Developing Artificial Intelligence to Support Human Intelligence

Sundong Kim

Assistant Professor @ GIST AI

✉ sundong@gist.ac.kr | 🏠 https://sundong.kim

Nov 1, 2022

Sundong Kim

- **Assistant Professor** @ GIST AI Graduate School (Nov 2022 - Present)

- Young Scientist Fellow @ Data Science Group, IBS (Host: Meeyoung Cha, Sep 2019 - Nov 2022)

  - Applied AI: Predictive analytics, representation learning, interpretable AI, and reasoning

  - Democratizing AI: Led collaborations between IBS and World Customs Organization

Sundong Kim

- Ph.D., KAIST (Sep 2019, Advised by Jae-Gil Lee)

    - User modeling, behavior prediction, One of the best papers in ICDM 2018

    - Microsoft Research Asia (Fall 2018)

    - iPodia (Classroom Without Borders, 2013-2018)

    - NUS, TU-Berlin, Deloitte

Research Background

User Modeling & Prediction

Offline mobility: ICDM'18, KAIS'19, PAKDD'20

Online browsing: ECML-PKDD'20, Frontiers'21

Social networking service: ICDEW'15
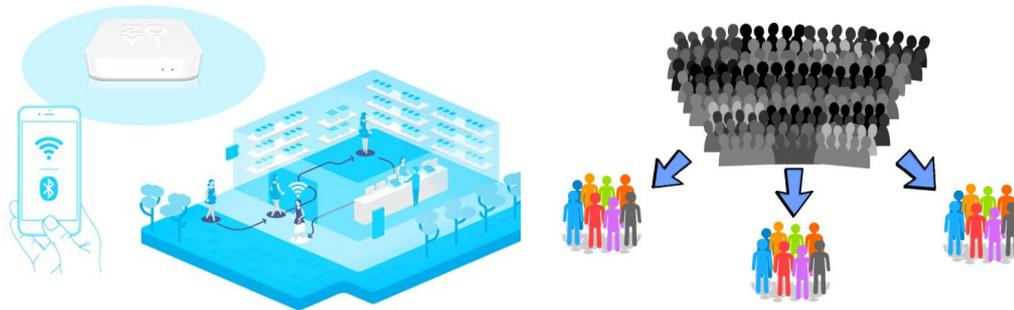
Human-in-the-loop ML & Active Learning

Applied: KDD'20, TKDE'22, ICDMW'21 (Customs)

General: CIKM'20, MLJ'21 (Image), ICLR'22 (Time series)

Representation Learning

Applied: AAAI'22 (Customs)

General: ECCV'20, CVPR'21 (Clustering)
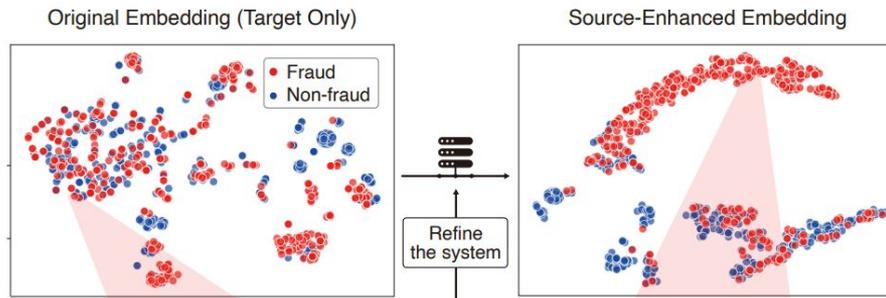
User Modeling and Prediction

Motivation

Image from Walkinsights

Revisit or Not?
If Yes, 60 days?

> "**Revisit Prediction** for **Targeted Marketing**"

Potential to revisit?

High → Invite to premium brands (Upselling)

Low → Discount or Mass sale
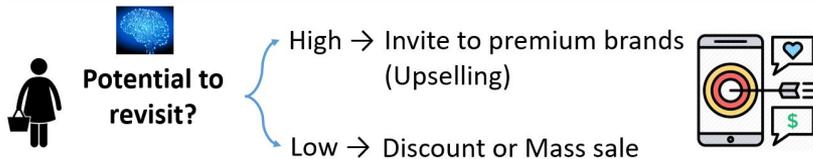
Offline mobility data

- 7 Flagship stores
- 110K-2M visits/store
- 220-990 days collected
- Average number of areas = 6.56

Feature engineering (ICDM'18, KAIS'20)

Average Revisit rate

Customers who use back door revisit more!

Back ←→ Front

f9: Exit gate

Average Revisit rate

People who stroll around the area revisit very often!

$f17 - \mu_{30m}$: Avg IA time(*days*)
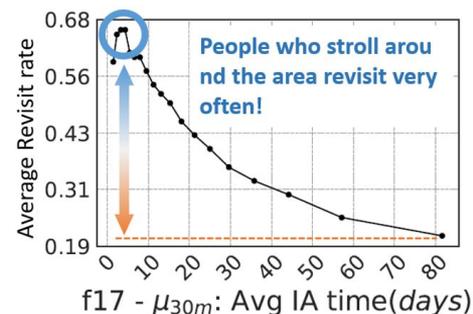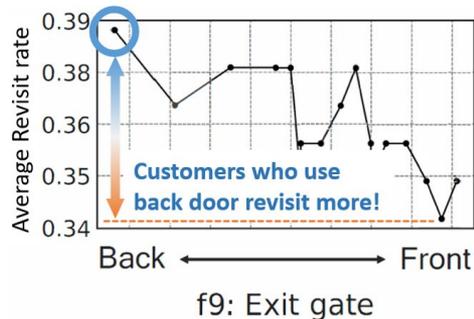
Deep survival analysis (PAKDD'20)

Loss minimization

Rates for next 365 days ◄┈┈► **Revisit labels** (120 days, False)

High-level event rate predictor

FC Layers

LSTMs → LSTMs → LSTMs

Low-level visit encoder

v_1 v_2 $\mathbf{v_3}$

120 days

Train period | t_1 | Test period | t_2

?

