Designing optimizing procedure for task switching to ensure efficiency in the hospital laboratory

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Abstract

This study aims to **improve the efficiency of task switching in hospital laboratories**. In a laboratory, several medical technicians perform multiple tasks. Technicians are not aware of the marginal amount of time it takes to switch between tasks, and this accumulation of lost minutes can cause the technician to worry more about the remaining working time than work quality. They rush through their remaining tasks, thereby rendering their work less efficient.

For time optimization, we identified work changeover times to help maintain the work quality in the laboratory while reducing the number of task switching instances. We used the turnaround time (TAT) compliance rate of emergency room (ER) samples as an indicator to evaluate laboratory performance and the number of task switching instances as an index of the task performer perspective (TPP). We experimented with a monitoring system that populates the time for sample classification according to the optimal time for task switching.

Terminology and Background

			TAT						
Non-analytical Phase			Pre-analytical Phase			Analytical Phase		Post-analytical Phase	
Prescribe	Registration	Phlebotomy	Laboratory arrival	Pre-treatment	Put into equipment	Check the list of tests from LIS	Analysis	Verification	Report to HIS
	(Barcode Printing)	(Phlebotomy)	(Receipt 1)		(Receipt 2)				(report)

Figure 1. Laboratory workflow in a ward at the ST. Vincent's hospital.

In this study, we set the **the goal to have an ER TAT of one hour or less** (based on the TAT guideline of ST. Vincent's Hospital). We assumed that one person would take charge of the business processes and execute multiple tasks. The processing order of each sample task was fixed and had a time limit. When multiple samples were mixed, the worker was required to switch tasks during the process within a short time. To briefly explain task switching using the example, we apply the following values:

P_i: Pre-treatment process of ith sample with a time limit of 60 min
A_i: Analytical process of the ith sample with a time limit of 60 min

The expected orders are
Case 1. $P_1P_2P_3P_4\text{-}A_1A_2A_3A_4$
Case 2. $P_1-A_1-P_2P_3-A_2A_3-P_4-A_4$
Case 3. $P_1P_2P_3-A_1A_2A_3-P_4-A_4$

Data

[ER biochemical samples]

- Barcode printing time, blood collection time, pre-reception time, reception time, and final report time
- Overall, 71,623 samples
- Collected from January 2018 to December 2019
- Through Hospital Information System (HIS) and approved by the IRB Ethics Committee of ST. Vincent's Hospital

Mathematical Optimization for finding optimal unit work interval

Our goal is to minimize task switching, which requires us to reduce the number of tasks. An optimal sample processing time interval was proposed based on the algorithm

[Define Variables]

1. Input

- i : *order of the sample*
- $\mathrm{D} = \{(x_i, y_i, z_i) \mid i \in I\}$: *input data*
- x_i : *the time of receipt 1 of ith sample*
- y_i : *the time of receipt 2 of ith sample*
- z_i : *the time of report to HIS of i th sample*

