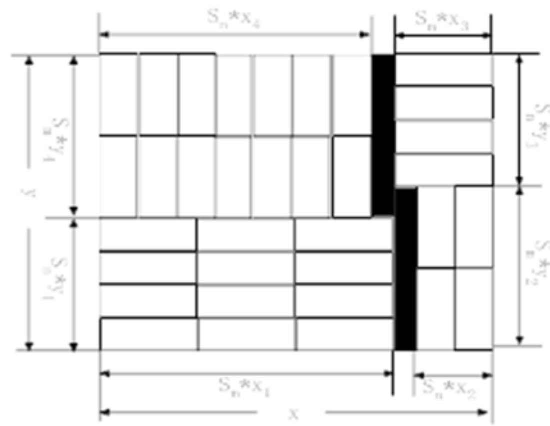
Stacking Layer Method





(a) Stacking Model 1 (b) Stacking Model 2





(c) Stacking Model 3 (d) Stacking Model 4

Figure 1 General Packing Model

In the stacking model of this paper, if the parameters x_1, y_1 are know, then

$$x_2 = \lfloor (x - s_m x_1)/s_n \rfloor \tag{2}$$

$$y_4 = \lfloor (y - s_n y_1)/s_m \rfloor \tag{3}$$

When using parallel stacking method, to maintain the stability of the loading, there is

$$y_2 = \min(\lceil s_n y_1 / s_m \rceil, \lfloor y/s_m \rfloor) \tag{4}$$

" $\lceil\ \rceil$ " means to round up. To use the smaller value is to ensure that y_2 is not greater than $\lfloor y/s_m \rfloor$.

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Stacking Layer Method

When $y_2 = \lfloor y/s_m \rfloor$, there is $x_3 = y_3 = 0$ and

$$x_4 = \lfloor (x - s_n x_2)/s_n \rfloor \tag{5}$$

Otherwise

$$y_3 = \lfloor (y - s_m y_2)/s_n \rfloor \tag{6}$$

and for the pile of (x_3, y_3), when $s_n x_2 - s_m \lfloor s_n x_2 / s_m \rfloor \le s_m / 2$, if we load cargos horizontally, the center of gravity will fall outside of the cargo supporting surface (x_2, y_2), so we let

$$x_3 = \lfloor s_n x_2 / s_m \rfloor \tag{7}$$

When the gap between pile (x_3, y_3) and pile (x_4, y_4) is satisfied with $x - s_m x_3 - s_n x_4 > s_n$, the cargos can be placed vertically (as illustrated in Fig. 2), we name this cargo heap as pile (x_5, y_5). Thus,

$$x_5 = \lfloor (x - s_m x_3 - s_n x_4)/s_n \rfloor \tag{8}$$

$$y_5 = \lfloor (y - s_m y_2)/s_m \rfloor \tag{9}$$

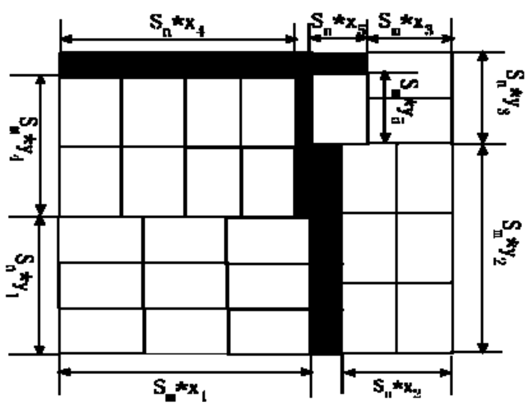

Figure 2 Example of appearing (x_5, y_5) cargo heap

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Stacking Layer Method

The objective function is Max L-sum = $x_1y_1 + x_2y_2 + x_3y_3 + x_4y_4 + x_5y_5$.

When $s_n x_2 - s_m \lfloor s_n x_2 / s_m \rfloor > s_m/2$,

$$x_3 = \lfloor s_n x_2 / s_m \rfloor + 1 \tag{10}$$

$$x_4 = \lfloor (x - s_m x_3)/s_n \rfloor \tag{11}$$

The objective function is Max L-sum = $x_1y_1 + x_2y_2 + x_3y_3 + x_4y_4$. So in such stacking model, the parameters can be solved as long as x_1 and y_1 are known. The range of x_1, y_1 are $0 \le x_1 \le \lfloor x/s_m \rfloor$ and $0 \le y_1 \le \lfloor y/s_n \rfloor$, which becomes to $\lfloor x/2s_m \rfloor \le x_1 \le \lfloor x/s_m \rfloor$ and $\lfloor y/2s_n \rfloor \le y_1 \le \lfloor y/s_n \rfloor$ on considering the symmetry of stacking model 4. The objective optimization value can be found after the traversal of all the combinations of x_1, y_1 .

The detailed algorithm of plane optimal layout program L-Sum (s_m , s_n) is as follows:

1) Input x, y, s_m , s_n
2) determine whether the small rectangle can be embedded into the place, return 0 if not
3) For ($y_1 = \lfloor y/2s_n \rfloor; y_1 \le \lfloor y/s_n \rfloor; y_1{+}{+}$)

{ for ($x_1 = \lfloor x/2s_m \rfloor; x_1 \le \lfloor x/s_m \rfloor; x_1{+}{+}$)

{ initialize $x_5 = y_5 = 0$ and compute x_2, y_4 using Eq. (2) and (3);

If ($\lceil s_n y_1 / s_m \rceil \ge \lfloor y/s_m \rfloor$)

{ $y_2 = \lfloor y/s_m \rfloor$; $x_3 = y_3 = 0$ Compute x_4 using Eq. (5)}

else

{ $y_2 = \lceil s_n y_1 / s_m \rceil$; Compute y_3 using Eq. (6);

If ($s_n x_2 - s_m \lfloor s_n x_2 / s_m \rfloor > s_m/2$) { compute x_3, x_4 using Eq. (10) and (11).}

else { compute x_3, x_4 using Eq. (7) and (5);

If($x - s_m x_3 - s_n x_4 > s_n$){ compute x_5, y_5 using Eq. (8) and (9)}

}

}

Compute the total number of L-Sum= $x_1y_1 + x_2y_2 + x_3y_3 + x_4y_4 + x_5y_5$.