Type of losses
- Neg. log-likelihood
- Binary cross entropy
- RMSE (revisited)
- Pairwise ranking

5
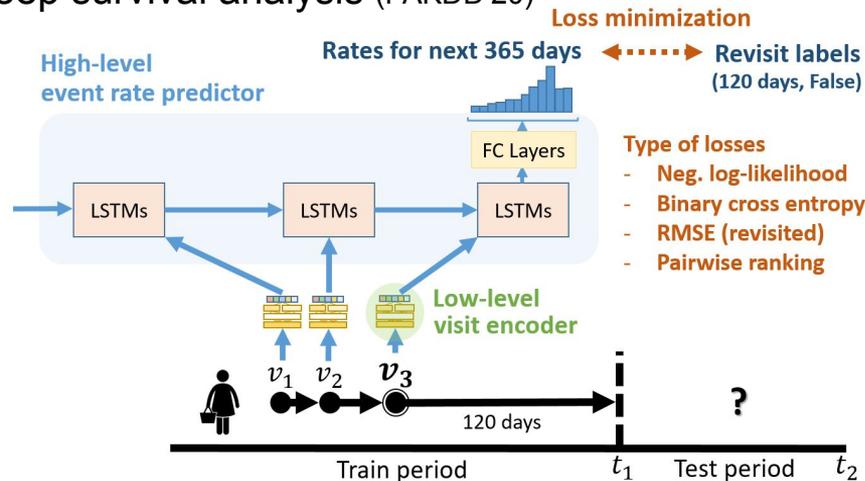
Human-in-the-loop ML

Customs control

COMMON METHODS OF CUSTOMS FRAUD

Transshipment
Routing a shipment through a third country to disguise its origin

Undervaluation
Falsifying a shipment's declared value

Misclassification
Falsely describing merchandise

Structuring
Splitting a shipment into multiple shipments

Control less, but better → **Customs Selection**

Clearance process

Import declarations → **Selection model** → **Items to inspect** → **Officer (Oracle)** → **Collect duties**

Update

Inspected items (Labeled)

Import declaration data

Attributes	Descriptions
Importer	Jim
Office	Tincan office
Import date	2022-04-15
Tariff code	870322
Tariff description	Used Diesel car > 3,000cc
Price (incl. shipping)	$7,500
Gross weight	1,200kg
Country code	KOR
Illicit (label)	1

## Customs selection system (KDD'20, TKDE'22, ICDMW'21, AAAI'22)

Exploitation by DATE

$\hat{y}_i^{cls}$ $\hat{y}_i^{rev}$

Inspect Fraudulent Records

Randomness

Exploration by gATE

Weekly trades waiting for inspection

DATE Model

Gradient embeddings

$\times$ { Uncertainty scale, Revenue scale }

Candidates selected

K-means++ for diverse selection

Gatekeeping

Inspect Uncertain Records
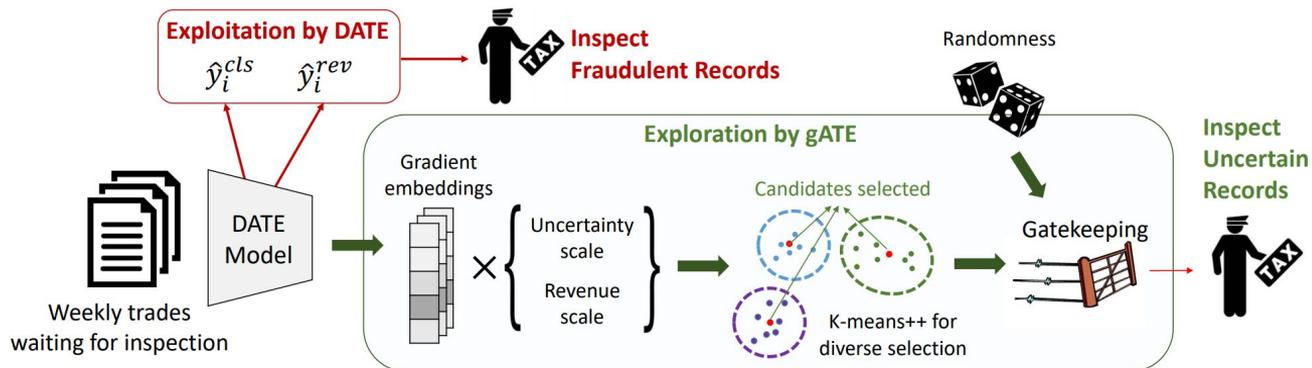
Representation Learning

Using user browsing logs (ECML-PKDD'20)
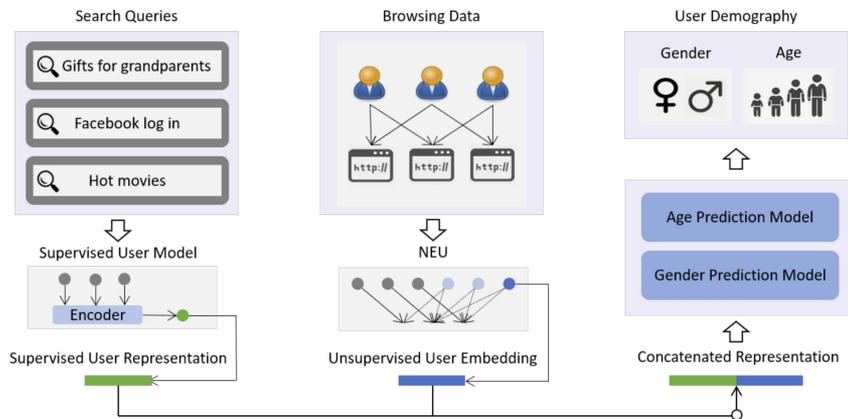
Image clustering (ECCV'20, CVPR'21)
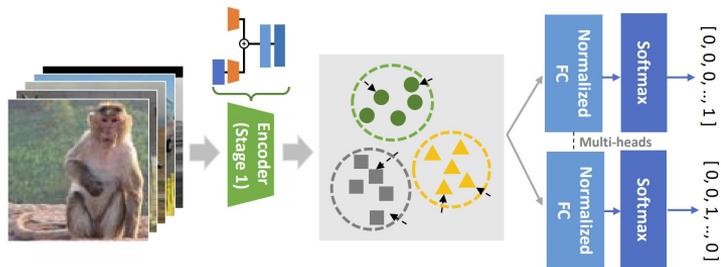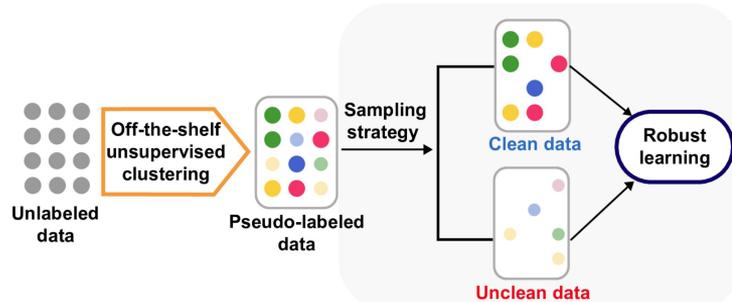
Recent Publications

