Introduction to the Course of Service Intelligence (IE308)

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2022. 08. 29

Overview

Title	Service Intelligence
Objective	Solve service problems in industry/society with learning intelligence
Class Meetings	MW 10:30 – 11:45; 106-T101
Instructor and Main TAs	Chiehyeon Lim: chlim@unist.ac.kr Hyunwoo Seo: ta57xr@unist.ac.kr Hansol Jung: sol0917@unist.ac.kr
Office Hours	By appointment through email communications
Key Topics	Recommender systems Service quality representations Learning customer data for service advancement Customer segmentation with clustering Service process assessment and improvement Industrial service intelligence Other special lectures

Service??

Restaurant Service

Health Care Service

taskrabbit UBER

Location-based Mediation Service

E-learning Service

Amusement Park Service

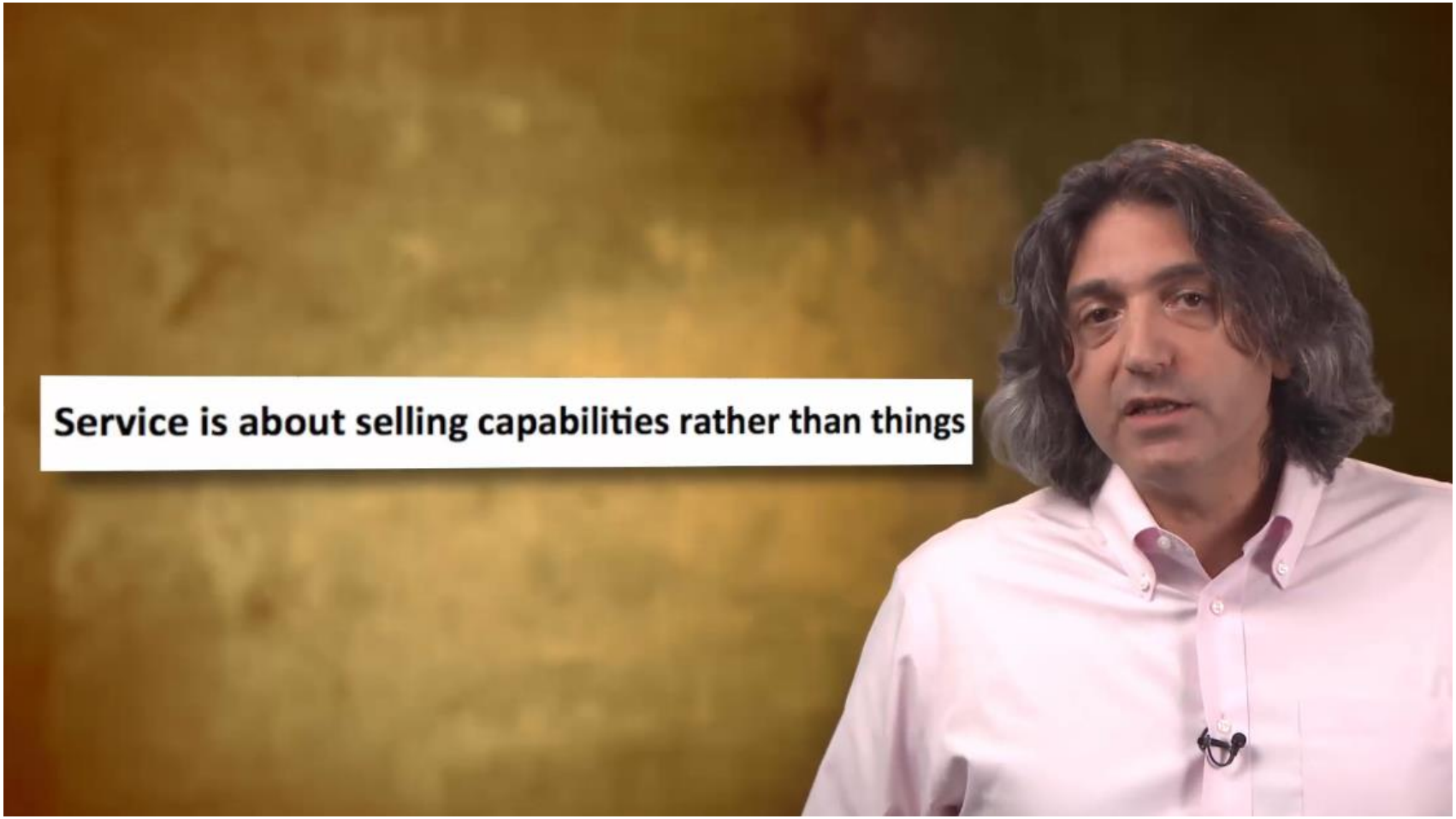
Ingredients Delivery Service

Car Sharing Service

Leisure Service

Mobile Game Service

Service is Simply to Serve Customers: Help Tasks or to Do the Tasks



Service is Simply to Serve Customers: Help Tasks or to Do the Tasks

- Data are collected in a connected network of objects and people
- Data contribute to monitoring the concerned objects and people, evaluating the status and condition, and identifying what tasks should be supported for the customers in which way
- A.I. solutions contribute to automate and/or improve specific tasks involved in the service

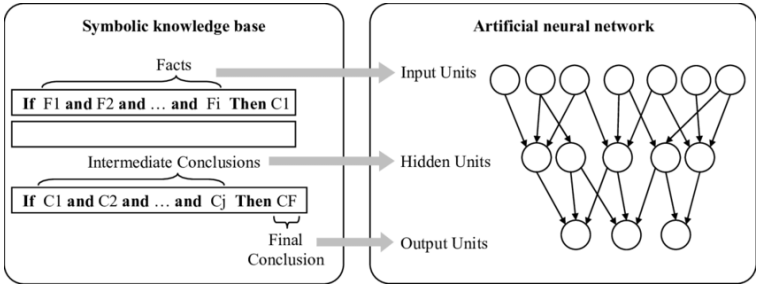
Volvo Trucks:
Telematics Gateway

BMW:
ConnectedDrive

IBM:
Precision Agriculture

More cases with
consumer electronics

Intelligence??



Restaurant Service

Health Care Service

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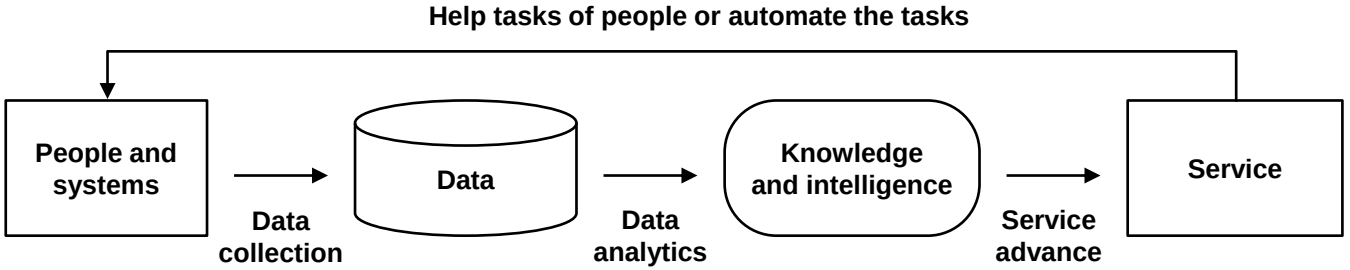
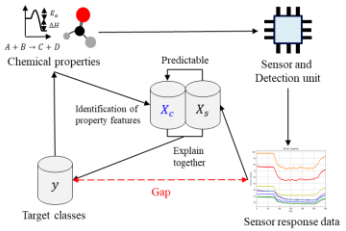
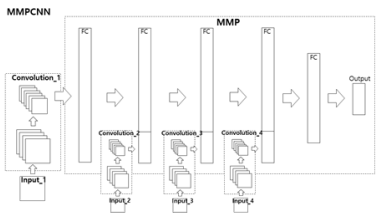
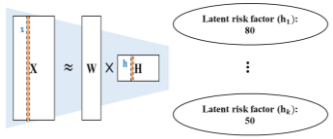
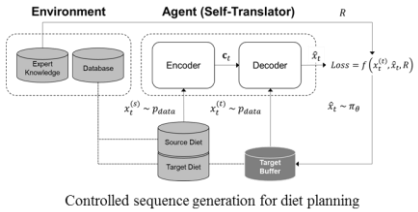
A Framework of Service Intelligence









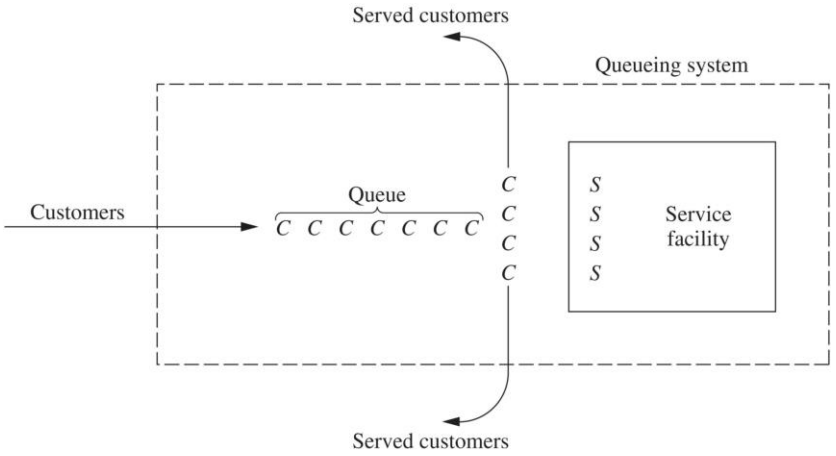


Controlled sequence generation for diet planning

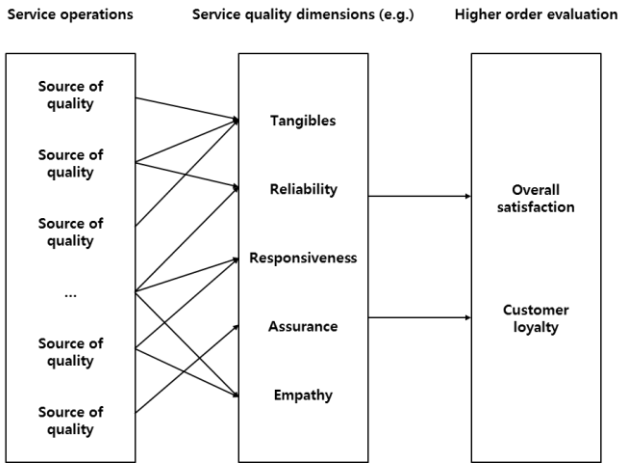
knowledge discovery and intelligence development