Compare and record the maximum number and the arrangement method.

}

};

4) Output the optimized result.

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Algorithm Combining Position of Compartment Door

Supposed that the length of compartment door is L, the width W and the height H, the direction of the layers vary from each other due to different position of compartment door, and the x, y, z mentioned above correspondingly represents different value. If the compartment door is located behind of compartment, then x equals to W, y equals to H, and z equals to L, which means the direction of the layer is along with the length of compartment. If the compartment door is located in the side of compartment, then x equals to L, y equals to H, z equals to W, and the direction of the layer is along with the width of compartment. If there are two doors set respectively behind and side of the compartment, then x equals to W, y equals to L, z equals to H, and the direction of the layer is along with the height of compartment.

Call the best layer loading program and the plane optimal layout program to solve these and the specific steps are as follows:

1) Enter the compartment size L, W, H, the cargo box size s_1, s_2, and s_3 (make $s_1 \geqq s_2 \geqq s_3$). Assign x, y, z with L, W, H according to the position of the compartment door;
2) Call the best layer loading program to compute a, b, c;
3) Calculate the optimal layout of each layer:
   ① If a ≠ 0, make $s_m = s_2$, $s_n = s_3$, call the plane optimal layout program L-Sum (s_2, s_3) ;
   ② If b ≠ 0, make $s_m = s_1$, $s_n = s_3$, call the plane optimal layout program L-Sum (s_1, s_3) ;
   ③ If c ≠ 0, make $s_m = s_1$, $s_n = s_2$, call the plane optimal layout program L-Sum (s_1, s_2) ;
4) Calculate the total number of the loading container Sum= a*L-Sum (s_2, s_3) + b*L-Sum (s_1, s_3) + c*L-Sum (s_1, s_2) ;
5) Output Sum, a, b, c, and the corresponding values of the parameters of the layout.

Space Utilization Test

In this section, the space utilization of packing with the layer stack heuristic algorithm is mainly tested. We realize the algorithm combining C# with Matlab2009a and run the program on a PC with the Core Duo processor 2.27GHz, 4G of memory. Table 1 compares the space utilization using the algorithm described, general batch method and major domestic packing software. Use our layer stack method to solve the above packing problem, and the result is shown in Table 2.

From Table 1 and Table 2, we can find that the heuristic algorithm from literature has the best solution with highest utilize rate and loading number. The utilize rate showed in Table 2 is generally higher than that of general batch method, and maximum utilization of each row is about the same or even higher than that from literature. For example, when the size of container is (1201, 233, 239) and the size of the small box is (60, 50, 30), the maximum number obtained by our algorithm is 720, which is more than the result from literature by 20, and the utilization rate is 96.89%, which is 20 more than the result from literature in number and higher by 2.97%. Especially when the size of container is (1201, 233, 239) and the small box is (61, 56, 39), our algorithm achieves the highest utilization rate 99.20%.

Also, from Table 2, we can conclude that the utilization rate of our algorithm relates with the position of the compart-

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Space Utilization Test

ment door. Different position of the door determines different direction of the layer, and further produce different utilization rate. In the view of the experiment, when packing the layer in the length direction of the compartment, the utilization rate will generally lower than the case along with the width and height direction. However, sometimes the layer packing along with the length direction may result in high utilization rate, for example in the experiment with the highest utilization rate 99.20% and the experiment in which the size of container is (1201, 233, 239), the small box is (60, 50, 30) and its highest utilization rate is 96.89%.

Table1 Results comparison of some algorithms

Container	Size of Box	Trivial Algorithm		Great Fox Software		Heuristic	
		Numbers	Spc util (%)	Numbers	Spc util (%)	Numbers	Spc util (%)
（5800,2300,2450）	390,320,310	756	89.49	804	95.17	806	95.41
	510,330,290	560	83.63	640	95.57	645	96.32
	530,310,470	390	92.15	401	94.75	402	94.98
	560,370,310	432	84.9	490	96.30	492	96.69
	600,530,310	288	86.87	312	94.1	316	95.31
（1201,233,239）	60,50,30	644	86.66	692	93.12	700	93.92
	60,50,40	460	82.50	524	94.02	524	94.02
	61,56,39	476	94.82	480	95.62	487	97.01
	63,87,32	316	82.87	361	94.67	361	94.67
	87,68,52	172	78.81	196	90.16	212	93.1

Table 2 Computing results of layer stack method

Container	Size of Box	Back Door		Side Door		Back and Side Door	
		Numbers	Spc util (%)	Numbers	Spc util (%)	Numbers	Spc util (%)
（5800,2300,2450）	390,320,310	782	92.57	801	94.82	806	95.41
	510,330,290	580	86.61	636	94.98	632	94.38
	530,310,470	380	89.78	408	96.40	400	94.51
	560,370,310	486	95.51	492	96.69	483	94.92
	600,530,310	301	90.79	310	93.50	316	95.31
（1201,233,239）	60,50,30	720	96.89	648	87.20	653	88.55
	60,50,40	500	89.71	524	94.02	525	94.20
	61,56,39	498	99.20	488	97.21	487	97.01
	63,87,32	329	86.28	350	91.79	358	93.88
	87,68,52	174	80.04	196	90.16	191	87.86

Conclusion

On packing the specifications of the goods, the previous algorithms only consider the maximization of space utilization. Although high utilization rate can be obtained, yet it is hard to achieve actually due to irregular arrangement. Our algorithm takes the convenience of loading before distribution, and the convenience of unloading in the delivery into account, and put forward the layer along with the direction of easy loading and unloading, according to the location of the compartment doors. If the car has only one door, make the layer parallel to the door, and if the car is equipped with two doors, make the layer perpendicular to the height direction of compartment door. The algorithm considers the actual packing factors better and is easier for loading and unloading. Compared with other packing algorithm, it is a more practical algorithm with high space utilization rate.

Research Highlight 2: Research on Regional Agglomeration Efficiency of Shipbuilding Industry in China, By Dr. FU Haiwei (Track Leader: Associate Professor LEE Loo Hay)

Motivation

Shipbuilding industry is an important strategic industry, and is also key pillar of regional economic growth and employment. Recently, with the rapid development of shipbuilding industry in China, multiple agglomeration areas of shipbuilding industry have formed. Agglomeration effect of shipbuilding industry agglomeration provides strong support for healthy and sustainable development of regional shipbuilding industry.