Active learning for data stream (ICLR'22)
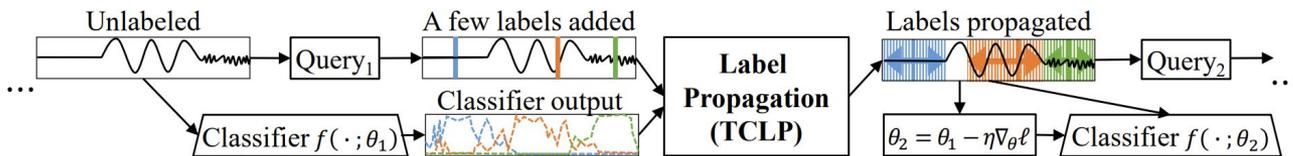
Fairness
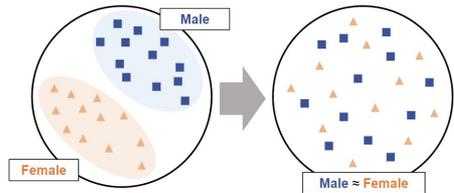
(a) Group fairness: One cannot distinguish the membership of the individual with the learned embedding.

(b) Counterfactual fairness: Embeddings of two samples in counterfactual relationship should be placed nearby.

Hierarchical classification

Probabilistic programming

Current Interests: Abstraction and Reasoning

ARC Task 1caeab9d

Training Examples

Test Example

?

ARC Task 39a8645d

Training Examples

Test Example

?

ARC Task 7c008303

Training Examples
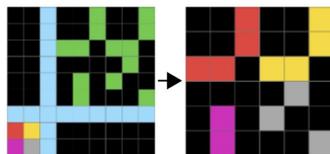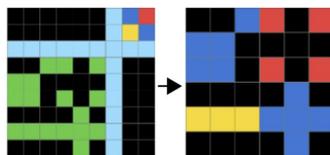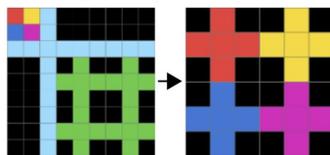
Test Example

?
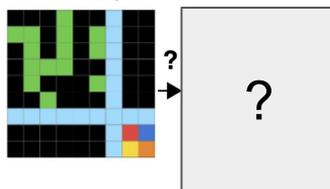
Goal: Build a human-like AI which can do Abductive reasoning (귀추):

Begins with an incomplete set of observations and proceeds to the likeliest possible explanation for the set (May be true)

https://www.kaggle.com/c/abstraction-and-reasoning-challenge
More visualizations: https://tinyurl.com/58mpu4d5

Research Background

User Modeling & Prediction

Offline mobility: ICDM'18, KAIS'19, PAKDD'20

Online browsing: ECML-PKDD'20, Frontiers'21

Social networking service: ICDEW'15
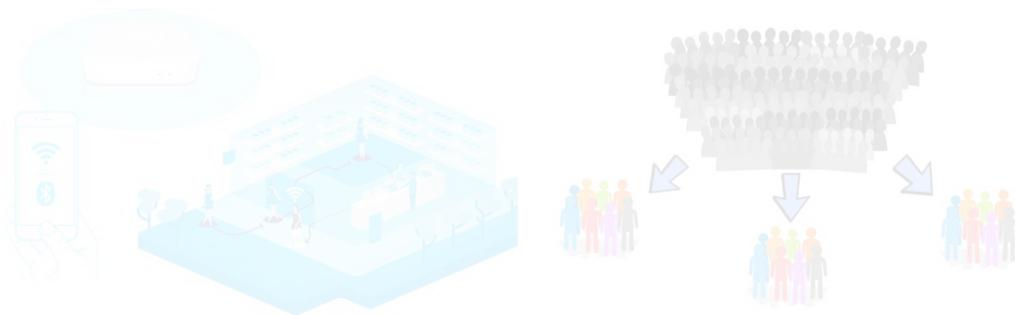
Human-in-the-loop ML & Active Learning

Applied: KDD'20, TKDE'22, ICDMW'21 (Customs)

General: CIKM'20, MLJ'21 (Image), ICLR'22 (Time series)

Representation Learning

Applied: AAAI'22 (Customs)

General: ECCV'20, CVPR'21 (Clustering)
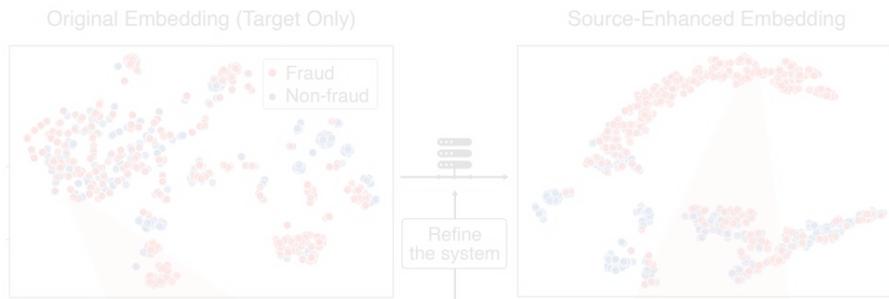
Human-in-the-loop ML & Active Learning

Supporting Digital Transformation of the Customs Service

- DATE: Dual Attentive Tree-aware Embedding for Customs Fraud Detection, KDD 2020

- Active Learning for Human-in-the-Loop Customs Inspection, TKDE 2022

- Customs Fraud Detection in the Presence of Concept Drift, ICDMW 2021

- Knowledge Sharing via Domain Adaptation in Customs Fraud Detection, AAAI 2022

- Classification of Goods Using Text Descriptions With Sentences Retrieval, KAIA 2021

Other articles in this Edition >>

Flash Info

BACUDA: supporting Customs with data analytics

By the WCO Secretariat

WCO Members asked the Secretariat to place a new focus on the development of guidance and capacity to support the use of data analytics. As one of the responses, a team of experts was put in place under a project called BACUDA. The project's name is an acronym, which stands for "BAnd of CUstoms Data Analysts." It is also a Korean word that means "to change." Indeed, the aim of the project is to help Customs administrations in embracing analytical tools and methodologies, a major move for many.