for advancing services in industry and society

Traditional Service Engineering and Management: Examples



Service efficiency modeling

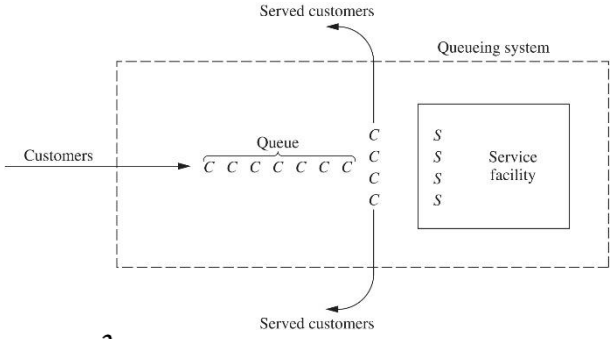


Service quality measurement

Service visualization and design

Service sales and delivery

Example: Service Modeling Approach in OR



$$\rho = \frac{\lambda}{\mu}$$

$$P_0 = 1 - \rho$$

$$P_n = (1-\rho)\rho^n$$

$$L = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu - \lambda}$$

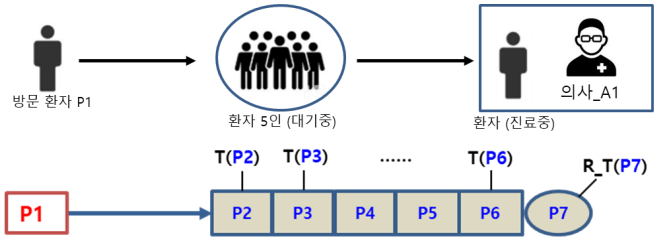
$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)} = \lambda W_q$$

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)}$$

$$W = \frac{1}{\mu-\lambda} = W_q + 1/\mu$$

Example: Data-driven Approach with ML

Input Data
(Pre-processed)

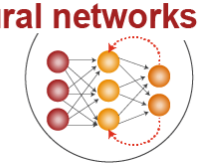


대기시간 예측용 데이터		
컬럼 명	**설명**	**변수 출처**
RCPN_NO	데이터 key	공통
PID	환자 ID	공통
DEPT_NM	진료과 명	공통
MDCR_DR_ID	의사 ID	공통
RCPN_APNT_DVNM	예약 여부	공통
RCPN_APNT_KIND_NM	접수경로	공통
MCCH_FREE_RESN_NM	특이사항	공통
FVNR_DVNM	환자종류	환자 접수 데이터
MDCR_DATE	날짜	공통
weekday	요일	파생
Time_Call	방문호출 시점 (진료시작시점)	호출 이벤트 데이터 가공
Time_next_patient_Call	다음 환자의 방문호출 시점 (진료종료시점)	호출 이벤트 데이터 가공
Time_resister	전산상 '대기' 등록 시점 (대기시작시점)	호출 이벤트 데이터 가공
Doctor_time	진료시간	파생
Waiting_time	대기시간	파생

Model

$$y = f(\mathbf{x}, \boldsymbol{\theta}) + \varepsilon$$

neural networks

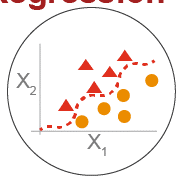


Nonlinearity consideration

Decision trees

Rule-based explanation (e.g., RF model)

Regression

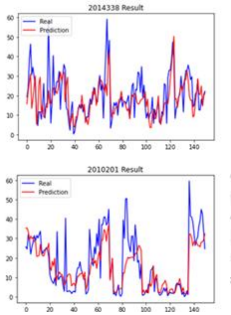


Linear coefficient calculation (LR with penalty)