Although most scholars considered industry agglomeration to be beneficial for shipbuilding industry, must high industry agglomeration intensity bring high agglomeration effect? Are shipbuilding industry agglomeration effects of different regions the same? There has not been much related research, but these problems demand prompt solution when shipbuilding industry is faced with development of transformation and upgrading.

Objectives

Location Quotient method is used to calculate shipbuilding industry agglomeration degree of different provinces and cities. DEA is selected to evaluate agglomeration efficiency of provinces and cities with high agglomeration. Based on empirical analysis results, different regional shipbuilding industry agglomeration efficiencies are analyzed.

Agglomeration Degree Calculation Method

Location Quotient can reflect degree of different regions specializing in one particular activity, so it can be uses to calculate regional industry agglomeration degree. LQ index E_i of shipbuilding industry's different factor agglomeration degree can be shown as the following calculation formula:

$$E_i = \frac{q_i \Big/ \sum_{i=1}^{n} q_i}{Q_i \Big/ \sum_{i=1}^{n} Q_i} \qquad (1)$$

whereby, q_i is one shipbuilding industry factor indicator of region i, Q_i is one industry factor indicator of region i; n is the number of regions. Hence, molecule is the proportion of one certain shipbuilding industry factor to nation, and denominator is the proportion of one certain industry factor to nation. If E_i is larger than 1, it reflects that the distribution of one shipbuilding industry factor of region i is higher than national average level, which mean the certain factor relatively agglomerates in the region.

Facing with factor choosing of shipbuilding industry agglomeration degree calculation, the paper picks out labor agglomeration degree and corporation agglomeration degree as regional agglomeration degree indicators of shipbuilding industry. According to formula (1), LQ indexes of labor agglomeration degree and corporation agglomeration degree can be respectively shown as following:

$$E_{Labor} = \frac{\textit{Shipbuilding industry employment of region } i / \textit{National shipbuilding industry employment}}{\textit{Industry employment of region } i / \textit{National industry employment}}$$

$$E_{Corporation} = \frac{\textit{Shipbuilding industry corporation number of region } i / \textit{National shipbuilding industry corporation number}}{\textit{Industry corporation number of region } i / \textit{National industry corporation number}}$$

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Agglomeration Efficiency Calculation Model

Data Envelopment Analysis is short for DEA, and was initially brought out by Charnes etc., which is an efficiency evaluation method used to handle multiple input and multiple output problems. Its basic principle is to identify relative efficiency of decision-making units(DMUs), through constructing efficient production frontier.

Supposing there are n regional DMU_j, $j = 1,\dots, n$, each region has m inputs and s outputs. X_j and Y_j respectively reflects input and output of region j. v and u are respective weight vectors of input and output. Then agglomeration efficiency h_j of region j can be shown as following:

$$h_j = \frac{u^T Y_j}{v^T X_j} \qquad j = 1,\dots,n \tag{2}$$

When the condition $h_j \leq 1$ is satisfied, to solve the linear programming problem is to evaluate agglomeration efficiency evaluation of DMU_0:

$$\begin{cases} \max \mu^T Y_0 \\ \omega^T X_j - \mu^T Y_j \geq 0 \\ \omega^T X_0 = 1 \\ \omega \geq 0, \ \mu \geq 0 \qquad j = 1,\dots,n \end{cases} \tag{3}$$

Whereby, $\omega = tv, \mu = tu, t = \frac{1}{v^T X_0}$.

Choosing input and output indexes of DEA, the paper picks out LQ index of labor agglomeration degree and corporation agglomeration degree as input indicators, as to reflect industry agglomeration intensity's influence on the regional shipbuilding industry development. Meanwhile, it picks out shipbuilding industry profit per capita, shipbuilding industry product per capita and shipbuilding industry export delivery value per capita as output indicators, as to reflect profit effect, product effect and export effect of shipbuilding industry agglomeration.

Empirical Analysis

The data of this paper mainly comes from China Shipbuilding Industry Yearbook 2011 and China Statistical Yearbook 2011. Because China Shipbuilding Industry Yearbook 2011 just gave only 24 related provinces and cities' statistic data of shipbuilding industry, the paper selects these 24 provinces and cities as calculation samples of shipbuilding industry agglomeration degree.

Through LQ method, LQ indexes of labor agglomeration degree and corporation agglomeration degree of those provinces and cities' shipbuilding industry in 2010 can be calculated, which is shown in Table1:

In general, only Liaoning, Shanghai, Jiangsu, Zhejiang and Hubei have realized that both labor agglomeration degree and corporation agglomeration degree are larger than 1, so it's thought that these 5 provinces and cities are main agglomeration regions of shipbuilding industry in China

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Empirical Analysis

In order to analyzing regional agglomeration efficiency of shipbuilding industry, the paper selects five main provinces and cities' shipbuilding industry agglomeration, namely Liaoning, Shanghai, Jiangsu, Zhejiang and Hubei as DMUs, whose LQ indexes of labor agglomeration degree and corporation agglomeration degree are larger than 1. Main shipbuilding industry data of five provinces and cities is shown in Table 2. On the basis of input and output indicators before, the paper uses DEAP2.1 software to analyze agglomeration efficiency and gives out evaluation result of those provinces and cities' agglomeration efficiency (AE) in Table 3.

