

Designing optimal procedures for task switching to ensure efficiency in the hospital laboratory

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Motivation - Insight into task switching

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- A_i : Analytical process of the i th sample

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This study aims to **improve the efficiency of task switching** in the hospital laboratories.

Outline

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- 2 Terminologies and background
 - Terminologies
 - Background
 - Data
- 3 Methods
 - Mathematical Optimization for finding the optimal work interval
 - Algorithm
 - Interpretations
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 - Monitoring System
 - Results

Terminologies

Non-analytical Phase			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.

Turnaround Time¹ Guideline of ST.Vincent's Hospital

In this study, we set **the goal to have ER² TAT as one hour or less.**

¹Turnaround Time (TAT)

²Emergency Room (ER)

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We assume that

- one person takes charge of the process and execute multiple tasks.
- the processing order of each sample is fixed and has a time limit.
- when multiple samples are mixed, the laboratorian has to switch tasks.

¹Turnaround Time (TAT)

²Emergency Room (ER)

Data

We use biochemical samples arriving at ER:

- Overall, 71,623 samples.
- Collected from January 2018 to August 2019.
- Barcode printing time, blood collection time, pre-reception time, reception time, and final report time.
- Through Hospital Information System and approved by the IRB³Ethics Committee of ST. Vincent's Hospital.

³Institutional Review Board (IRB)

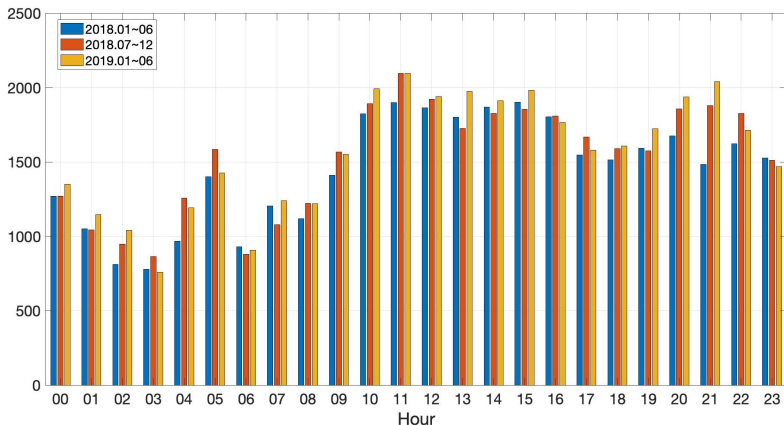


Figure 2: The number of ER samples arriving at the department of laboratory medicine by time from January 2018 and to June 2019.

Defining Problem

Again, our goal is not only to **minimize task switching** but also to **maintain TAT goal** (60 minutes) at the laboratory. An optimal sample processing time interval is proposed based on the algorithm.

I. Variables Definition

Non-analytical Phase			TAT						
			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.

1. Input

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

II. Variables Definition

For each duration time (min) M ,

2. Output

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

II. Variables Definition

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

$$\text{Find } M_0 = \underset{M}{\operatorname{argmin}} \ g(f_1(M), f_2(M))$$

$$\text{where } f_1(M) = 1 - r_M, \ f_2(M) = l_M$$

$$\text{subject to } M \in \mathbb{N}^+$$

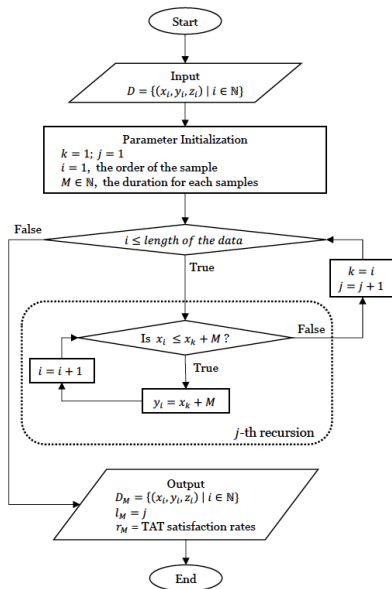


Figure3. Flowchart for task switching.