BACUDA team members are all data experts with whom the Secretariat has been collaborating for some years. They are Customs officials in charge of risk management, statistics and IT systems, as well as professional economists and data scientists with an academic background in computer science. Data scientists of various nationalities from the Institute of Basic Science (IBS), the Korea Advanced Institute of Science and Technology (KAIST), and the National Cheng Kung University (NCKU) are involved in the project and leading the development of state-of-the-art algorithms. However, any qualified data experts working in Customs administrations or in academia may join the BACUDA team.

WCO BACUDA experts develop and share a neural network model to assist Customs to detect potential fraudulent transactions

19 May 2020

WCO BACUDA experts develop and share a neural network model to assist Customs to detect potential fraudulent transactions

As part of the WCO BACUDA (Band of Customs Data Analysts) project with the Institute of Basic Science (IBS) and the National Cheng Kung University (NCKU), WCO has developed a Dual-Attentive-Tree-aware-Embedded (DATE) neural network model to assist Customs administration to better detect transactions presenting risks of fraud. The DATE model has been accepted by KDD2020[1] Conference (Applied Data Science Track) and will be published in the KDD2020 proceedings as a full paper[2].

The WCO BACUDA project was launched in September 2019 as a collaborative research platform focused on data analytics. With the participation of Nigeria Customs Service (NCS), BACUDA experts successfully developed the DATE model, and have been implementing a pilot test to verify its performance with real-time import data of the two Nigerian ports in Tin Can (in Lagos) and Onne (in Port-Harcourt) since March 2020.

The model employed a cutting-edge Artificial Intelligence (AI) mechanism called "ATTENTION" that is used as a language translation tool and for self-driving cars. Thanks to this innovative technology, the model has outperformed other traditional machine learning models (such as XGBoost) in detecting potential fraudulent transactions. The model noticeably outperforms even with relatively small-sized training data (from countries with low trade volumes) and low inspection rates (from countries with huge trade volumes).

11

Customs

Customs are government authorities responsible for controlling the flow of goods and passengers across borders and collecting customs duties and taxes from traders.

World Trade Value (billion USD)

$19.7 trillion

Control less, but better → **Customs Selection**

Workflow

"How to maintain a customs selection system effectively?"

Customs Fraud

Definition: Fraudulent attempt to avoid the customs duty imposed on goods

Causes: To be more competitive on the market, rather than complying with customs regulations.

COMMON METHODS OF CUSTOMS FRAUD

Transshipment
Routing a shipment through a third country to disguise its origin

Undervaluation
Falsifying a shipment's declared value

Misclassification
Falsely describing merchandise

Structuring
Splitting a shipment into multiple shipments
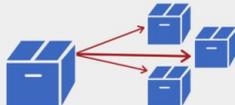
Attributes	Descriptions
Importer	Jim
Office	Tincan office
Import date	2022-04-15
Tariff code	870322
Tariff description	Used Diesel car > 3,000cc
Price (incl. shipping)	$7,500
Gross weight	1,200kg
Country code	KOR
Illicit (label)	1

Examined by KIM, A.G, 2013 Hyundai Elantra, odo 100,000km, Post entry modification: tariff $200 raised based on low value and wrongly classified.

DATE Model: Securing Revenue Together

"Tree-enhanced attention model with dual-task learning"

DATE: Dual Attentive Tree-aware Embedding for Customs Fraud Detection, KDD 2020, http://bit.ly/kdd20-date

Yu-Che, Karandeep, Yeonsoo, Etim, Cheng-Te, Mia
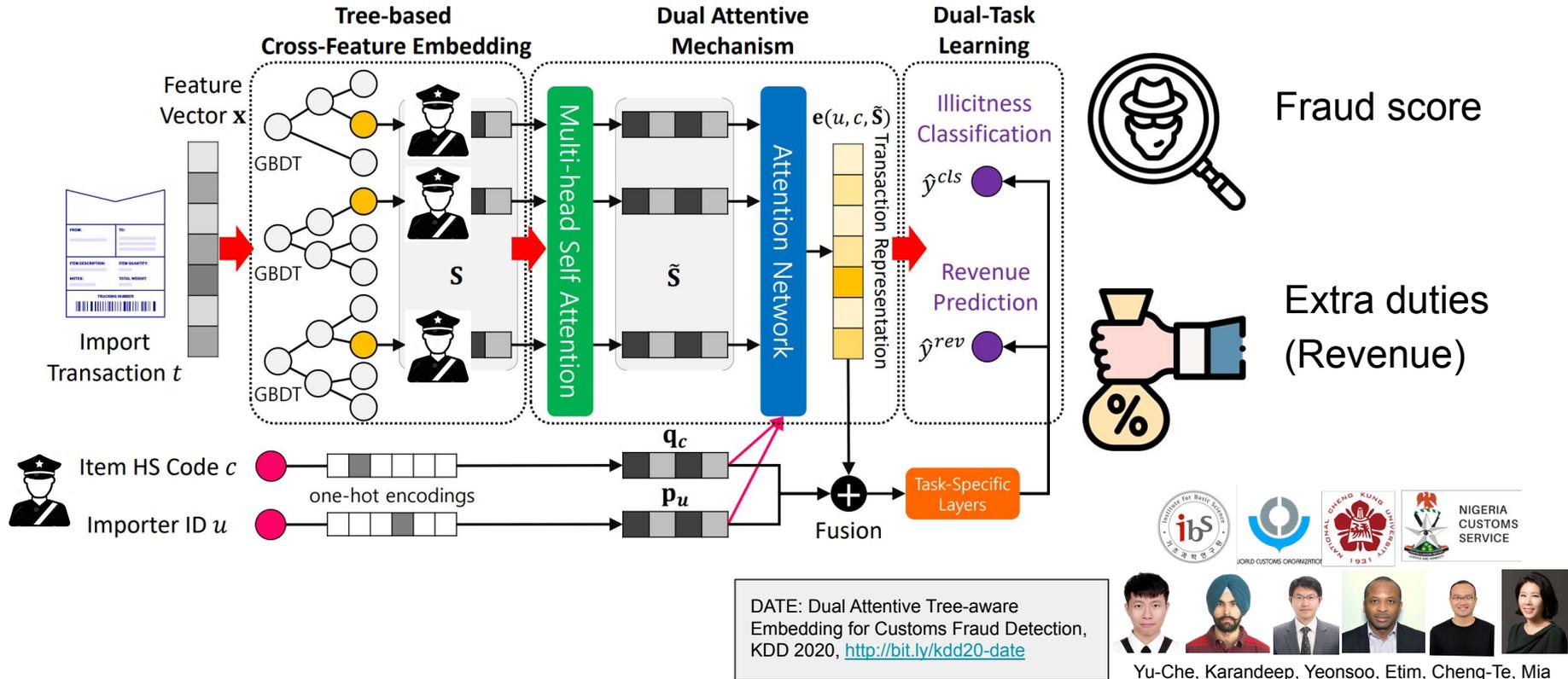
Evaluation Results - DATE