Table 1 LQ indexes of labor agglomeration degree and corporation agglomeration degree of provinces and cities' ship building industry in 2010

Region	labor agglomeration degree	corporation agglomeration degree	Region	labor agglomeration degree	corporation agglomeration degree
Beijing	0.021	0.091	Jiangxi	0.509	0.552
Tianjin	1.015	0.968	Shandong	0.751	0.774
Hebei	0.206	0.209	Henan	0.143	0.138
Inner Mongolia	0.025	0.045	Hubei	1.078	1.510
Liaoning	4.636	1.640	Hunan	0.171	0.390
Jilin	0.015	0.067	Guangdong	0.809	0.677
Heilongjiang	0.038	0.136	Guangxi	0.507	1.231
Shanghai	3.923	1.806	Hainan	0.674	1.255
Jiangsu	3.465	2.009	Chongqin	0.977	1.603
Zhejiang	1.362	1.159	Sichuan	0.037	0.091
Anhui	0.565	1.315	Guizhou	0.008	0.070
Fujian	0.910	0.908	Shanxi	0.151	0.046

Table 2 Relative data of main shipbuilding industry agglomeration provinces and cities in 2010

Region	Average annual employment (ten thousand)	Shipbuilding industry profit(one hundred million yuan)	Shipbuilding industry product (one hundred million yuan)	Shipbuilding industry export delivery value (one hundred million yuan
Liaoning	9.645	65.1524	901.938	466.782
Shanghai	4.835	35.964	677.109	420.161
Jiangsu	26.333	267.965	2294.531	969.498
Zhejiang	9.382	44.017	857.585	466.752
Hubei	3.474	21.626	268.146	52.998

Data source: *China Shipbuilding Industry Y earbook 2011*

Table 3 Main regional agglomeration efficiency of shipbuilding industry in 2010

Region	Profit AE value	Profit per capita (RMB 10,000 per capita)		Product AE value	Product per capita (RMB 10,000 per capita)		Export AE value	Export per capita (RMB 10,000 per capita)	
		Actual	Target		Actual	Target		Actual	Target
Liaoning	0.813	6.75	8.306	0.724	93.51	129.235	0.614	48.390	78.747
Shanghai	0.812	7.440	9.167	0.982	140.050	142.631	1.000	86.910	86.910
Jiangsu	1.000	10.180	10.180	0.550	87.140	158.391	0.400	36.820	91.954
Zhejiang	0.889	4.690	5.278	1.000	91.410	91.410	1.000	49.750	49.750
Hubei	1.000	6.230	6.230	1.000	77.200	77.200	0.386	15.260	39.507

Research Highlight 2: Research on Regional Agglomeration Efficiency of Shipbuilding Industry in China, By Dr. FU Haiwei (Track Leader: Associate Professor LEE Loo Hay)

Conclusions

he result shows that there are big differences in agglomeration efficiency among different regions of shipbuilding industry. Profit agglomeration efficiency of Jiangsu and Hubei shipbuilding industry is the highest. Product agglomeration efficiency of Zhejiang and Hubei shipbuilding industry is the highest. Export agglomeration efficiency of Shanghai and Zhejiang shipbuilding industry is the highest. Therefore, it is important to independently develop regional shipbuilding economy by combining with regional comparative advantage.

The paper puts forward following suggestions: firstly, distributing industry resources rationally and making the most of regional agglomeration efficiency advantage. Different regional agglomeration advantages reflect on different aspects. For example, eastern coastal province and city, such as Shanghai and Zhejiang, have obvious advantage of export agglomeration efficiency of shipbuilding industry. It shows that these regions are suitable for developing export-oriented shipbuilding industry. Thus, it's considered that export resources of Chinese shipbuilding industry can be agglomerated in these advantage regions, so as to improve utility ratio of export resources. Secondly, attaching great importance to regional industry agglomeration efficiency, and enhancing factor agglomeration quality. The goal of industry development is not agglomeration degree, and high agglomeration degree may not bring high agglomeration efficiency. During the development of regional shipbuilding industry, do not just pursue agglomeration degree, but ignore industry agglomeration efficiency. It should be that the reason to regional agglomeration inefficiency is fully analyzed, so as to enhance development environment of shipbuilding industry. to guide labor and corporation factors to really play the effects and finally to improve regional competitive force of shipbuilding industry.

Published Technical Papers (with Abstracts)

1. **Feiyang Zhao, Wenming Yang, Woei Wan Tan, Siaw Kiang Chou, and Wenbin Yu, (2015), An overall ship propulsion model for fuel efficiency study.** ***Energy Procedia, Volume 75, Pages 813-818.***

Abstract:
An overall ship propulsion plant involving marine engine, propeller and ship dynamic model was presented in this work. The cycle mean value model was utilized to describe the operation process in engine dynamic, intake/exhaust and turbocharger system. The ship shafting system was modelled using the power balance and its efficiency. The predicted results of fuel consumption, engine delivered power and vessel speeds were tested with measured data under different engine response. The whole ship voyage model will be used to predict fuel consumption and exhaust emissions under different sailing conditions in further study.

2. **Chenhao Zhou, Ek Peng Chew, Loo Hay Lee, and Daqi Liu, (2015), An introduction and performance evaluation of the GRID system for transhipment terminals.** ***Simulation: Transactions for the Society for Modelling and Simulation International, 17 pages.***

Abstract:
While the global container trade, especially transshipment, keeps growing rapidly, land scarcity and sustainability pose severe challenges to port operators. To maintain their competitiveness, they have to maximize land utilization and improve productivity. As applications of the GRID (Goods Retrieval and Inventory Distribution) system prototype proposed by BEC Industries LLC, this paper discusses two new designs—the single GRID system and hybrid GRID system—from different angles. In particular, the configuration and mechanism of the single GRID system are introduced with different layouts. Given the GRID structure, one of the most critical aspects of the proposed architecture is the high incidence of conflicts among transfer units (TUs). Hence, the authors identify different conflict scenarios and subsequently provide the TU control logic to avoid conflicts. A simulation study then investigates the performance of the single GRID system and its robustness with respect to horizontal and vertical expansion. Due to the limitations of the single GRID system, the hybrid GRID system is then proposed and simulated for terminals demanding huge capacity and productivity. A new flexible and scalable simulation model is designed for the new system. Both the results on land utilization and productivity show that the hybrid GRID system is promising for future transshipment terminals.

3. **Weng Sut Sou, and Ghim Ping Ong, (2015), Effect of trade data aggregation on international commodity mode choice.** ***Journal of the Eastern Asia Society for Transportation Studies, Volume 11, Pages 2459-2471.***

Abstract:
Different widely accepted principles are used to determine the transport mode in which particular commodity is to be carried at the strategic planning level. One such rule is the commodity value-weight ratio. Discrete choice model is being employed in this paper using available macroscopic commodity trade information. The selection of appropriate data aggregation level for analysis is studied and its corresponding impacts are presented. By examining international commodity flows between countries, the modal split between air and sea transport are compared. After investigating four separate international trade routes and three trade data classification levels, it was found that aggregated trade classification data yields comparable results to detailed trade classification data. With respect to the Harmonized Commodity Description and Coding System, our analyses showed that for the purpose of mode choice studies at the planning level, it may be more efficient to develop models using HS two-digit commodity trade data.