Algorithm Interpretations

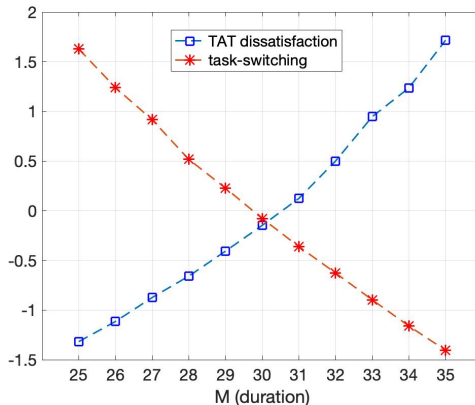


Figure 4: Graph with normalized variables $1 - r_M$ and I_M . For each M (duration), the red line shows the number of tasks and the blue line denotes the proportion of the samples that exceeded the TAT, 60 min.

Algorithm Interpretations

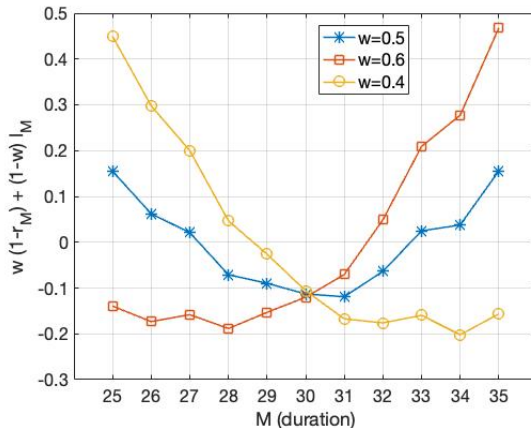


Figure 5: Linear combination of task switching and TAT dissatisfaction reflecting different weights. $(w \times (1 - r_M) + (1 - w) \times I_M)$.

Improved Results

Based on the Algorithm, we propose **the optimal work change over interval as 30 minutes.**

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Monitoring system

- developed to alert technicians about switching their work based on the algorithm.
- 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).
- had been used since 2019.

The data from January -August 2019 and January - August 2018 were used for the analysis.

Overall Statistics

		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

Table1. 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.

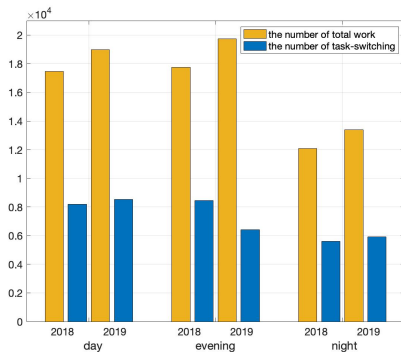


Figure 6: Number of total works at the laboratory, and the number of task switching instances.

	Task-switching counts per 100 work	
Duty	2018	2019
Day	40	39
Evening	36	30
Night	43	36
Total	39	35

Table2. Task-switching counts for every 100 works for each duty in hospital.

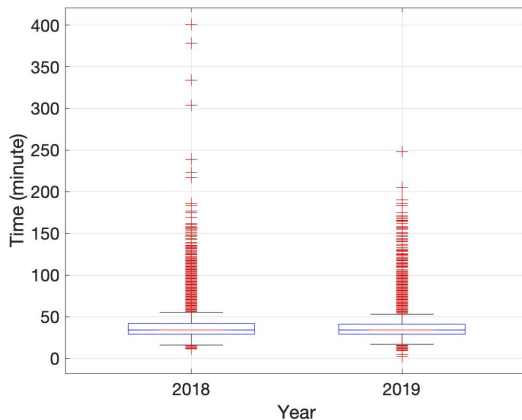


Figure 7: Boxplot with the TAT of the laboratory for each year. In each box, the central mark indicates the median, and the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The outliers are plotted individually using the '+' symbol.

References

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2. Rogers, R.D. and S. Monsell, Costs of a predictable switch between simple cognitive tasks. Journal of experimental psychology: General, 1995. 124(2): p. 207.

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