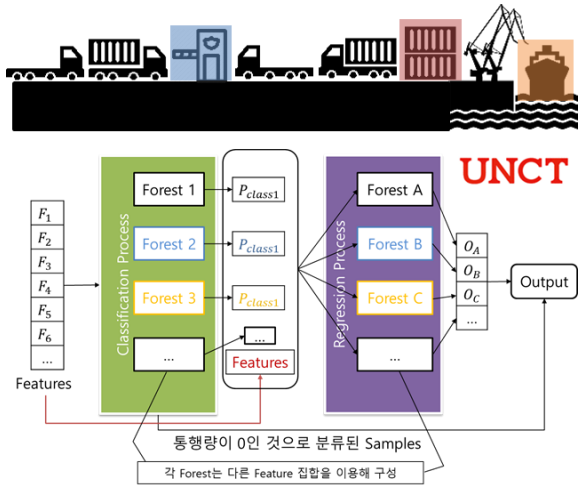
Result

$$\hat{y}(\mathbf{x})$$

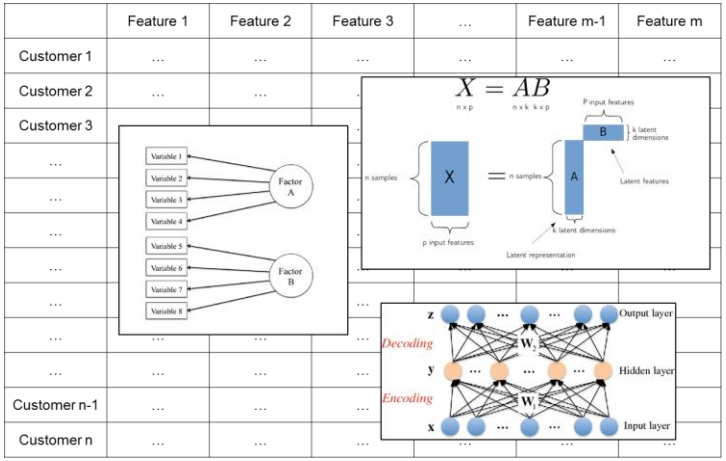
Number of waiting patients



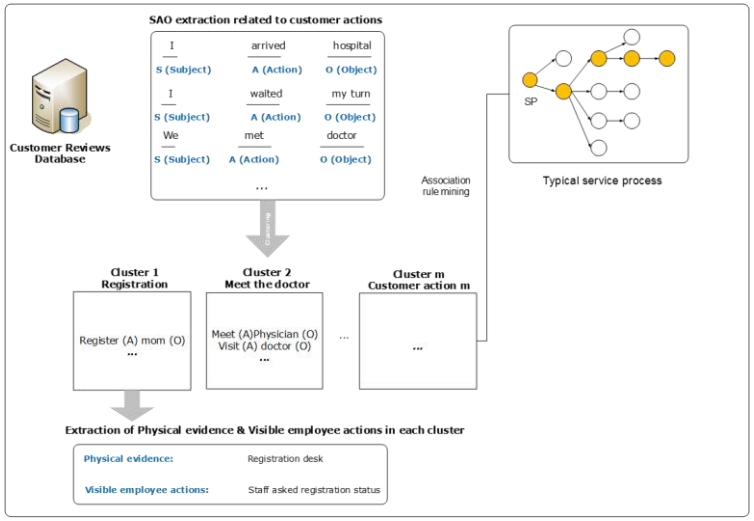
Modern Service Intelligence: Examples



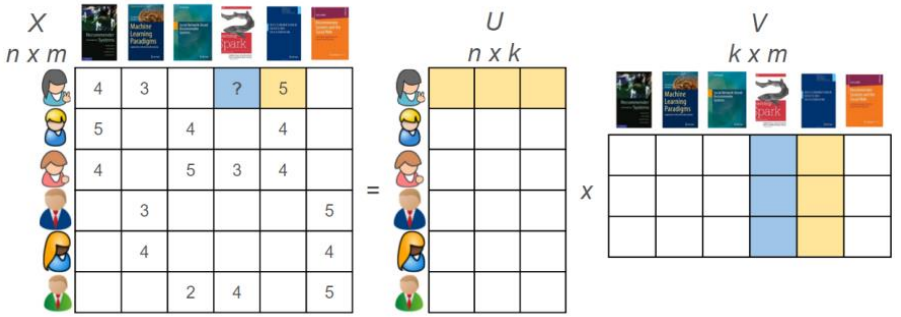
Service efficiency prediction



Service quality representation

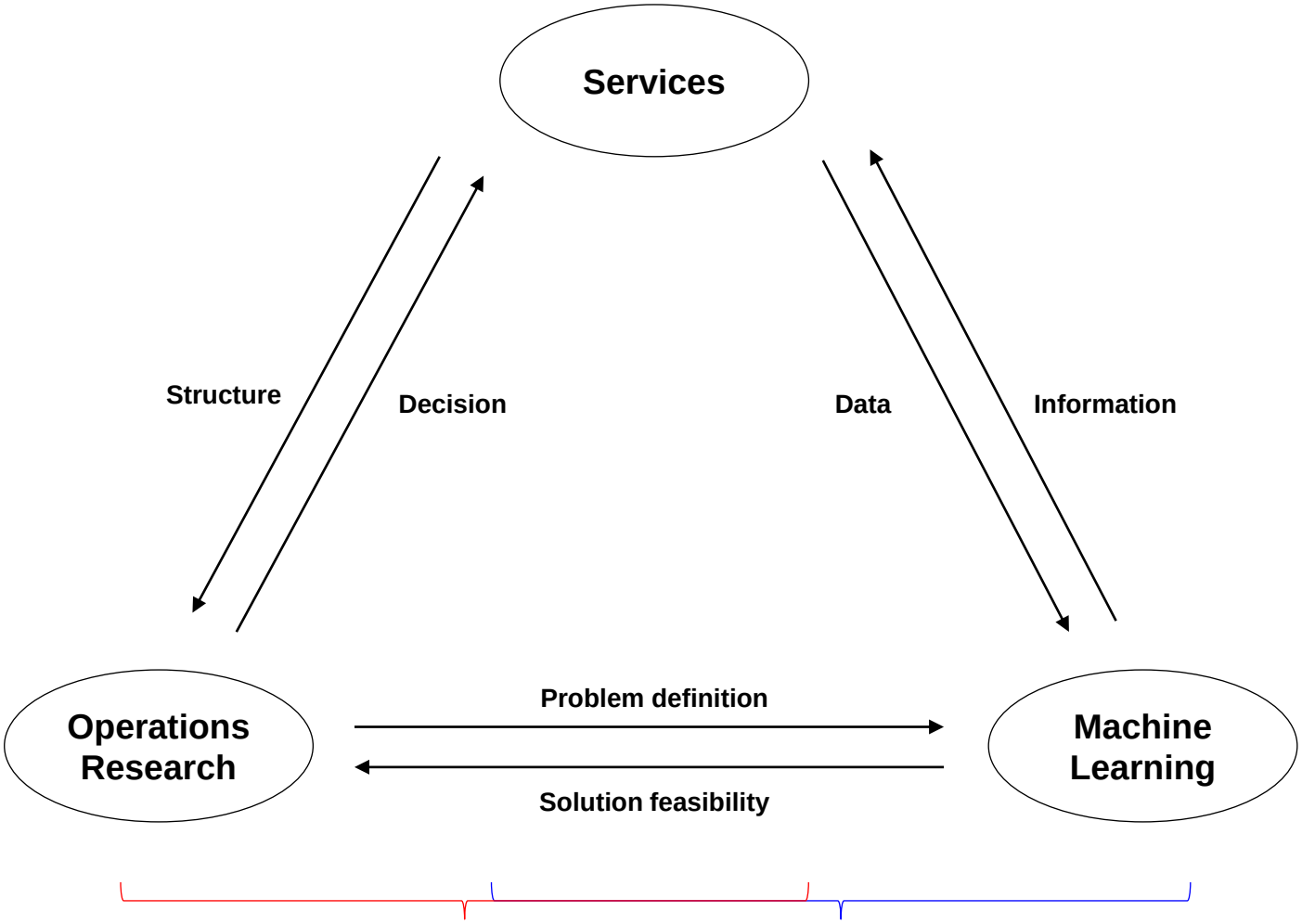


Data-driven service visualization and design



Recommender system for service delivery

Operations Research + Machine Learning



Topics of the Service Intelligence Course

Service Review Mining

Behavioral Data Mining

Recommender Systems Development

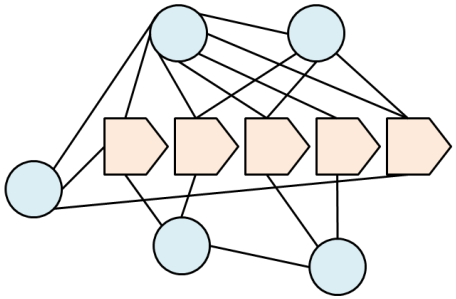
consumer behaviors (user behaviors)

service delivery and experience

Service Quality Evaluation and Improvement

All Weeks

technology and self-service



quality

value cocreation

relationship

innovation

design and development

productivity

Customer Segmentation and Service Customization

Special Lectures on Service Intelligence

knowledge and employee management

cost and pricing

service operations and supply chain management

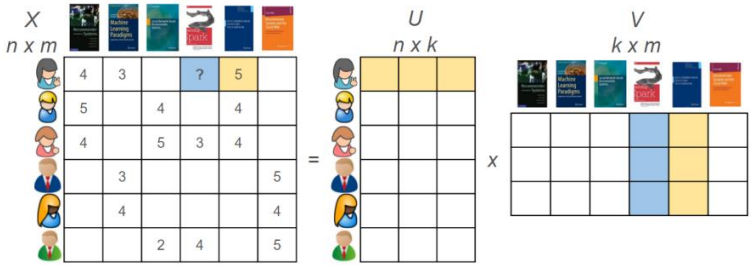
Service Process Assessment and Improvement

Service Optimization

Industrial Service Intelligence

This Course is a Practice-intensive Course

Normal lecture to learn key concepts and methods



$$\min_{q^*,p^*} \sum_{(u,i)\in\kappa} (r_{ui} - q_i^T p_u)^2 + \lambda(\| q_i \|^2 + \| p_u \|^2)$$

$$\min_{p^*,q^*,b^*} \sum_{(u,i)\in\kappa} (r_{ui} - \mu - b_u - b_i - p_u^T q_i)^2 + \lambda$$
$$(\| p_u \|^2 + \| q_i \|^2 + b_u^2 + b_i^2)$$

$$\hat{r}_{ui}(t) = \mu + b_i(t) + b_u(t) + q_i^T p_u(t)$$

Lab class for the practice of method application

Build the dataset (user-item matrix)

For the fast implementation, I randomly select 100 users and their all interactions.

```
[10] 1 from surprise import Reader, Dataset

1 reader = Reader()
2
3 # just get interactions of 500 users randomly
4 n_users = 500
5 all_users = df.Cust_Id.unique()
6 sampled_users = np.random.choice(all_users, n_users, replace=False)
7 df_sample = df.loc[df['Cust_Id'].isin(sampled_users)]
8 print('{} interactions, {} users, {} movies are selected.'.format(len(df_sample), df_sample.Cust_Id.nunique(), df_sample.Movie_Id.nunique()))
9 print('only {:.2f}% of possible interactions are observed'.format(len(df_sample) / (df_sample.Cust_Id.nunique()*df_sample.Movie_Id.nunique()) *100))
10
11 data = Dataset.load_from_df(df_sample[['Cust_Id', 'Movie_Id', 'Rating']], reader)
12 unobserved_data = data.build_full_trainset().build_anti_testset()
13
```

```
26124 interactions, 500 users, 2191 movies are selected.
only 2.38% of possible interactions are observed
```

```
1 from surprise import SVD, NMF, accuracy
2 from surprise.model_selection import cross_validate
3
4 # hyperparameters for training the model
5 n_factors = 30
6 n_epochs = 100
7 biased = True
```

Setting parameters

```
[12] 1 algo = SVD(n_factors=n_factors, n_epochs=n_epochs, biased=biased, random_state=seed,)
```

```
[140] 1 cv_result = cross_validate(algo, data, measures=['RMSE', 'MAE'], cv = 5, verbose = True)

Evaluating RMSE, MAE of algorithm SVD on 5 split(s).
```

Cross-validation of SVD

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Std
RMSE (testset)	1,0591	1,0331	1,0488	1,0567	1,0567	1,0509	0,0095
MAE (testset)	0,8204	0,8157	0,8195	0,8281	0,8269	0,8221	0,0047
Fit time	3,08	3,06	3,04	2,98	2,96	3,02	0,05
Test time	0,05	0,03	0,03	0,03	0,03	0,04	0,01

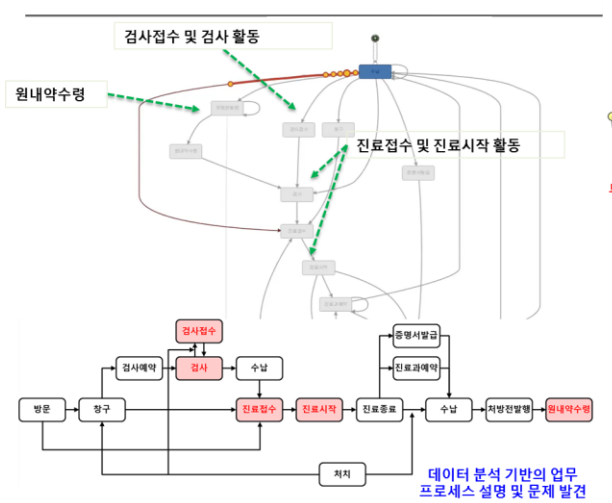
```
[141] 1 algo = NMF(n_factors=n_factors, n_epochs=n_epochs, biased=biased, random_state=seed,)
      2 cv_result = cross_validate(algo, data, measures=['RMSE', 'MAE'], cv = 5, verbose = True)

Evaluating RMSE, MAE of algorithm NMF on 5 split(s).
```

Cross-validation of NMF

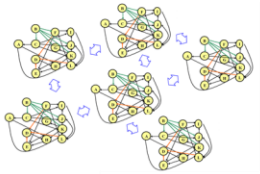
	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Std
RMSE (testset)	1,8985	1,5922	1,6829	1,4256	1,8489	1,6896	0,1722
MAE (testset)	1,5083	1,2255	1,3277	1,0870	1,4772	1,3251	0,1570
Fit time	4,14	4,12	4,08	4,11	4,05	4,10	0,03
Test time	0,03	0,03	0,04	0,03	0,04	0,04	0,00

This Course is a Practice-intensive Course

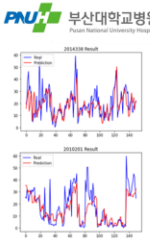
Normal lecture to learn key concepts and methods