Published Technical Papers (with Abstracts)

4. **Yadong Wang, Qiang Meng, and Yuquan Du, (2015), Liner container seasonal shipping revenue management.** ***Transportation Research Part B, Volume 82, Pages 141-161.***

Abstract:

This paper proposes a liner container seasonal shipping revenue management problem for a container shipping company. For a given weekly multi-type shipment demand pattern in a particular season, the proposed problem aims to maximize the total seasonal shipping profit by determining the number of multi-type containers to be transported and assigned on each container route, the number of containerships deployed on each ship route, and the sailing speed of containerships on each shipping leg subject to both the volume and capacity constraints of each containership. By adopting the realistic bunker consumption rate of a containership as a function of its sailing speed and payload (displacement), we develop a mixed integer nonlinear programing with a nonconvex objective function for the proposed liner container seasonal shipping revenue management problem. A tailored branch and bound (B&B) method is designed to obtain the global ε-optimal solution of the model. Numerical experiments are finally conducted to assess the efficiency of the solution algorithm and to show the applicability of the developed model.

5. **Feiyang Zhao, Wenming Yang, Woei Wan Tan, Wenbin Yu, Jiasheng Yang, and Siaw Kiang Chou, (2016), Power management of vessel propulsion system for thrust efficiency and emissions mitigation.** ***Applied Energy, Volume 161, 1 January 2016, Pages 124-132.***

Abstract:

To meet the stringent gas emissions legislation in marine industry achieving green shipping, the ship operational behavior in actual sailing condition is one of the major concerns for designers and ship owners. In this study, the assessment of fuel consumption and pollutant gas emissions during a container ship operating scenarios was carried out by a hydrodynamic vessel movement model capable of representing the vessel propulsion behavior. The marine engine equipped with turbocharger as well as shafting system and fixed pitch propeller was included in vessel propulsion model by separated sub models connecting the required variables to each other. The propulsion system performance in calm water was well validated by a container ship seakeeping test published in 2003. When sailing encounters heavy weather, the severe ship motion induced by irregular waves bring the thruster very close to water surface, making propeller susceptible to ventilation and causing huge thrust loss. Step modulation strategy of power management system has been employed to save thrust loss and improve fuel efficiency in this study. It manages to save large thrust degeneration and along with benefit of thrust efficiency and emission mitigation, but at the expense of shortened sailing distance.

6. **Jiasheng Yang and Rui Ping Gao, (2016), Active control of a very large floating beam structure.** ***Journal of Vibration and Acoustic, Volume 138 Issue 2, 21 January 2016, Pages 021010-021010-7.***

Abstract:

In this paper, a novel boundary control method is investigated to suppress the vertical vibration of a very large floating structure (VLFS) with regular waves. The VLFS can be described as a distributed parameter system with partial differential equation (PDE). The proposed boundary controllers are developed based on Lyapunov's direct method to act on the upstream and downstream ends of the VLFS, respectively. Along with the suitable choice of control parameters, the proposed controllers could stabilize the vertical vibration of the VLFS subjected to regular waves. This study verifies the effectiveness of the proposed control methods to the VLFS. Then, the effects of wave amplitude and bending rigidity on the hydroelastic response of the VLFS are investigated.

Published Technical Papers (with Abstracts)

7. **Jun Yuan, Szu Hui Ng, and Weng Sut Sou, (2016), Uncertainty quantification of CO2 emission reduction for maritime shipping.** ***Energy Policy, Volume 88, Issue C, Pages 113-130.***

Abstract:

The International Maritime Organization (IMO) has recently proposed several operational and technical measures to improve shipping efficiency and reduce the greenhouse gases (GHG) emissions. The abatement potentials estimated for these measures have been further used by many organizations to project future GHG emission reductions and plot Marginal Abatement Cost Curves (MACC). However, the abatement potentials estimated for many of these measures can be highly uncertain as many of these measures are new, with limited sea trial information. Furthermore, the abatements obtained are highly dependent on ocean conditions, trading routes and sailing patterns. When the estimated abatement potentials are used for projections, these 'input' uncertainties are often not clearly displayed or accounted for, which can lead to overly optimistic or pessimistic outlooks. In this paper, we propose a methodology to systematically quantify and account for these input uncertainties on the overall abatement potential forecasts. We further propose improvements to MACCs to better reflect the uncertainties in marginal abatement costs and total emissions. This approach provides a fuller and more accurate picture of abatement forecasts and potential reductions achievable, and will be useful to policy makers and decision makers in the shipping industry to better assess the cost effective measures for CO2 emission reduction.

8. **Qiang Meng, Yuquan Du, and Yadong Wang, (2016), Shipping log data based container ship fuel efficiency modeling.** ***Transportation Research Part B, Volume 83, Pages 207-229.***

Abstract:

Container shipping lines have been initiating various ship fuel efficiency management programs because bunker fuel costs always dominate the daily operating costs of a container ship. As the basis of these kinds of programs, we develop a viable research methodology for modeling the relationship between the fuel consumption rate of a particular container ship and its determinants, including sailing speed, displacement, sea conditions and weather conditions, by using the shipping log data available in practice. The developed methodology consists of an outlier-score-based data preprocessing procedure to tackle the fuzziness, inaccuracy and limited information of shipping logs, and two regression models for container ship fuel efficiency. Real shipping logs from four container ships (two with 13000 TEUs and two with 5000 TEUs) over a six-month sailing period are used to exhibit the applicability and effectiveness of the proposed methodology. The empirical studies demonstrate the performance of three models for fitting the fuel consumption rate of a ship and the industrial merits of ship fuel efficiency management. In addition, we highlight the potential impacts of the models developed in this study on liner shipping network analysis, as these models can serve as base models for additionally considering the influence of displacement and weather conditions on ship fuel efficiency and exhaust emissions.