For each duration time (min) M,

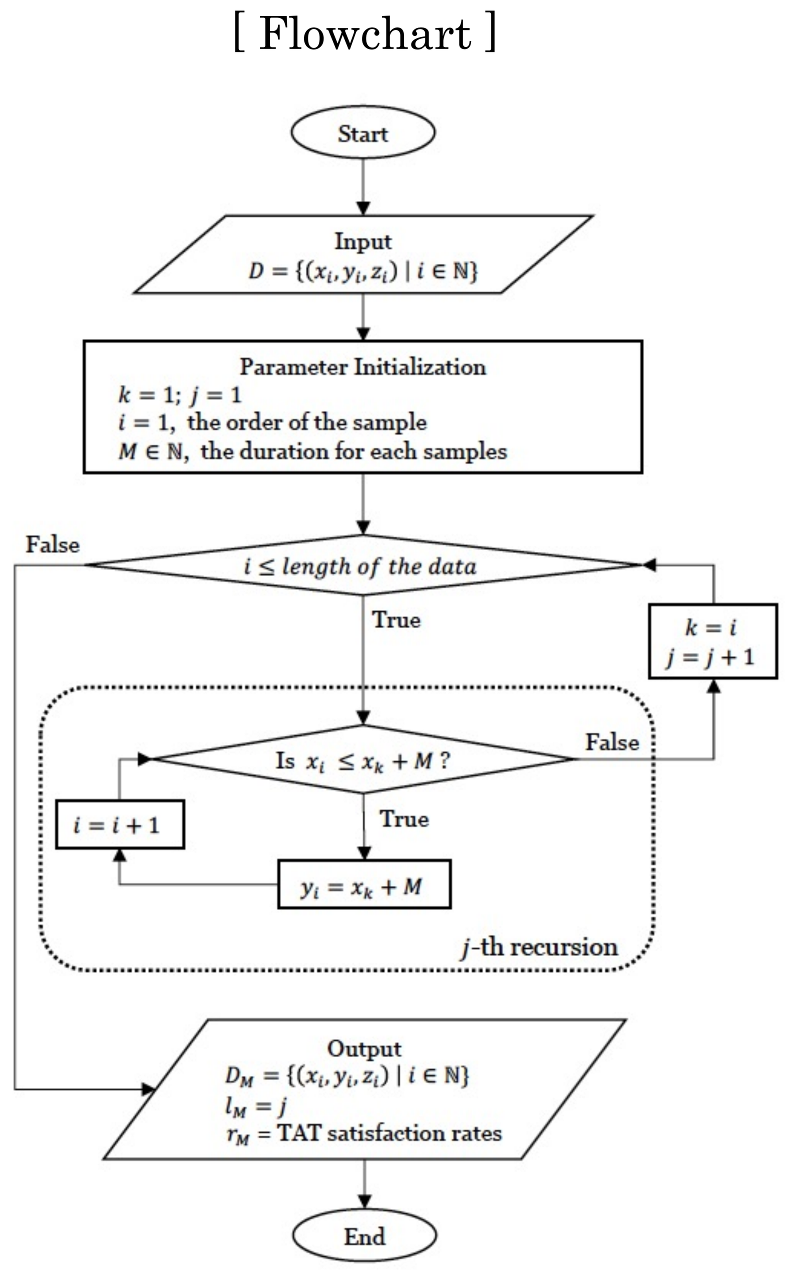
2. Output

- $D_M = \{(x_i, y_i, z_i) \mid i \in I\}$: *modified data*
- l_M : *the number of task switching instance*
- r_M : *TAT satisfaction rates*

[Mathematical Form]

$$\begin{aligned} &\textit{find} \quad M_0 = \underset{M}{\operatorname{argmin}} \; g(f_1(M), f_2(M)) \\ &\textit{where} \quad f_1(M) = 1 - r_M,\ f_2(M) = l_M \\ &\textit{subject to} \quad M \in \mathbb{N}^+ \end{aligned}$$

[Flowchart]



Algorithm Interpretations

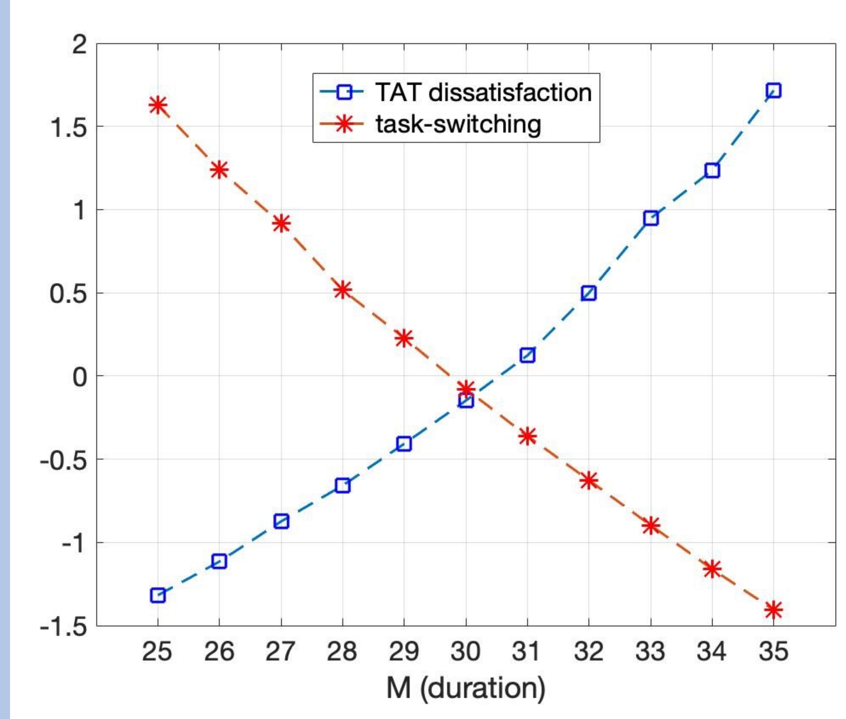


Figure 2. Graph with normalized variables $1 - r_M$ and l_M. For each M (duration), the red line shows the number of tasks and the blue line denotes the proportion of the samples that exceeded the TAT, 60 minutes.