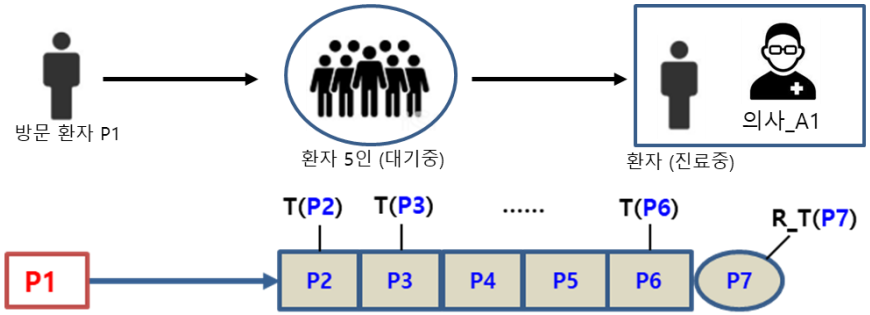
데이터 분석 기반의 업무 프로세스 설명 및 문제 발견



부서 간, 부서 내 복잡한 업무 프로세스들



인공지능의 외래환자 대기시간 예측 및 서비스 개선 방향 파악



Lab class for the practice of method application

MLP

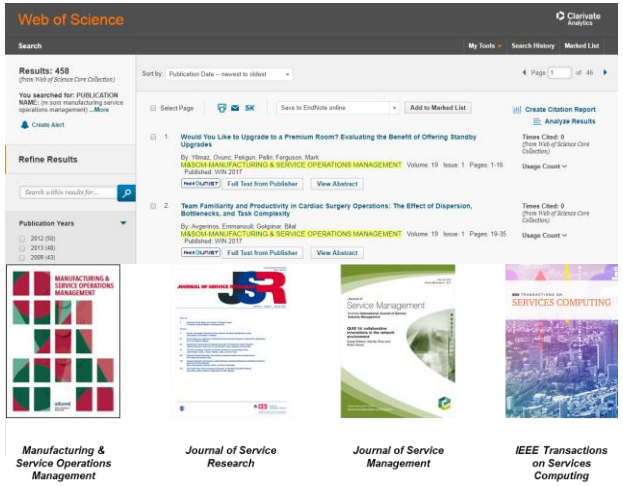
In [15]:
```
#모델 준비
model = MLPRegressor()
#하이퍼파라미터 범위 세팅
HyperParameter_dic = dict(
    hidden_layer_sizes=[(128,64,32),
                        (256,128,64,32,16,8),
                        (16,8,32,16,8),
                        (128,64,32,16),
                        (8,16,32,64,128,64,32,16,8),
                        (16,8,32,16,8)],
    alpha=[0.01],
    learning_rate_init=[0.001],
    max_iter = [4000],
    activation = ['relu'] ,
    solver = ['adam'],
    learning_rate = ['constant'] )
#Cross Validation 옵션 준비
CV_option = model_selection.KFold(n_splits = 3, random_state= 1, shuffle= True)

#GridSearch 준비
grid = model_selection.GridSearchCV(estimator= model, param_grid= HyperParameter_dic, cv= CV_option, n_
jobs = -1, verbose = 1, refit = True)
#모델 학습 및 하이퍼파라미터 자동 선택
grid_results = grid.fit(X_train, y_train)
#베스트 하이퍼파라미터 출력
print(grid.best_params_)

#학습 모델로 부터 예측
pred_train = grid_results.predict(X_train)
pred_test = grid_results.predict(X_test)

#Square root 취한 대기시간(waiting time)을 다시 원래의 스케일로 변환
pred_train = np.square(pred_train)
pred_test = np.square(pred_test)

#학습 데이터셋, 테스트 데이터셋에서의 결과 출력
train_MLP_rmse, train_MLP_r2 = Model_Result(train_df.loc[:,"waiting_time"], pred_train, "Train")
MLP_rmse, MLP_r2 = Model_Result(test_df.loc[:,"waiting_time"], pred_test, "Test")
```

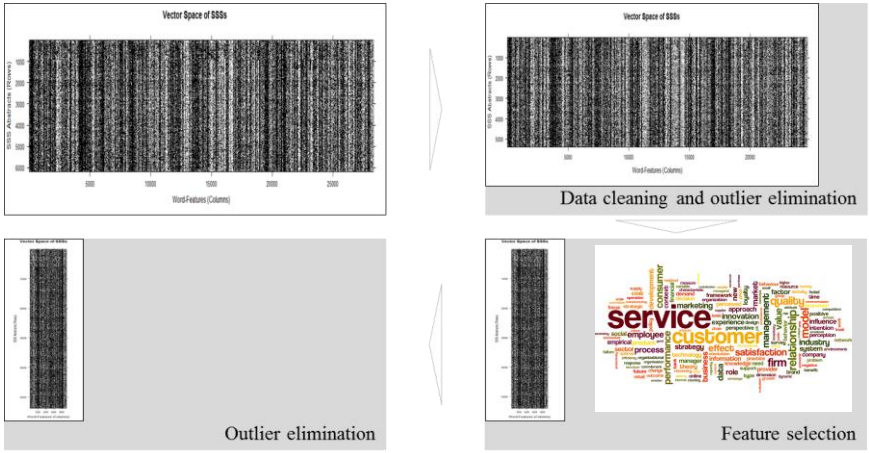
```
Fitting 3 folds for each of 6 candidates, totalling 18 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done  18 out of  18 | elapsed:   39.0s finished
{'activation': 'relu', 'alpha': 0.01, 'hidden_layer_sizes': (128, 64, 32, 16), 'learning_rate': 'cons
tant', 'learning_rate_init': 0.001, 'max_iter': 4000, 'solver': 'adam'}
*****Train-dataset-result*****
RMSE of MLP model : 14.681
R_2 of MLP model : 0.59
*****Test-dataset-result*****
RMSE of MLP model : 16.991
R_2 of MLP model : 0.552
```

Random Forest

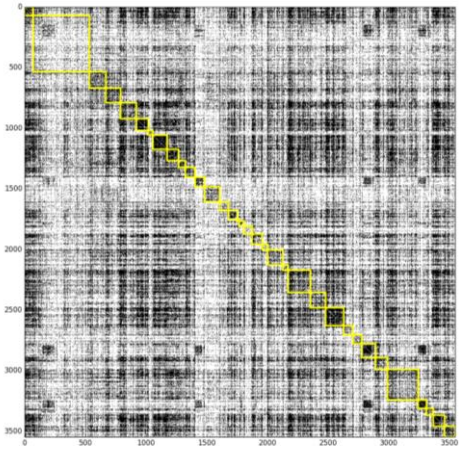
In [16]:
```
#모델 준비
model = RandomForestRegressor()
```

Week 1. Understanding of the Service Tasks and Domains





Research topic	Some of the keywords identified from topic modeling and the five metrics
1. service experience	experience, service, customer, interaction, dimension, process, emotion, satisfaction, etc.
2. service management model	service, model, customer, management, industry, cost, system, factor, performance, business, etc.
3. professional service	firm, service, professional, industry, client, performance, relationship, business, manufacturing, etc.
4. service innovation	innovation, service, firm, performance, business, customer, strategy, empirical, company, etc.
5. service quality measurement	quality, service, customer, scale, satisfaction, dimension, perception, measurement, etc.
6. service failure and recovery	service, recovery, failure, customer, satisfaction, negative, influence, compensation, etc.
…	…



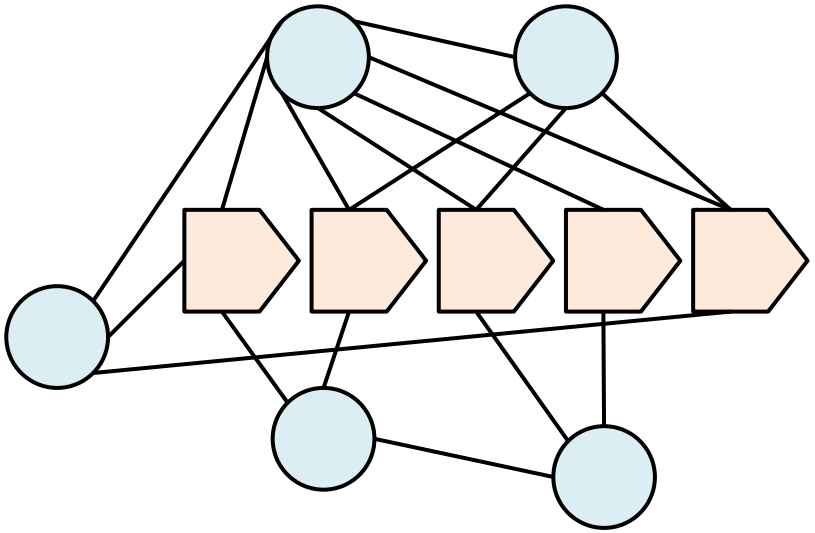
Reference: Toward a unified model of service systems (Lim and Maglio, 2017)

Week 1. Understanding of the Service Tasks and Domains

consumer behaviors
(user behaviors)

service delivery
and experience

technology and
self-service



quality

value cocreation

relationship

innovation

design and
development

productivity

knowledge and
employee
management

cost and pricing

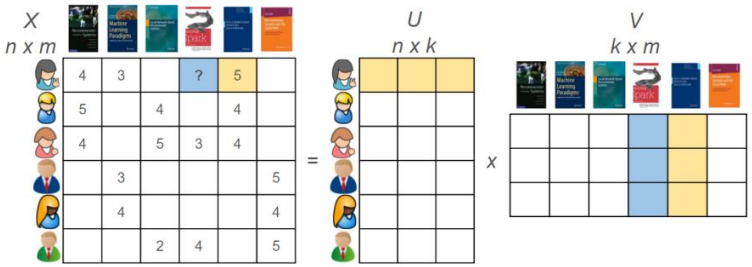
service operations
and supply chain
management

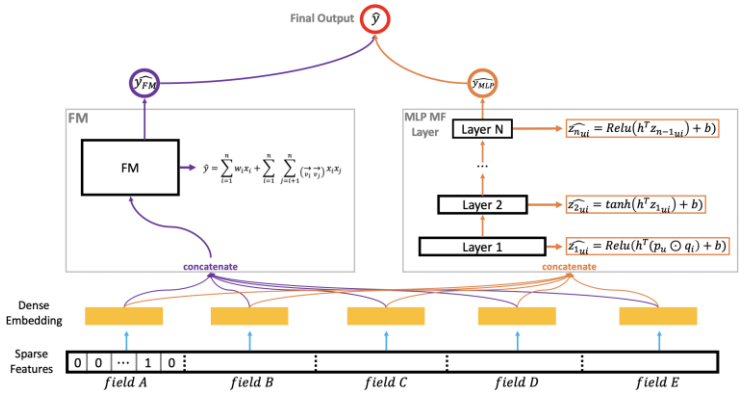
Week 2. Recommender Systems

- Recommender systems use analytic techniques to compute the value that a user would purchase one of the items; the techniques vary according to the purposes and data

	Item 1	Item 2	Item 3	…	Item m-1	Item m
User 1	…	…	…	…	…	…
User 2	…	…	…	…	…	…
User 3	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
User n-1	…	…	…	…	…	…
User n	…	…	…	…	…	…

	Feature 1	Feature 2	Feature 3	…	Feature m-1	Feature m
Transaction 1	…	…	…	…	…	…
Transaction 2	…	…	…	…	…	…
Transaction 3	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…
Transaction n-1	…	…	…	…	…	…
Transaction n	…	…	…	…	…	…