Published Technical Papers (with Abstracts)

9. Tianbao Qin, Yuquan Du, and Mei Sha, (2016), Evaluating the solution performance of IP and CP for berth allocation with time-varying water depth. ***Transportation Research Part E, Volume 87, Pages 167-185.***

Abstract:

This paper considers the berth allocation problem (BAP) with time-varying water depth at a tidal river port. Both integer programming (IP) and constraint programming (CP) models are developed. Numerical experiments find that CP tends to be superior to IP when the feasible domain is small (e.g. dynamic vessel arrivals), when the restriction of the objective towards decision variables is loose (e.g. makespan, departure delay), or when the size of IP models is too large due to fine time resolution. Meanwhile, CP's incapability of proving optimality can be compensated by post-optimization with IP, by using a simple CP/IP hybrid procedure.

Conference Papers (with Abstracts)

1. **Pedrielli, G., Zhu, Y., and Lee, L.H. (2015). Single-run simulation optimization through time dilation and optimal computing budget allocation. In *Proceedings of the 10th Conference on Stochastic Models of Manufacturing and Service Operations, 1-6 June 2015, Greece.***

Abstract:
Simulation–Optimization has acquired an important role in the optimal configuration of stochastic manufacturing systems, where the different alternatives can be evaluated by means of a discrete event simulation. In order to improve the computational efficiency of this family of techniques in presence of finite budget, methods for simulation budget allocation have also been thoroughly investigated. Optimal Computing Budget Allocation (OCBA), with a number of its variants, has played a fundamental role as one of the most successful of these techniques. However, in traditional simulation–optimization methods the simulator is treated as a black box and no information can be accessed while the simulation is running. On the contrary, Time Dilation (TD) is a technique that allows dynamic allocation of computational effort to a set of system configurations while the related simulation model is running. This allows to access a fairly larger amount of information, benefiting of the efficiency characterizing single–run optimization procedures. This work proposes a new procedure, TD–OCBA, which integrates TD and OCBA. In order to apply OCBA to single run optimization, we rely on the concept of standardized time–series. Numerical results are presented to show that TD–OCBA is a consistent and robust algorithm. An example over a job–shop system shows the improved performance over the traditional TD.

2. **Li, H., Zhu, Y., Pedrielli, G., Pujowidianto, N., and Chen, Y. (2015). The object-oriented discrete evel simulation modeling: a case study on aircraft spare part management. In *Proceedings of the 47th Conference on Winter Simulation, Winter Simulation Conference, 6-9 December 2015, USA.***

Abstract:
Object–Oriented DES (O2DES) is an effort to implement the object oriented paradigm in the scope of ease the development of discrete event simulation models in both education as well as industrial settings. In particular, O2DES offers several functionalities which support the integration of the tool with optimization techniques, thus making it easier to the students to understand the concept of simulation–optimization. It also supports the application of different variance reduction techniques such as budget allocation and time dilation. In order to do so, the provided toolkit exploits the C# language and the .NET Framework and it guarantees the efficient generation of DES models, as well as the effectiveness of the developed models in being integrated with sampling solutions. We propose a case study related to the aircraft spare part management problem to show case the main functionalities of the proposed tool.

3. **Pedrielli, G., and Ng, S.H. (2015). Kriging-based simulation optimization: a stochastic recursion perspective. In *Proceedings of the 47th Conference on Winter Simulation, Winter Simulation Conference, 6-9 December 2015, USA.***

Abstract:
Motivated by our recent extension of the Two–Stage Sequential Algorithm (eTSSO), we propose an adaptation of the framework in Pasupathy et al. (2015) for the study of convergence of kriging–based procedures. Specifically, we extend the proof scheme in Pasupathy et al. (2015) to the class of kriging–based simulation–optimization algorithms. In particular, the asymptotic convergence and the convergence rate of eTSSO are investigated by interpreting the kriging–based search as a stochastic recursion. We show the parallelism between the two paradigms and exploit the deterministic counterpart of eTSSO, the more famous Efficient Global Optimization (EGO) procedure, in order to derive eTSSO structural properties. This work represents a first step towards a general proof framework for the asymptotic convergence and convergence rate analysis of meta–model based simulation–optimization.

Conference Papers (with Abstracts)

4. **Pedrielli, G., Matta, A., and Alfieri, A. (2015). Discrete event optimization: single-run integrated simulation optimization using mathematical programming. In *Proceedings of the 47th Conference on Winter Simulation, Winter Simulation Conference, 6-9 December 2015, USA.***

Abstract:
Optimization of discrete event systems conventionally uses simulation as a black–box oracle to estimate performance at design points generated by a separate optimization algorithm. This decoupled approach fails to exploit an important advantage: simulation codes are white-boxes, at least to their creators. In fact, the full integration of the simulation model and the optimization algorithm is possible in many situations. In this contribution, a framework previously proposed by the authors, based on the mathematical programming methodology, is presented under a wider perspective. We show how to derive mathematical models for solving optimization problems while simultaneously considering the dynamics of the system to be optimized. Concerning the solution methodology, we refer back to retrospective optimization (RO) and sample path optimization (SPO) settings. Advantages and drawbacks deriving from the use of mathematical programming as work models within the RO (SPO) framework will be analyzed and its convergence properties will be discussed.

5. **Li, H, Pedrielli, G., Li, Y., Lee, L.H., Chew, E.P., and Chen, C.H. (2015). Multi-Objective Multi-Fidelity optimization with ordinal transformation and Optimal Sampling. In *Proceedings of the 47th Conference on Winter Simulation, Winter Simulation Conference, 6-9 December 2015, USA.***

Abstract:
In simulation–optimization, the accurate evaluation of candidate solutions can be obtained by running a high–fidelity model, which is fully featured but time–consuming. Less expensive and lower fidelity models can be particularly useful in simulation–optimization settings. However, the procedure has to account for the inaccuracy of the low fidelity model. Xu et al. (2015) proposed the MO2TOS, a Multi–fidelity Optimization (MO) algorithm, which introduces the concept of ordinal transformation (OT) and uses optimal sampling (OS) to exploit models of multiple fidelities for efficient optimization. In this paper, we propose MO–MO2TOS for the multi–objective case using the concepts of non–dominated sorting and crowding distance to perform OT and OS in this setting. Numerical experiments show the satisfactory performance of the procedure while analyzing the behavior of MO–MO2TOS under different consistency scenarios of the low–fidelity model. This analysis provides insights on future studies in this area .