- Used data: Import trades of Nigeria

  - Maintaining 100% inspection

  - Average illicit rate: 2.2%

- Training: Y2013 – Y2016

- Testing: Y2017

Evaluation Metrics

Precision, Recall   Revenue

Model	$n = 1\%$ (Selecting top 1%)			$n = 2\%$			$n = 5\%$		
	Pre.	Rec.	Rev.	Pre.	Rec.	Rev.	Pre.	Rec.	Rev.
Price	2.75%	1.23%	15.17%	2.23%	1.99%	20.64%	2.06%	4.60%	34.95%
Importer	11.43%	5.10%	4.36%	9.41%	8.39%	7.56%	6.47%	14.43%	13.18%
IForest	5.61%	2.50%	14.30%	6.19%	5.52%	23.14%	5.66%	12.62%	40.62%
GBDT	90.01%	40.15%	24.59%	66.16%	59.04%	38.89%	32.19%	71.80%	57.20%
GBDT+LR	90.95%	40.40%	27.18%	72.94%	65.09%	44.22%	35.02%	78.11%	63.77%
TEM	88.72%	39.59%	39.48%	74.70%	66.43%	58.48%	37.39%	83.41%	78.58%
DATE$_{CLS}$	**92.66%**	**41.33%**	44.97%	**80.79%**	**72.05%**	67.14%	**38.77%**	**86.49%**	84.35%
DATE$_{REV}$	82.25%	36.63%	**49.29%**	79.93%	71.22%	**68.48%**	38.74%	86.41%	**84.57%**

Interpretable Cross Features

Reduce the document reviewing costs by field officers, and even pacify angry traders who suffer from additional cost and delays due to the inspection

	Illicit case	Licit case
Item	Used TOYOTA VENZA, $16,863	Used TOYOTA CAMRY, $4,673
CF 1	risk.importer=0 & tax.ratio<43.7% & gross.weight<3327.43 & fob.value>$1,366	12.2%<tax.ratio<16.8% & face.ratio>62.5%
CF 2	value/kg>$2 & cif.value>$1,912 & risk.(office,importer)=0 & tax.ratio <0.18%	risk.HS.origin=0 & value/kg<$2 & cif.value>$1,640 & risk.(office,importer)=0
$\hat{y}^{cls}$	0.9849	0.0001

Suspicious

Make sense

Research Impact

"With this project, we hope to bring innovations and change of mindsets to customs community." – Kunio Mikuriya, Secretary General of the WCO


Kunio Mikuriya

Secretary General, World Customs Organization

This is very helpful for customs, as risk management is the key to customs. Of course, we expect that this could be used beyond risk management but also performance measurement and border security.

Video: https://youtu.be/YhfxCHBNM2g?t=209

Research Impact

Research Partnership & Examples in Use

- Five countries provided their datasets for further research

- Weekly pilot tested in two ports in Nigeria

- Indonesia customs launched a project with WCO to apply DATE in their system

- Shipped our code to support fraud detection in various countries

- Field officers in Korea Customs Service are using our product classification service

Capacity Building

- DATE is included to the WCO e-learning platforms for data analytics

- Invited to several seminars by WCO (Belgium, Brazil, Seoul, Asia-pacific regional seminar, etc)

Dilemma

Short-term Revenue (Exploitation)

Which item to inspect?
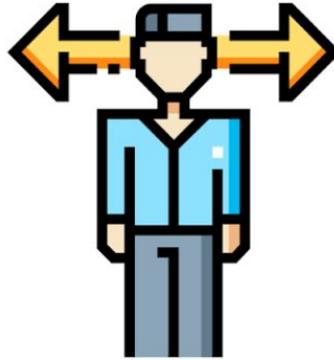
Long-term Advancement (Exploration)

High-risk Items

Unknown Items

→ **What would be the effective way to meet both criteria?**

Solution: Hybrid Selection Strategy

With some exploration, the model adapts to concept drift and secure long-term revenue.
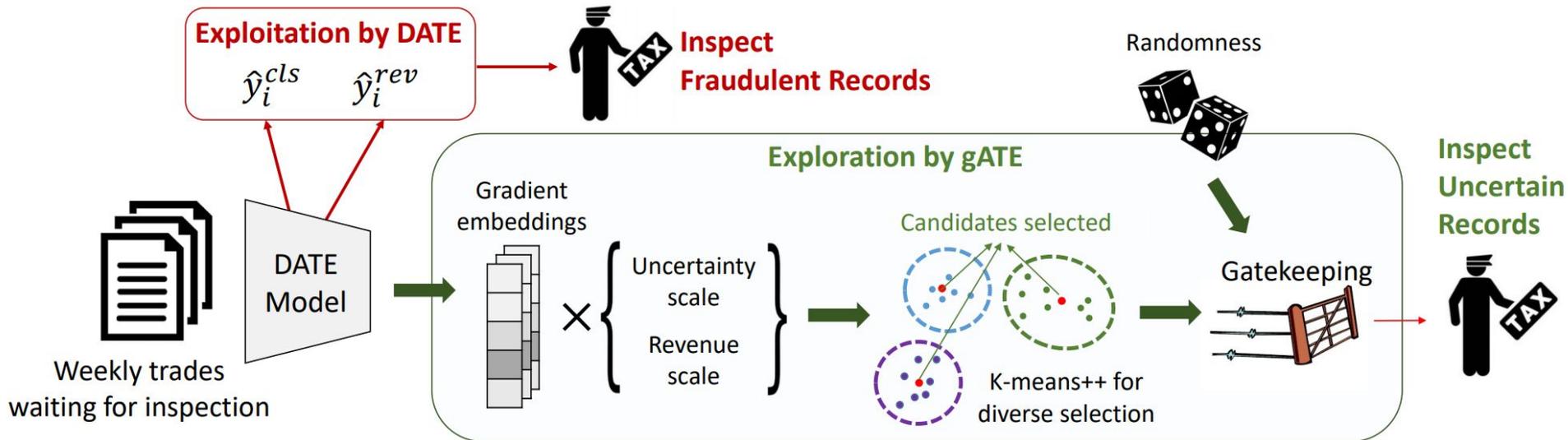
John, Brian, Ryan, Katie, Jaechan, Karandeep, Mia