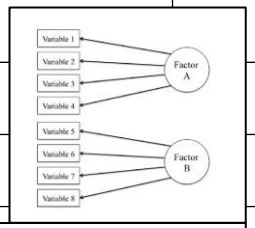
Week 3. Service Quality Representations

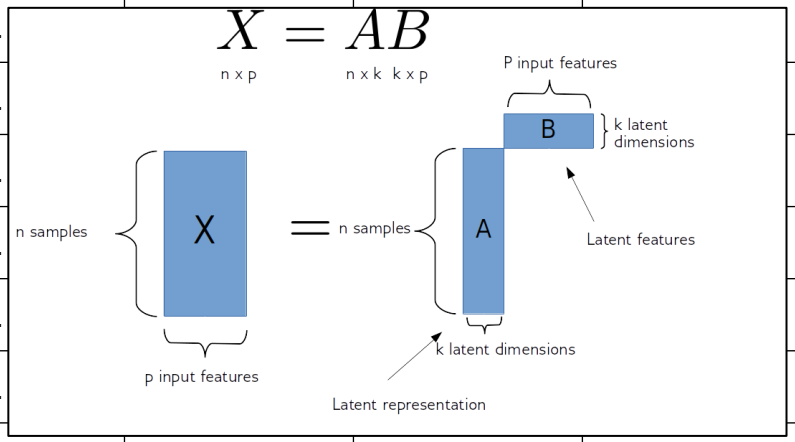
Latent quality representations

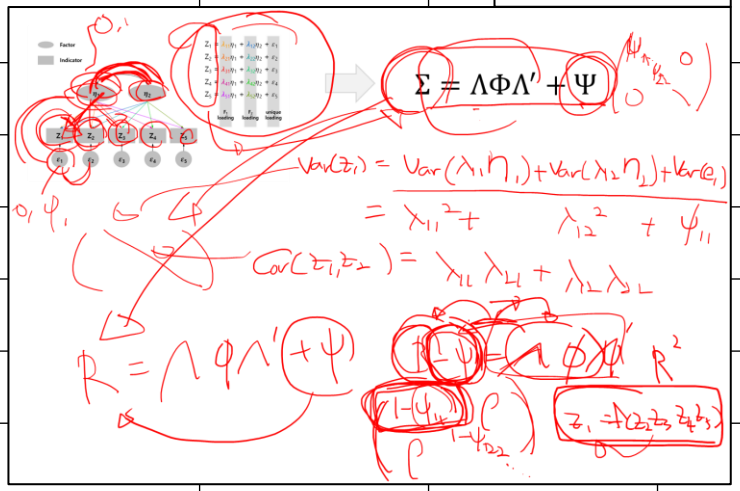
Observable quality incidents

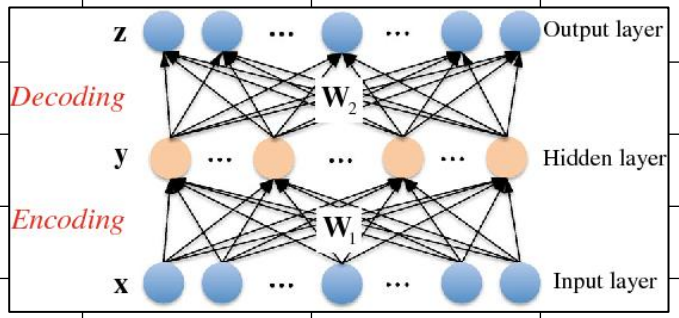
Quality perception

	Feature 1	Feature 2	Feature 3	…	Feature m-1	Feature m
Customer 1	…					
Customer 2	…					
Customer 3	…					
				…	…	…
				…	…	…
				…	…	…
				…	…	…
				…	…	…
Customer n-1	…	…	…			
Customer n	…	…	…	…	…	…









Week 3. Service Quality Representations

Construct Validity

1 Convergent Validity

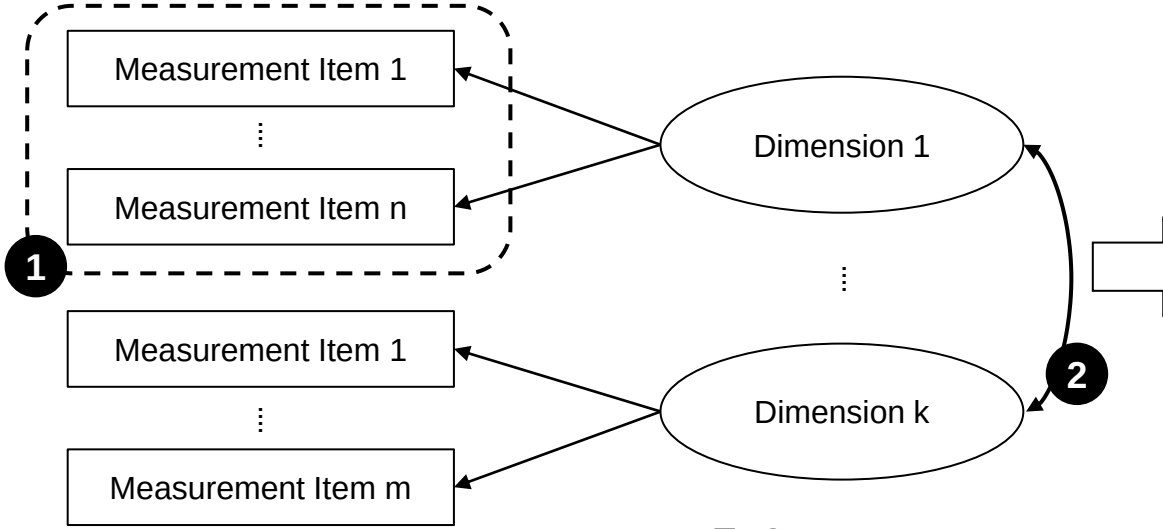
The extent to which a set of the items assumed to represent a dimension does in fact converge on the same dimension

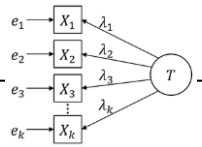
2 Discriminant Validity

The extents to which measures of theoretically unrelated dimension do not correlate with one another

3 Predictive Validity
(Nomological Validity)

The extents to which the score of one dimension is empirically related to the scores of other conceptually related constructs





$$\frac{(\sum \lambda_i{}^2)}{(\sum \lambda_i{}^2) + (\sum_i var\,(\varepsilon_i))}$$

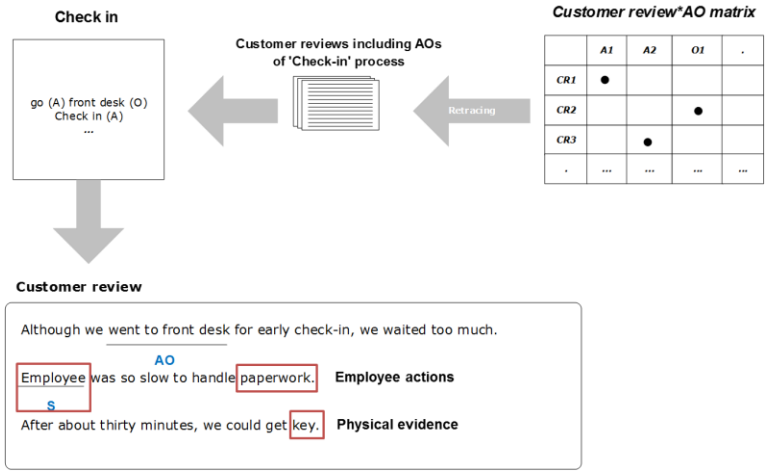
TABLE 6

Relative Importance of the Five Dimensions in Predicting Overall Quality

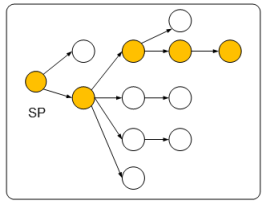
Dimension	Standardized Slope Coefficient	Significance Level of Slope[a]	Adusted R^2	
Bank				
Tangibles	.13	.07	.28 ($p < .00$)	
Reliability	.39	.00		
Responsiveness	.07	.35		
Assurance	.13	.09		
Empathy	.01	.89		

Reference: Peter (1981)

Week 4. Review Mining for Service Quality Improvement



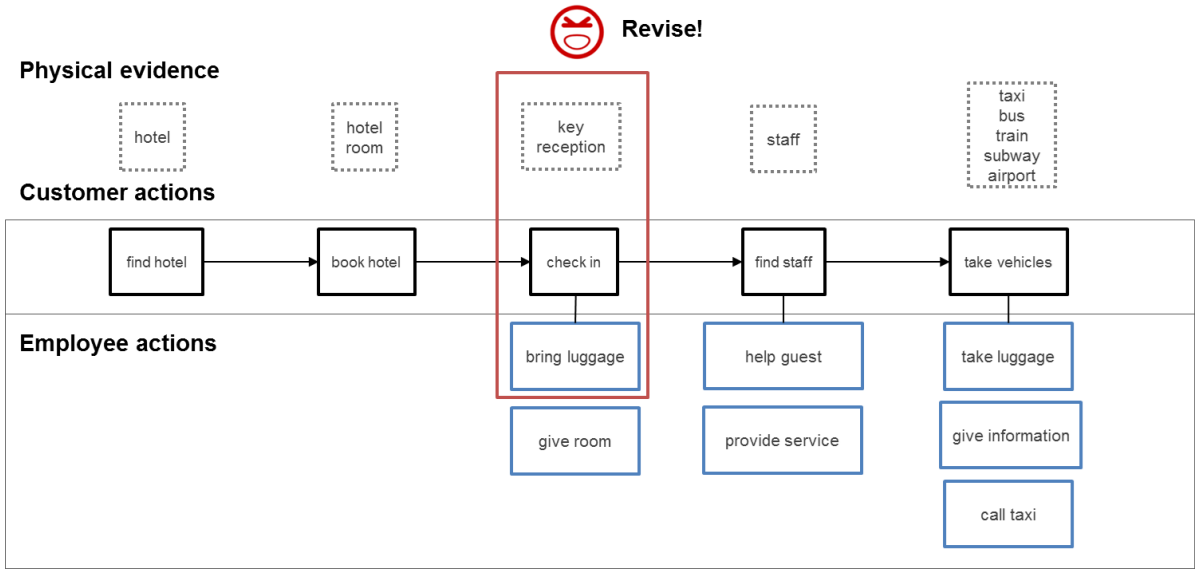
	Antecedent	Consequent	Lift
1	{find hotel}	{take vehicles, check in}	1.82
2	{find hotel}	{find staff, take vehicles}	1.78
3	{find hotel}	{find staff, book hotel}	1.59
…	…	…	…



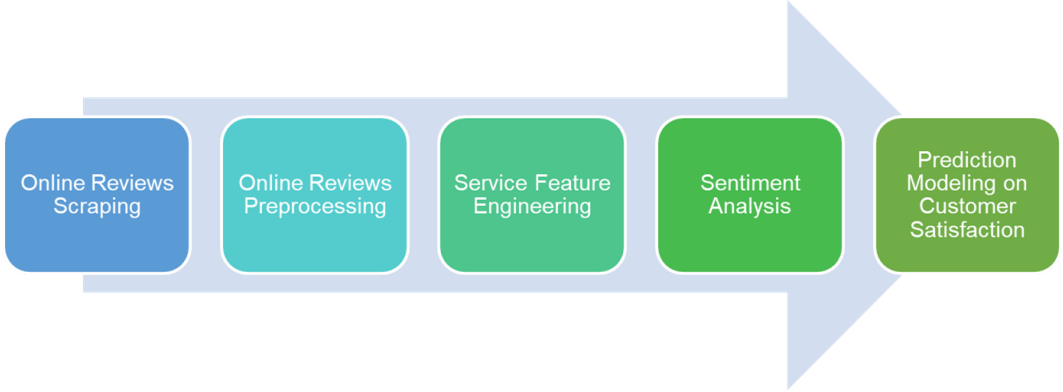
Expedia

tripadvisor

Rating = f($step_1$, $step_2$, $step_3$…)