6. **Zhang, L., Wang, H., and Meng, Q. (2016). Evidence-based ship accident consequence analysis using heterogeneous-source accident reports. Presented at *the 95th Annual Meeting of Transportation Research Board, 10-14 January 2016, USA.***

Abstract:
Shipping movements are operated in more and more complex environment due to increasing maritime traffic demand. Fatal ship accidents are nightmares for seafarers. A wide range of methods have been introduced for ship accident consequence analysis. However, almost all existing academic studies focus on experts' understanding, but overlook the potential valuable evidence in real ship accident cases. Actually, a large amount of ship accident reports with detailed accident information are available online and freely accessible. In this paper, we present a systemic framework for the evidence-based ship accident analysis using real ship accident reports and show some knowledge extracted from the real accident records. The first task of the proposed framework is to review ship accident reports and extract related accident information. Different from previous studies, the accident information of both during-accident stage and post-accident stage are considered and examined. To further show the fulfillment of this task, 477

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accident reports are reviewed. The next task is to explore ship accident frequency according to various accident types and accident consequences. The last framework component aims to investigate the relationship between contributory factors and accident consequences. Specifically, a series of statistic examinations including nonparametric statistics of Kendall's tau coefficient analysis, Cramér's V coefficient analysis and Kruskal-Wallis test are carried out to figure out the relationship. Our statistical analysis indicates that the significance of contributory factors exhibits distinguished diversity according to ship accident and consequence types. For example, ship speed remarkably contributes to human injury and fatality in ship collisions, but not significantly in ship groundings. The results are beneficial to facilitate the ship risk mitigation and, to validate and advance the existing accident consequence analysis models .

7. **Ong, G.P., and Sou, W.S. (2016). Forecasting global maritime container demand using an integrated trade-commodity flow modelling framework. Presented at *the 95th Annual Meeting of Transportation Research Board, 10-14 January 2016, USA.***

Abstract:
Global maritime trade has experienced increasing trade value and volume over the past decades. In particular, most of the trade commodities are transported through seaborne containers. Therefore, the ability to forecast maritime container demand is of particular importance to policy makers for them to keep their competitive advantage or to plan for infrastructure development. Numerous efforts have been made in the past to forecast container demand but most of these studies were either adopting an economic approach or a transportation model. Few studies actually consider the forecasting of maritime container demand from an integrative economic trade-transportation modelling perspective. This study therefore presents the development of a quantitative demand forecasting approach to predict future seaborne container demand in the global context. This integrated forecasting framework uses the transportation-based four-step model coupled with economic and trade theories. Computable general equilibrium models based on economic theories were first developed to derive the amount of trade flow among countries. Through the application of transportation mode choice models, the amount of seaborne trade between countries were then estimated. Statistical models with expert opinions were developed to convert commodity value into number of containers. The developed model framework was then applied to study the container demand trends in several countries between 2008 and 2018. Through this case study, it was found that the model framework is capable to simulate global maritime trade and container demand and could serve as a useful tool for planners in formulating relevant macroeconomic trade and transport policies.

8. **Zhang, Y., and Meng, Q. (2016). Current ship traffic analysis at northern sea route. Presented at *the 95th Annual Meeting of Transportation Research Board, 10-14 January 2016, USA.***

Abstract:
While the media vigorously propagates historic Northern Sea Route (NSR) transits and researchers demonstrate viability of the NSR, the current usage by the shipping industry has been neglected thus far. This study aims to analyze the current ship traffic characteristics at NSR. The ship traffic data provided by Russia and the port call data obtained through a commercial provider are examined. Transit shipping along the NSR was performed by 2, 4, 41, 46, 71 and 53 ships respectively in 2009-2014 in the summers. Trade volumes remained unstable over the years. The results show that navigation season lasts for 5 months at NSR, and ice classes of Arc4 and Arc5 are used extensively. Despite Arctic nations, China, South Korea and Japan are active participants in the transit activities. Thus far, oil-and-gas transportation dominates the transits and most activities are destinational or domestic. However, without actual trajectories of activities, it remains difficult to determine the vessel speed on the NSR. The paper provides real statistics that can add value to the viability analysis. It identifies key players of the transits, exhibits trade pattern at NSR, and presents facts that interest shipping companies.

CMS Research Seminars

1. The Popularization of Vogel Method of Optimizing the Initial Solution for Traveling Salesman Problem, by Researcher Dr. Liu Wangsheng (Track Leader: Associate Prof Lee Loo Hay)

Seminar Abstract:

Based on the similarity of characteristics of mathematical model between Traveling Salesman Problem and Transportation Problem, popularize Vogel method to obtain the initial optimization solution for Traveling Salesman Problem. Then give a computational example and the results show that the initial solution from Vogel method is closer to the optimum solution than that from Minimum Element method. Experiment comparing with the Nearest Neighbor and Nearest Insertion algorithm indicates that the method is effective. The future work is the popularization of Closed-loop method to optimize the initial solution, and expect to obtain the best solution.

2. Ensuring Cloud Data Reliability with Minimum Replication by Proactive Replica Checking, by Researcher Dr. Li Wenhao (Track Leader: Professor Meng Qiang)

Seminar Abstract:

Data reliability and storage costs are two primary concerns for current Cloud storage systems. To ensure data reliability, the widely used multi-replica (typically three) replication strategy in current Clouds incurs a huge extra storage consumption, resulting in a huge storage cost for data-intensive applications in the Cloud in particular. In order to reduce the Cloud storage consumption while meeting the data reliability requirement, in this paper we present a cost-effective data reliability management mechanism named PRCR based on a generalized data reliability model. By using a proactive replica checking approach, while the running overhead for PRCR is negligible, PRCR ensures reliability of the massive Cloud data with the minimum replication, which can also serve as a cost effectiveness benchmark for replication based approaches. Our simulation indicates that, compared with the conventional 3-replica strategy, PRCR can reduce from one-third to two-thirds of the Cloud storage space consumption, hence significantly lowering the storage cost in a Cloud.