Efficacy of Hybrid Strategies: Coverage & Revenue
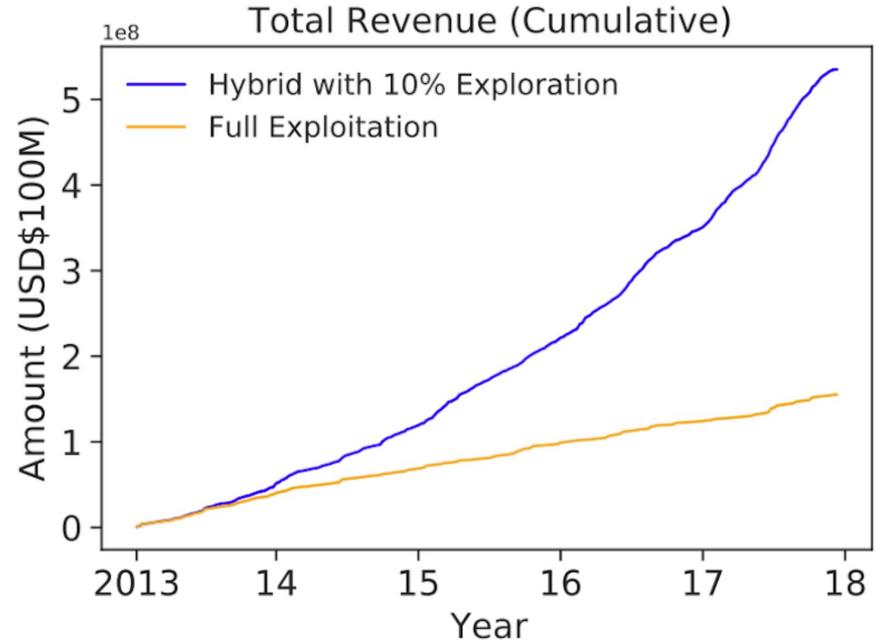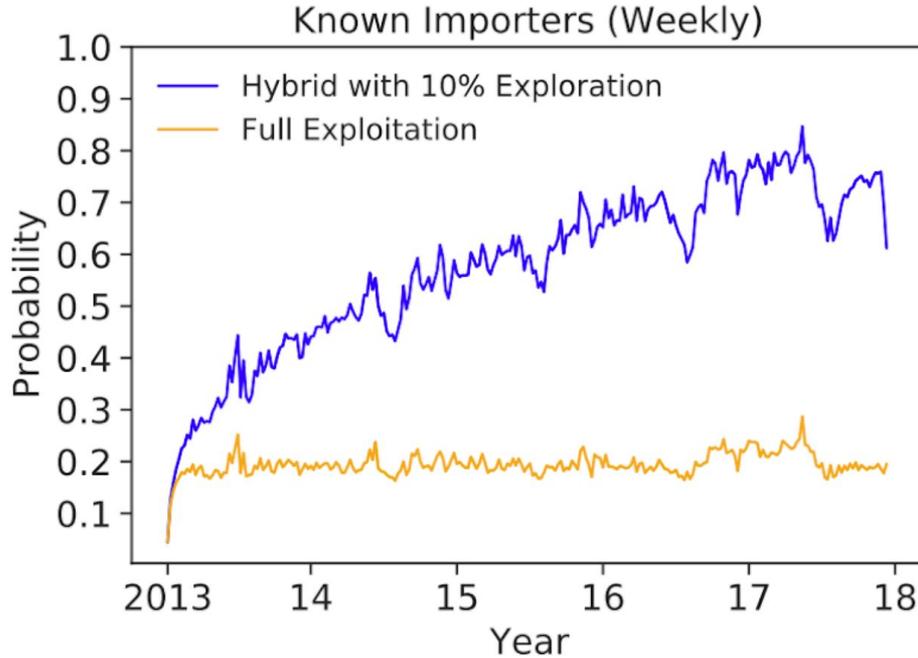
# Case Study: Detected Fraudster

**Successful case of detecting sequential frauds by the hybrid strategy**
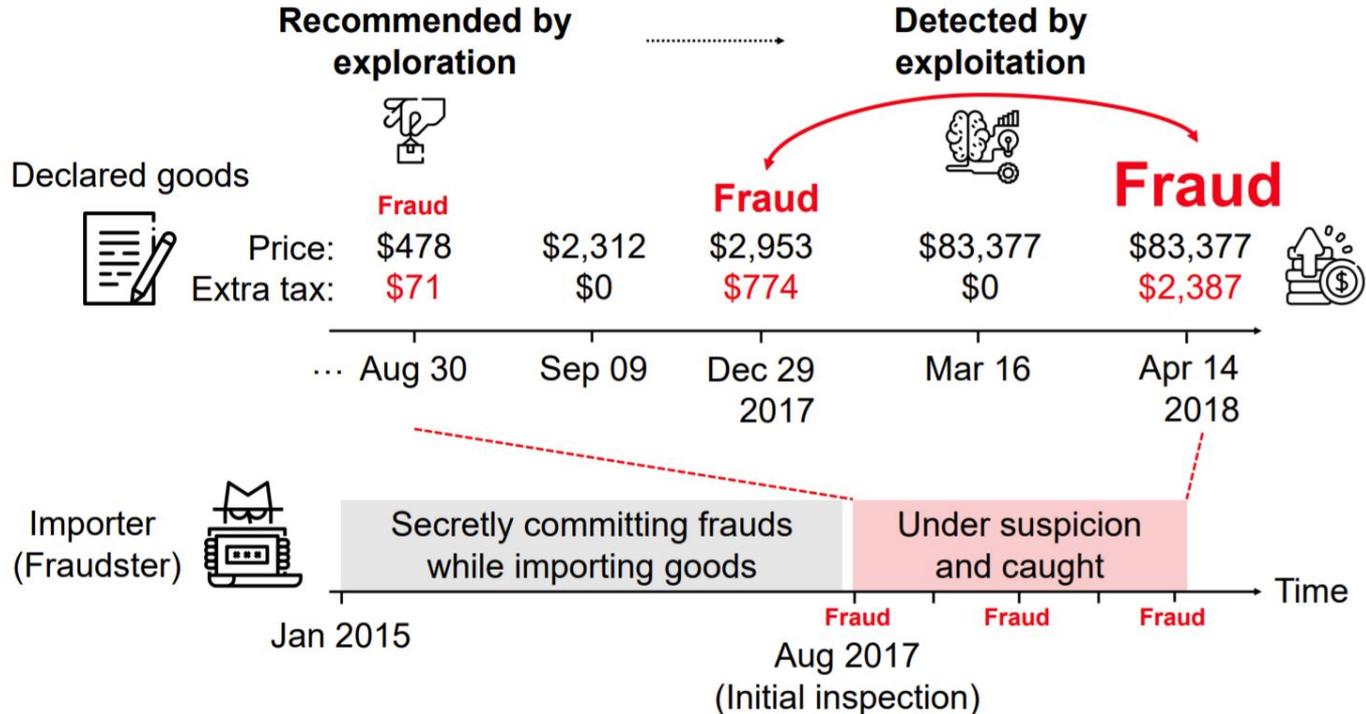
Next Question: Finding the Best Ratio