Week 4. Review Mining for Service Quality Improvement



	Feature 1	Feature 2	Feature 3	…	Feature m-1	Feature m	Rating
Review 1	?	?	?	?	?	?	5
Review 2	?	?	?	?	?	?	5
Review 3	?	?	?	?	?	?	4
…	?	?	?	?	?	?	3
…	?	?	?	?	?	?	4
…	?	?	?	?	?	?	1
…	?	?	?	?	?	?	4
…	?	?	?	?	?	?	5
…	?	?	?	?	?	?	4
…	?	?	?	?	?	?	3
Review n-1	?	?	?	?	?	?	2
Review n	?	?	?	?	?	?	4

Week 5. Customer Segmentation for Service Customization

- Customer-feature matrix

	Feature 1	Feature 2	Feature 3	…	Feature m-1	Feature m
Customer 1	…	…	…	…	…	…
Customer 2	…					…
Customer 3	…					…
…	…					…
…	…					…
…	…					…
…	…					…
…	…					…
…	…					…
…	…					…
Customer n-1	…					…
Customer n	…	…	…	…	…	…

Cluster 0. 스트레스 (Stress)

Cluster 1. 완벽주의 (Perfectionism)

Cluster 2. 스마트폰 (Smartphone)

Cluster 3. 너무피곤 (Tiredness)

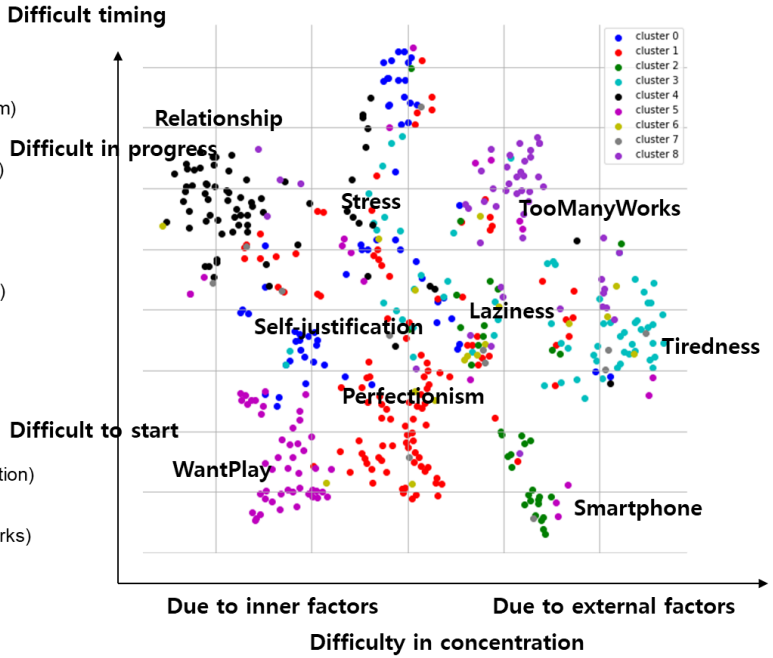
Cluster 4. 인간관계 (Relationship)

Cluster 5. 놀고싶어 (WantPlay)

Cluster 6. 귀차니즘 (Laziness)

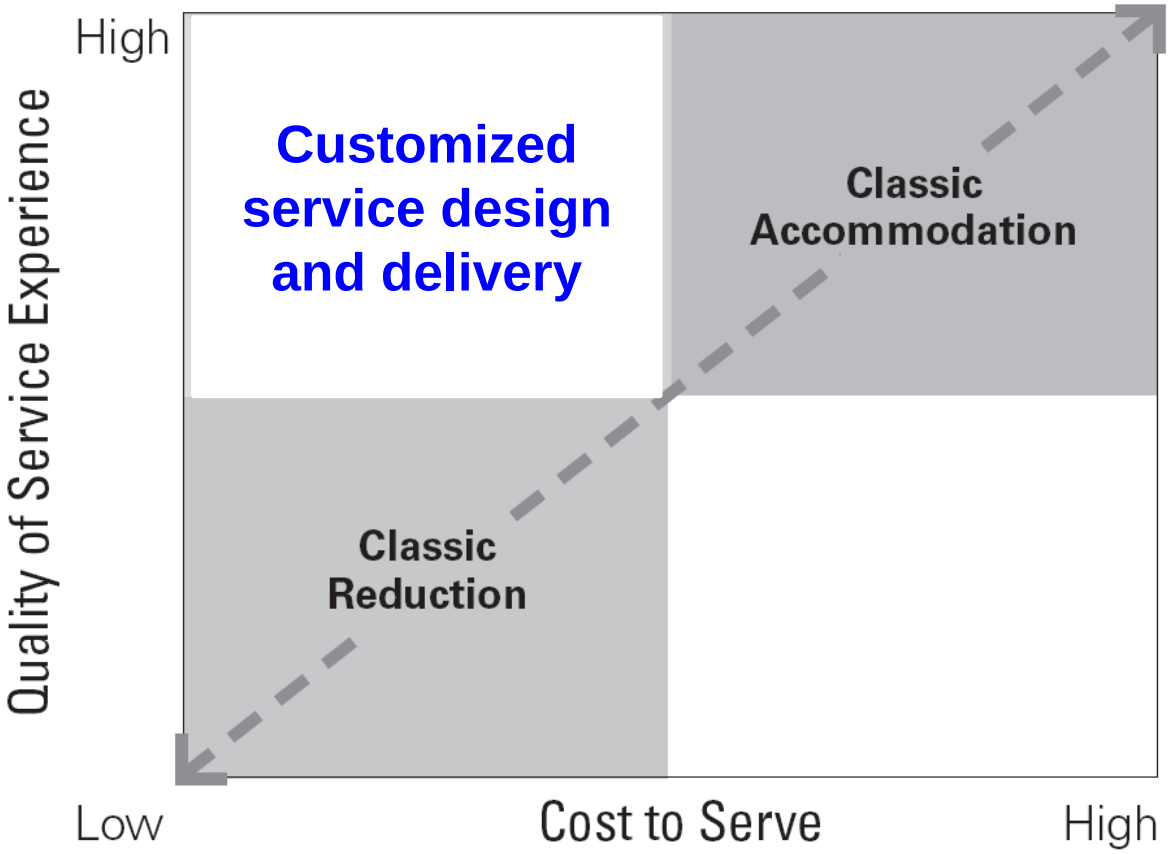
Cluster 7. 자기안심 (Self-justification)

Cluster 8. 일이많음 (TooManyWorks)

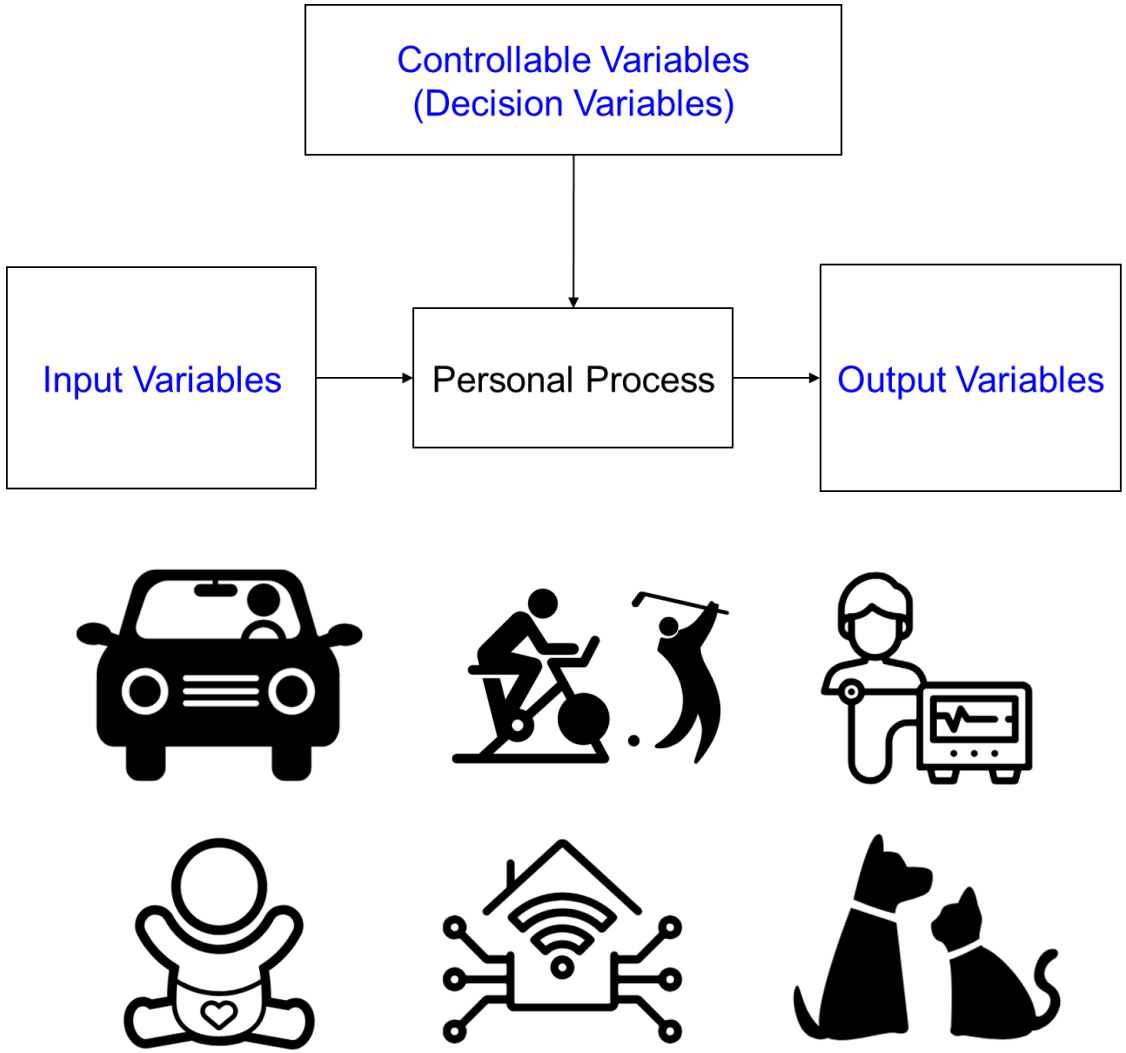


Week 5. Customer Segmentation for Service Customization

- Service customization is to accommodate and control customer variability at the same time