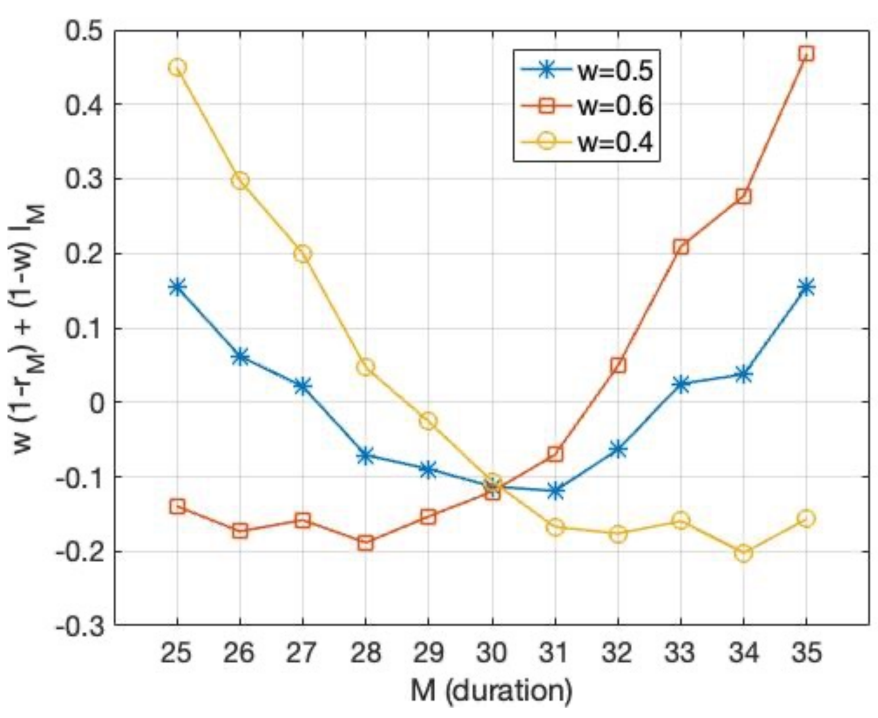


Figure 3. Linear combination of task switching and TAT dissatisfaction reflecting different weights (w).
$w \times (1 - r_M) + w \times l_M$

Improved results of Laboratory performance

A monitoring system was developed to alert technicians about switching their work based on the algorithm. This system automatically informs the medical technician 30 minutes after the sample arrives at the laboratory, so that they could meet the TAT guideline (1 hour or less). This monitoring system has been used since 2019, and data from January -August 2019 and January - August 2018 were used for the analysis.