"The amount of exploration needed differs by each country"
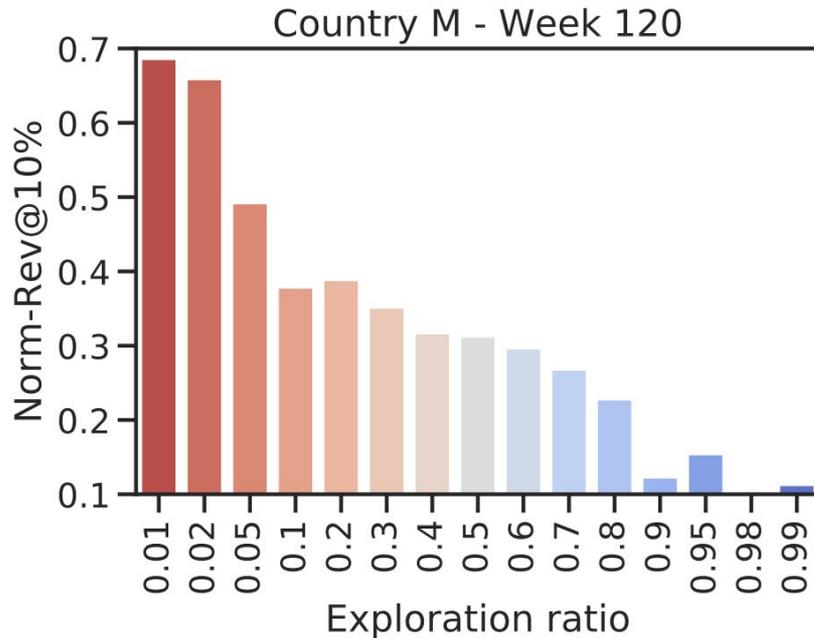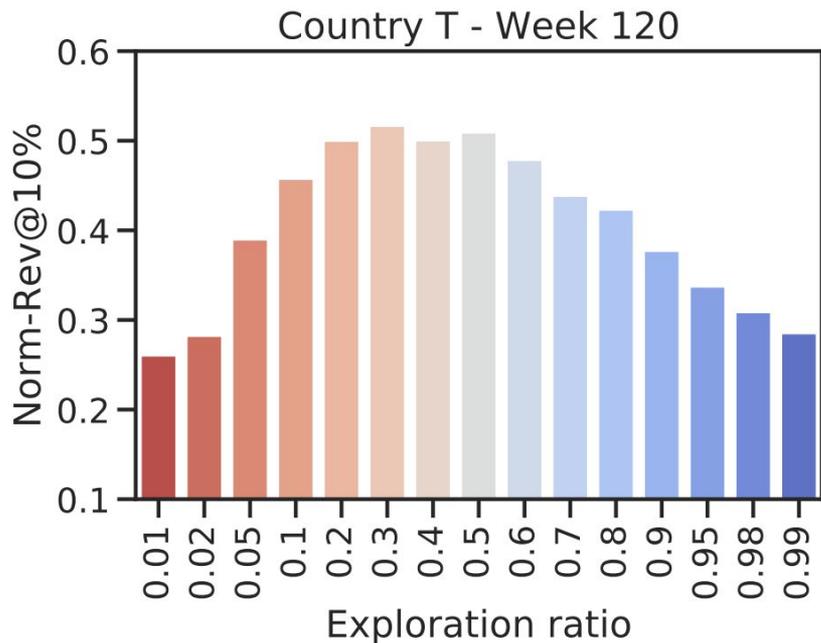
Adaptively Determining the Exploration Rate

"How to adaptively determine the best strategies?"
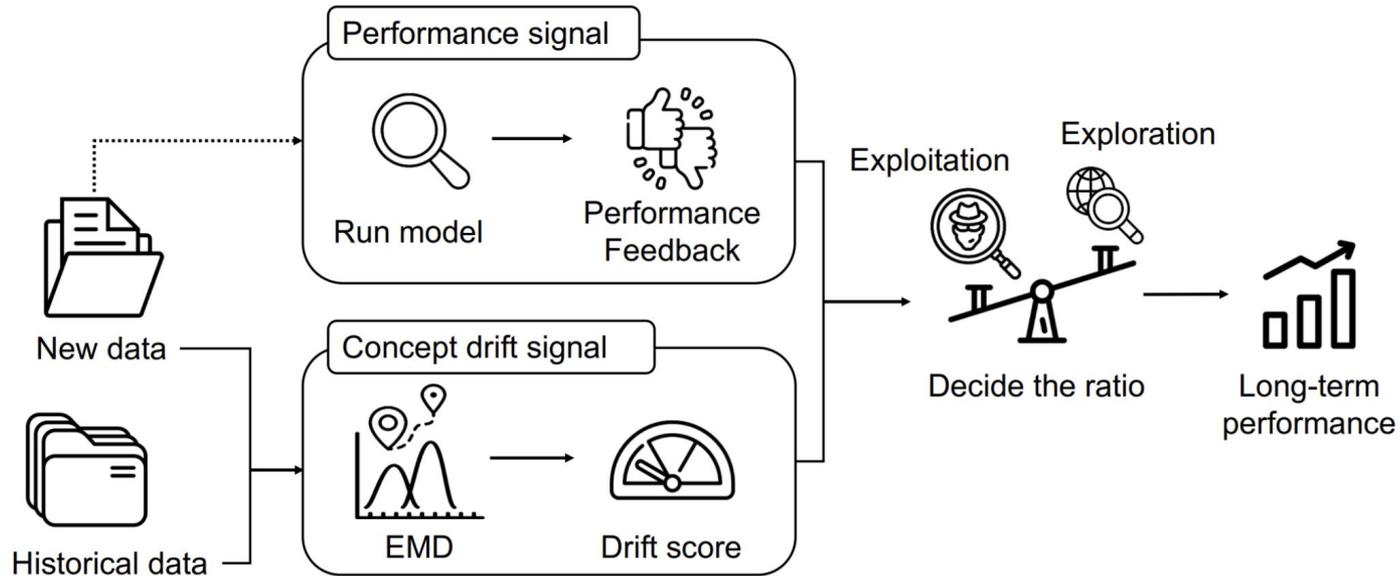
Collaborative Fraud Detection