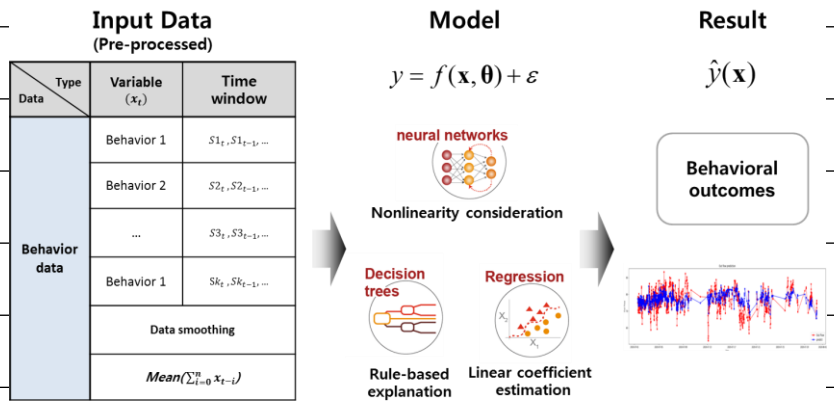


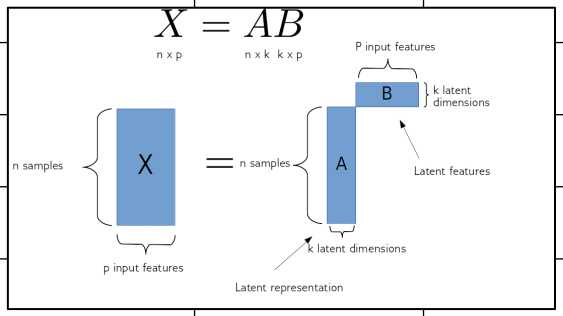
Weeks 6 and 7. Learning Behavioral Data of Users

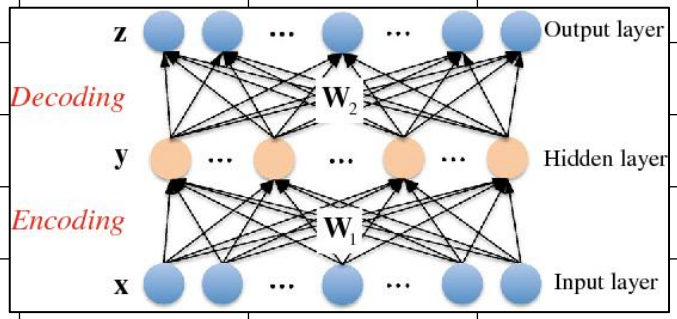


Weeks 6 and 7. Learning Behavioral Data of Users

	Behavioral feature 1	Behavioral feature 2	Behavioral feature 3	…	Behavioral feature m	Outcome label
Customer 1	…					…
Customer 2	…					…
Customer 3	…					…
…	…					…
…	…					…
…	…					…
…	…	…	…	…	…	…
…						
…						
…						
Customer n-1						
Customer n						







Week 9. Service Process Assessment and Improvement

Input Data

Model

$$y = f(\mathbf{x}, \boldsymbol{\theta}) + \varepsilon$$

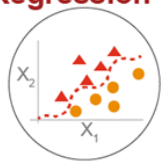
neural networks

Nonlinearity consideration

Decision trees

Rule-based explanation (e.g., RF model)

Regression

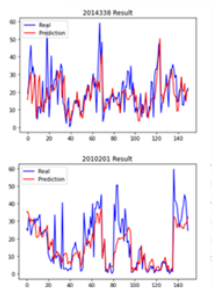


Linear coefficient calculation (LR with penalty)

Result

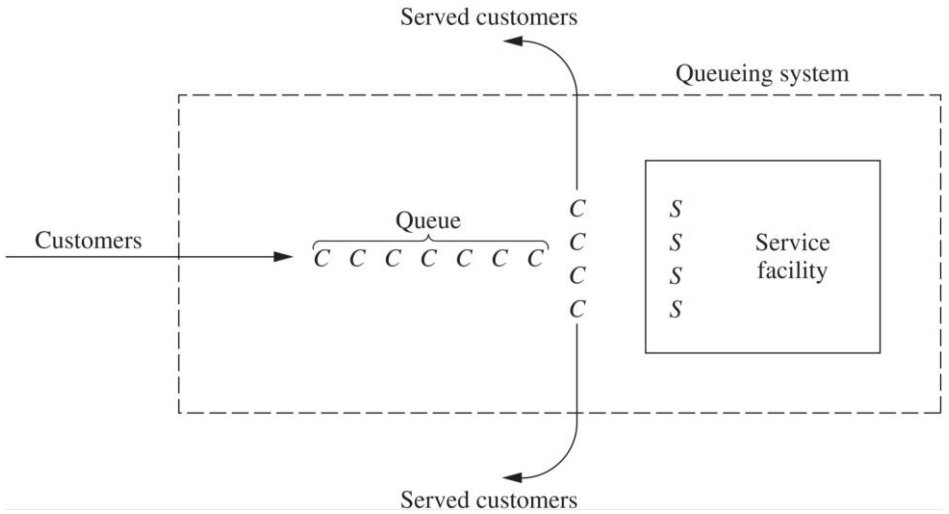
$$\hat{y}(\mathbf{x})$$

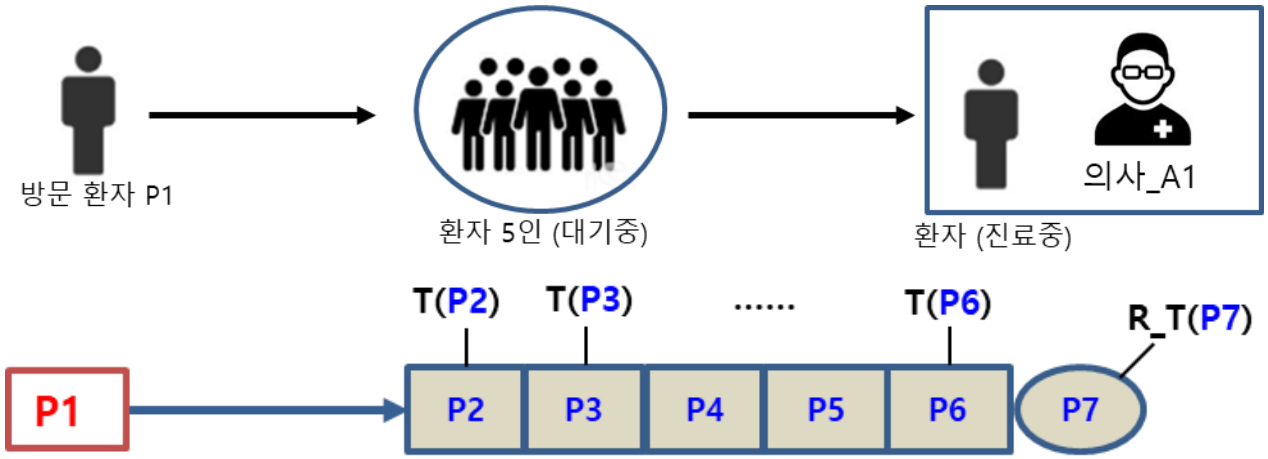
Number of waiting patients



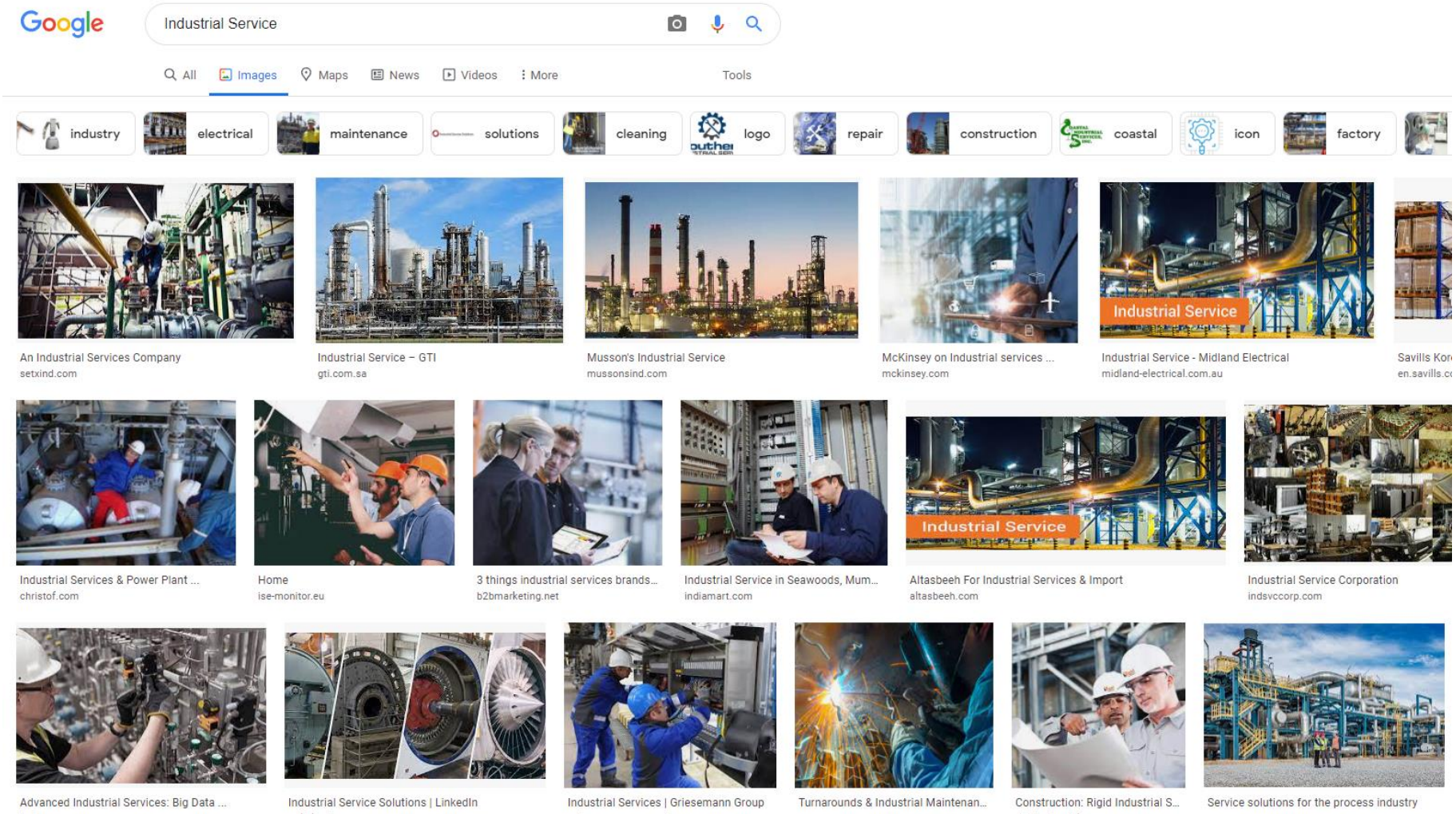
Week 9. Service Process Assessment and Improvement