3. Development of an Optimization Methodology for Pavement Management Systems, by Researcher Mr. André V. Moreira (Track Leader: Professor Fwa Tien Fang)

Seminar Abstract:

Pavement Management Systems (PMSs) are a useful tool to help road administrations to efficiently maintain the pavement asset within a road network. Pavement history database, maintenance and rehabilitation operations inventory, prediction models and decision support tools are fundamental parts of any PMS. In this seminar, an overview of these parts is performed, with special focus to the optimization methodology to support the decision making. An optimization methodology consists mainly in the definition of objective functions, constraints and optimization procedures. Two genetic algorithm based optimization approaches are compared for an hypothetical pavement management problem, highlighting their relative advantages, and future steps to be given towards the development of a more complete methodology to apply in real PMSs.

CMS Research Seminars

4. **An Overview of Ship Operation, by Invited Guests Capt. Zhan Jie and Capt. Wu Yuguo**

Seminar Abstract:

Shipping operations act as important part of entire shipping, this is a time consuming and issue overcoming procedures as well as saving time/money and protecting charters interests. A efficient operations team will not only execute the contract smoothly but also save time/efforts on the entire voyage (both time charter and voyage charter).

5. **Marine Salvage & Wreck Removal Operations in Singapore & Malacca Straits , by Invited Guest Mr. Reinder Th. Peek**

Seminar Abstract:

This talk gives a local perspective to salvage industry and also shows the full picture and case studies of what sort of operations SMIT Salvage does worldwide.

6. **Impact Analysis of Large Ships on Singapore Strait based on DMU Simulator, by Researcher Dr. Xie Yajuan (Track Leader: Professor Meng Qiang)**

Seminar Abstract:

As one of the most important and busiest shipping waterways in the world, the Straits of Malacca and Singapore (SOMS) are unique and vital to Singapore economics development. It can be foreseen that more and more large-sized ships will pass through the SOMS. In our project our aim is to develop models being able to quantitatively analyse the impacts of large ships on navigational accident risks and to simulate the interaction of large ships. However, we need to know the rules between the large ships. We can get the basic rules from some research papers, but those rules maybe incomplete and conditional. In this experiment, we can get the real rules based on DMU simulator, which is a platform for captains to ship in different scenarios. From these experiments we can build the interaction model combined real rules between ships and to simulate more realistic traffic conditions of SOMS in the future. In this research seminar, different experiment scenarios and methods on DMU simulator are introduced and discussed.

7. **Port Logistics Supplier Selection, by Research Dr. Fu Haiwei (Track Leader: Associate Prof Lee Loo Hay)**

Seminar Abstract:

Port logistics providers play an important role in the global supply chain which directly affect the costs and service levels on the entire supply chain. We used the SEM/DEA method in the decision-making process, in order to reflect the industry preferences and improve the performance.

CMS Research Seminars

8. A Disaggregate Approach to Estimate Noxious Emissions from Ships in Singapore Strait, by Researcher Dr. Zhang Liye (Track Leader: Professor Meng Qiang)

Seminar Abstract:

As Singapore is closely adjacent to the world's most populous coastal area, the government urgently needs to assess and control noxious emissions of ships passing through its narrow and busy channel. This study presents an activity-based approach based on big AIS data to estimate noxious emissions from ships in Singapore Strait by quantitatively analyzing the pollutant sources and their spatial-temporal features. In the analysis of pollutant sources, it was found that, as for ship types, the three largest pollutant sources are tankers, general cargos and carrier ships; whereas, regarding the ship flag states, the top three pollutant sources are ships from Singapore, Panama and Marshall Islands. More interestingly, the ships that transverse Singapore Strait but not visit Singapore Port, generate considerable pollutants, in details, 23.69% of SOx, 24.70% of NOx, 22.68% of PM, and 26.61% of NMVO. We further investigate the temporal-temporal features of the pollutants. It was found that the pollutants exhibit great variation over time, although with a relatively stable ship traffic volume. Meanwhile, the air pollutants distribute unevenly that the east bound of Singapore Strait has a much higher pollutant density. We finally evaluate two countermeasures, speed limit and using low sulfur fuel, to reduce the noxious pollutants. The experiments show that a strict speed limit of 12 knots can make significant reductions of the noxious pollutants, 27.41% of SOx, 27.65% of NOx, 27.40% of PM, 24.70% of CO and 29.85% of NMVO. The SOx reductions of using low sulfur fuels with the sulfur limits of 1% and 0.1% are 58.72% and 93.65%, respectively.

9. Optimal Bimodal Transportation Design in a Ring-Radial Urban System, by Researcher Mr. Wang Yadong (Track Leader: Professor Meng Qiang)

Seminar Abstract:

The last few decades have seen the rapid economic development and urbanization in large cities of Asia, which, however, leads to many concomitant serious problems, such as heavy traffic congestion, serious environmental issue and extremely high living costs and housing prices. This study analyses the equilibrium properties of the bi-modal urban system and formulates a maximization model for transit system design in a ring-radial two-dimensional monocentric city. This model takes into account two transportation modes (e.g. auto and bus) and analytically gives the properties of the three related equilibria (e.g. commuters' mode and route choice equilibrium, the household residential location choice equilibrium and the housing demand-supply equilibrium). This study also gives the solution algorithms for calculating the equilibrium solution of the urban system and analyses the equilibrium properties. The effects of two different regulation regimes (e.g. public and private regulations) on the optimal bus fare and frequency and urban system equilibrium are also compared. This study severs a theoretical basis in solving such problems as traffic congestion, emission pollution and high urban housing price.

CMS Research Seminars

10. Evaluating the Solution Performance of IP and CP for Berth Allocation with Time-Varying Water Depth: an Update, by Research Dr. Du Yuquan (Track Leader: Professor Meng Qiang)

Seminar Abstract:

This study considers the berth allocation problem (BAP) with time-varying water depth at a tidal river port. Both integer programming (IP) and constraint programming (CP) models are developed. Meanwhile, some hybrid algorithms combining the strength of IP and CP are also designed by leveraging the warm-start mechanism and Benders Decomposition. Numerical experiments find that (a) compared to IP, CP tends to be superior when the restriction of the objective towards decision variables is not tight (e.g. minimum makespan, or minimum total weighted departure delay over large-size instances), when the original feasible domain is smaller (e.g. dynamic arrival compared to static arrival), or when the time granularity is finely set; (b) a simple hybrid CP/IP procedure can significantly improve the optimality proving capability of CP, by paying minor additional computational effort; (c) on the contrary, the highbrow algorithm, Benders Decomposition, fails to improve the computational efficiency and effectiveness.