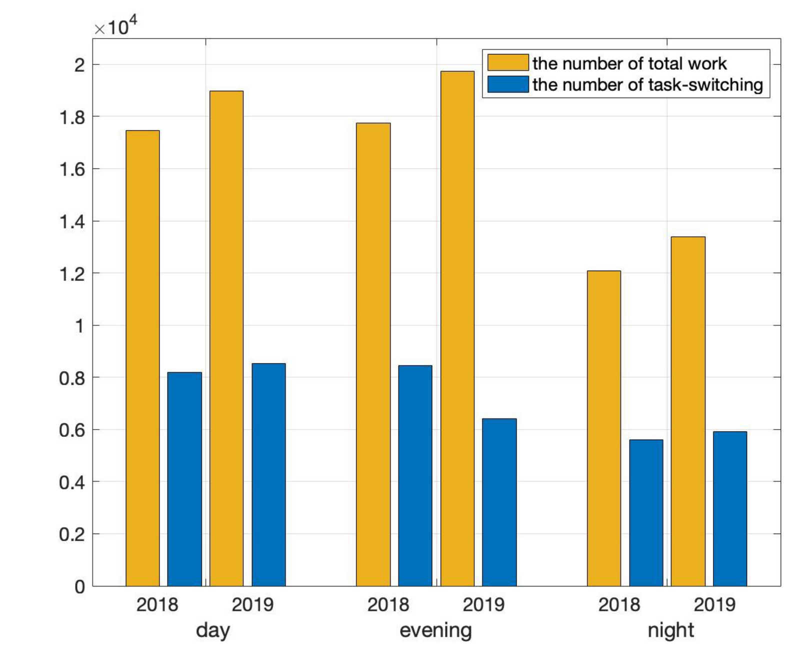


Figure 4. Number of total works at the laboratory, and the number of task-switching instances.

	Task switching counts per 100 tasks	
	2018	2019
Day	40	39
Evening	36	30
Night	43	36
total	39	35

Table 2. Task switching counts for every 100 works for each duty in the hospital.

		Sample no. (%)	Pre-analytical Phase	Analytical + Post-analytical Phase	Overall TAT
2018. 1~6.	Overall ER sample	34,875 (100.00%)	20.05 ± 8.51	16.93 ± 9.16	36.98 ± 12.82
	sample reported within 60 min.	33,141 (95.03%)	19.23 ± 6.77	15.79 ± 5.32	35.02 ± 8.43
	sample reported after 60 min.	1,734 (4.97%)	35.58 ± 18.05	38.75 ± 25.41	74.33 ± 21.84
2019. 1~6.	Overall ER sample	37,571 (100.00%)	19.13 ± 7.71	16.33 ± 6.90	35.46 ± 10.64
	sample reported within 60 min.	36,572 (97.34%)	18.67 ± 6.55	15.76 ± 5.08	34.43 ± 8.21
	sample reported after 60 min.	999 (2.66%)	35.90 ± 19.47	37.12 ± 20.03	73.02 ± 18.45

Table 1. Overall statistics of samples: mean and standard deviation (mean ± std) of each phase and overall TAT of clinical chemistry tests at ER, within 60 min and after 60 min.

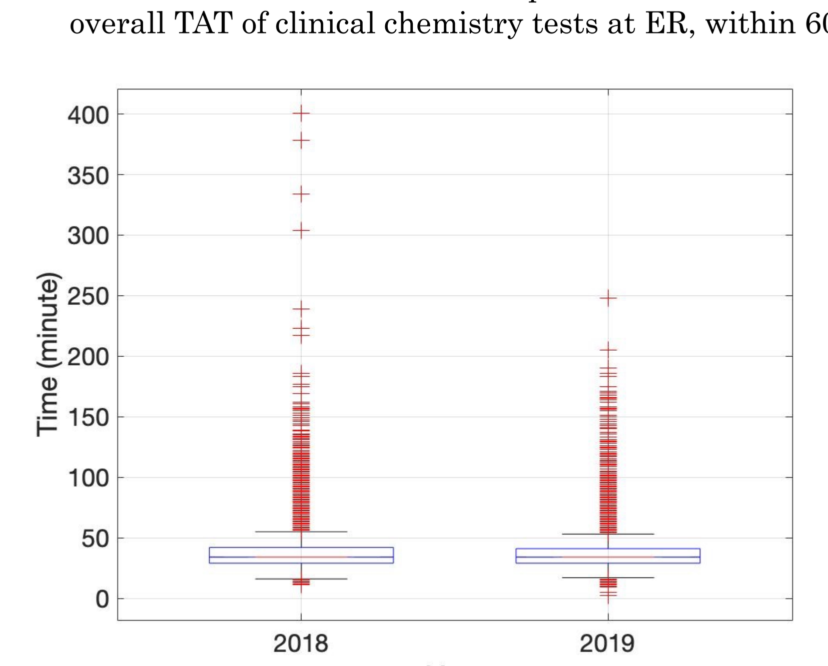


Figure 5. Boxplot with the TAT of the laboratory for each year.. In each box, the central mark indicates the median, and the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The outliers are plotted individually using the '+' symbol.

[Future Works]

- plan to study the artificial intelligence-based method of updating the reference point every hour by considering the various events of the laboratory in real-time, rather than the program for collectively determining the batch reference point used in this study

Reference & Acknowledgments

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