Index	Patient ID	Physician	Sequence	Activity	Event Time
1	Patient A	Physician A	1	Registration	2020-08-03 10:15:21
2	Patient A	Physician A	2	Addition into queue	2020-08-03 10:15:22
3	Patient B	Physician A	1	Registration	2020-08-03 10:15:36
4	Patient B	Physician A	2	Addition into queue	2020-08-03 10:15:38
5	Patient C	Physician B	1	Registration	2020-08-03 10:33:20
6	Patient C	Physician B	2	Preliminary examination	2020-08-03 10:33:26
6	Patient A	Physician A	3	Call for a consultation	2020-08-03 10:33:28
7	Patient B	Physician A	3	Call for a consultation	2020-08-03 10:36:12
8	Patient C	Physician B	3	Addition into queue	2020-08-03 11:23:45
...	...	...	...	...	...



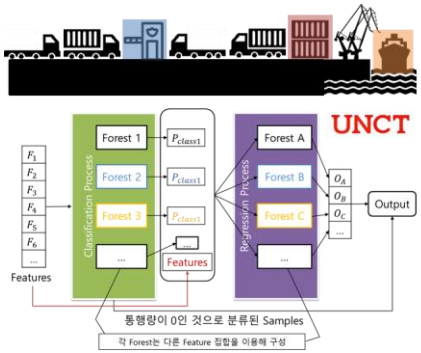


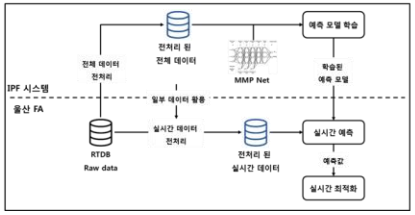
Week 10. Industrial Service Intelligence

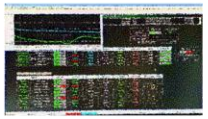


Week 10. Industrial Service Intelligence

Service







Input Data
(Pre-processed)

Data \ Type	Original (x_t)	window
Feed	Feed	$Feed_t, Feed_{t-1}, \dots$
Process Data	Stage I	$S1_t, S1_{t-1}, \dots$
	Stage II	$S2_t, S2_{t-1}, \dots$
	Stage III	$S3_t, S3_{t-1}, \dots$
	Stage IV	$S4_t, S4_{t-1}, \dots$
	Data Smoothing	
	$Mean(\sum_{i=0}^{n} x_{t-i})$	

Model

$$y = f(\mathbf{x}, \boldsymbol{\theta}) + \varepsilon$$

neural networks

Process-based explanation
(Skipped NN)

Decision trees

Rule-based explanation
(XGBoost)

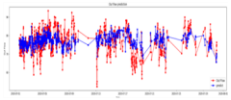
Regression

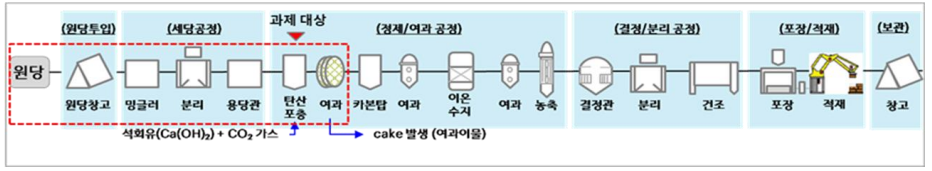
Linear coefficient calculation
(LR Bagging)

Result

$$\hat{y}(\mathbf{x})$$

Yield





Special Lectures on Service Intelligence

- Food service for children

식품의약품안전처

어린이급식관리지원센터
Center for Children's Foodservice Management

kidsnote

- Counseling service for youth

KAIST UNIST POSTECH

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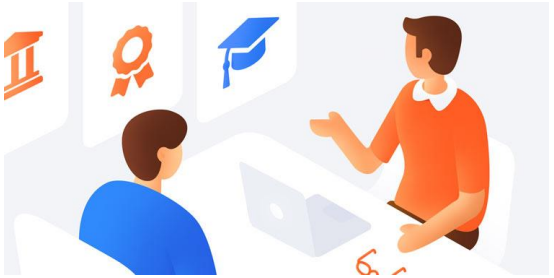


Special lecture (Dec. 01, 2021)

Quality Improvement with Interpretable Machine Learning

Research Assistant Professor, Junegak Joung

Department of Industrial Engineering

Ulsan National Institute of Science and Technology

Topics of the Service Intelligence Course

Service Review Mining

Behavioral Data Mining

Recommender Systems Development

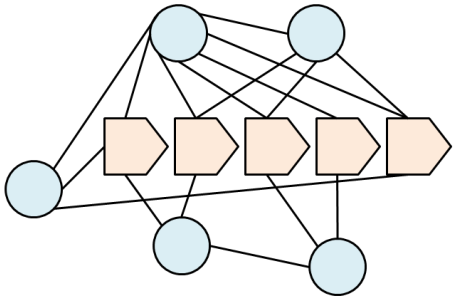
consumer behaviors (user behaviors)

service delivery and experience

Service Quality Evaluation and Improvement

All Weeks

technology and self-service



quality

value cocreation

relationship

innovation

design and development

productivity

Customer Segmentation and Service Customization

Special Lectures on Service Intelligence

knowledge and employee management

cost and pricing

service operations and supply chain management

Service Process Assessment and Improvement

Service Optimization

Industrial Service Intelligence

Previous Term Project Topics

Review-based food recommendation

Behavior-and-symptom -based health diagnosis

Animation recommender system
Book recommender system

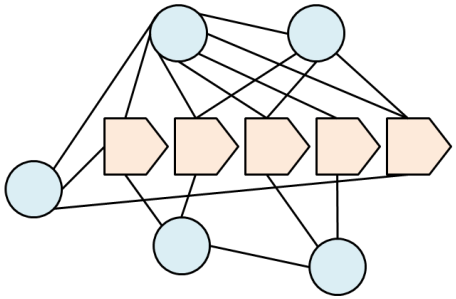
consumer behaviors (user behaviors)

service delivery and experience

Metainfo-and-review-based restaurant recommendation

All Projects

technology and self-service



quality

value cocreation

relationship

innovation

design and development

productivity

Customized service design for air conditioning machine users and clients

Allergy-free diet planning for children

knowledge and employee management

cost and pricing

service operations and supply chain management

Optimal routing for COVID-19 vaccine distribution

Industrial service solution development for shale gas productivity prediction and investment

The Gaps in Solving Real-World Service Problems with Intelligence

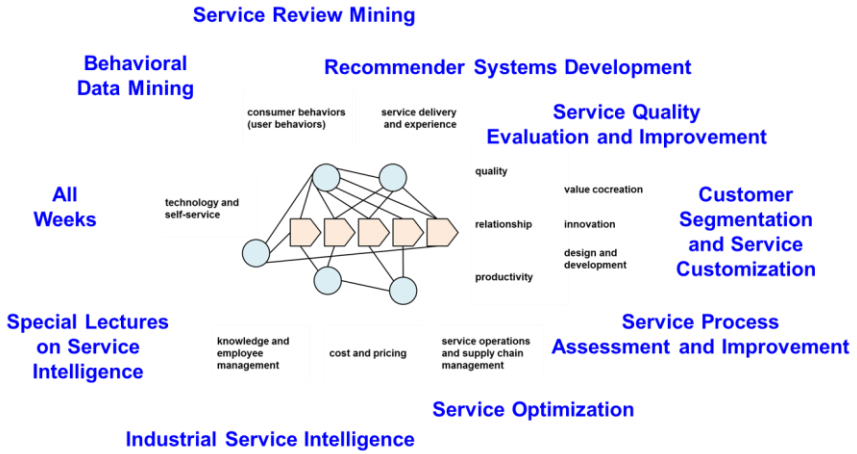
Learning tasks

- Classification
- Regression
- Clustering
- Generation
- Control
- Representation
- …

← Gap →

Service problems

- Customized delivery
- Professional tasks
- Service design and quality
- …



① machine capabilities – service requirements, the task scope gap

② learning infrastructure – machine requirements, the learning operations gap

③ intelligence contents – customer acceptance, the intelligence delivery gap

④ human employees – artificial intelligence, the collaborative intelligence gap

⑤ non-AI professionals – AI professionals, the interdepartmental cooperation gap

Assignments, Grading, and Policies

- Assignments
  - You need to complete an assignment as you follow along with the required class
  - Each assignment will require you to answer questions, solve problems, and/or write a report
  - Assignments must be done in the MS Word format and submitted with the filename “Assignment#_ID_Name.docx” (e.g., Assignment1_20201200_ChiehyeonLim.docx)
- Grading

Item	Portion	Criteria
Class Participation	10%	Attendance and In-Class-Presentation for Discussion
Assignments	40%	Comprehension, Completeness, and Creativity
Term Project	50%	Completeness, Adherence to the Course Material, and Creativity

- Other policies: Late work with penalty and NO cheating

We Will Interact Through Blackboard and Sometimes Use Zoom

Blackboard

https://unist-kr.zoom.us/j/2141204824

Next Class (2022.08.31)

- Topic: Understanding of the Service Tasks and Domains

- Assignment 1
  - Read the following Article 1 and think about the following questions
    Article 1: Data-Driven Understanding of Smart Service Systems Through Text Mining
  - Tell us who you are. What is your major? What is your year? What do you want to do in the future? What interests you about this class? What industrial and social service problems are you interested to solve with artificial intelligence? In short, who are you and why are you here?
  - Submit an MS Word document with your answers
  - *Due by 2022.09.04. 11:59 PM*