- Countries with a lack of reliable data struggles with potentially illicit trades.

- Unfortunately, data sharing may not be possible due to legal constraints.

- What if data by-products can be shared among countries?

- Proposed a domain adaptation method to advance the system by supporting each others.

Target	Revenue@5%			
M	0.05		0.54	(x11.7)
C	0.09	0.23		(x2.7)
N	0.18		0.74	(x4.0)
T	0.15	0.33		(x2.1)

■ Target only   ■ # of source: 1   ■ # of source: 2   ■ # of source: 3
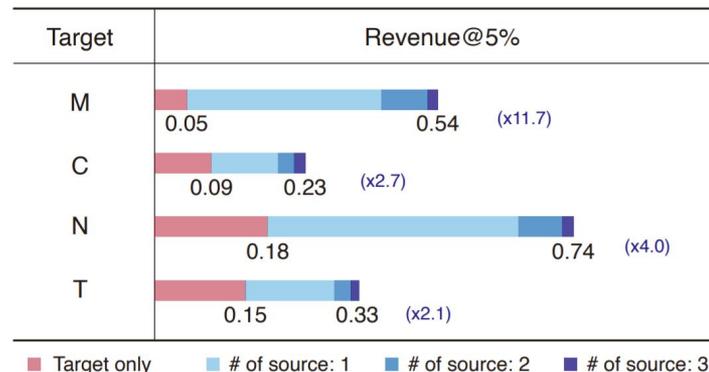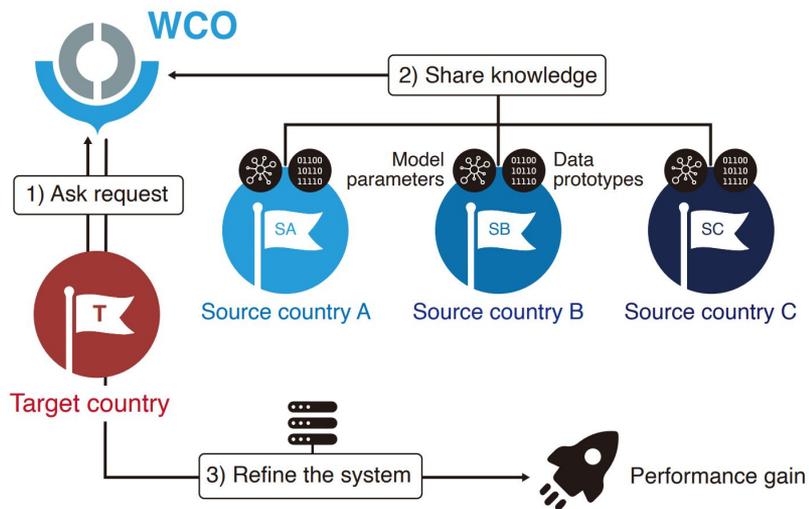
Knowledge Sharing via Domain Adaptation in Customs Fraud Detection, AAAI 2022

Ryan, Mia

Explainable Product Classification

Definition & Example for U.S. HTS Codes

[hts code example]
0901.21.0010

What these numbers mean

09 — *Coffee, Tea, Mate And Spices*
Chapter

0901 — *Coffee, Whether Or Not Roasted Or Decaffeinated; Coffee Husks And Skins; Coffee Substitutes Containing Coffee*
Heading

0901.**21** — *Coffee, Roasted, Not Decaffeinated*
Sub Heading (HS code)

0901.21.**00** — *No Distinction*
Subheading (Determines Duty)

0901.21.00**10** — *Coffee, Roasted, Not Decaffeinated, Certified Organic*
Statistical Suffix (Further Definition and Makeup)

DESCARTES
Datamyne

Receive Classification Request on Traded Goods

Smart Watch
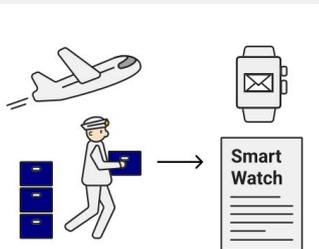
Classify the Goods and Provide Supporting Decisions

Refer to HS Manual, Previous Cases

Competing Codes and Tariffs
4 - 10%   0%
8225.50
Finalize the case

Impose Tariffs

0%

Tariff Rate: 0%
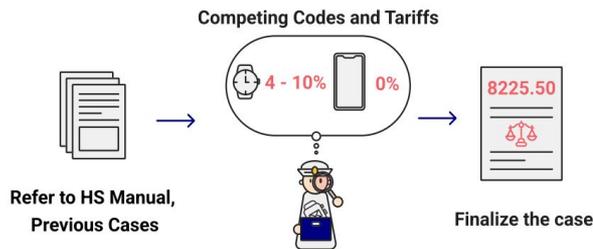
- Suggest the right HS code of the contientious product

- Provide supporting facts based on HS explanatory notes

- Our final goal is make AI follow General Rules for the Interpretation

World Customs Organization

KOREA CUSTOMS SERVICE

KAIST 1971

Classification of Goods Using Text Descriptions
With Sentences Retrieval, KAIA 2021

Eunji, Sihyeon, Soyeon, Yeonsoo, Mia

Model and Result
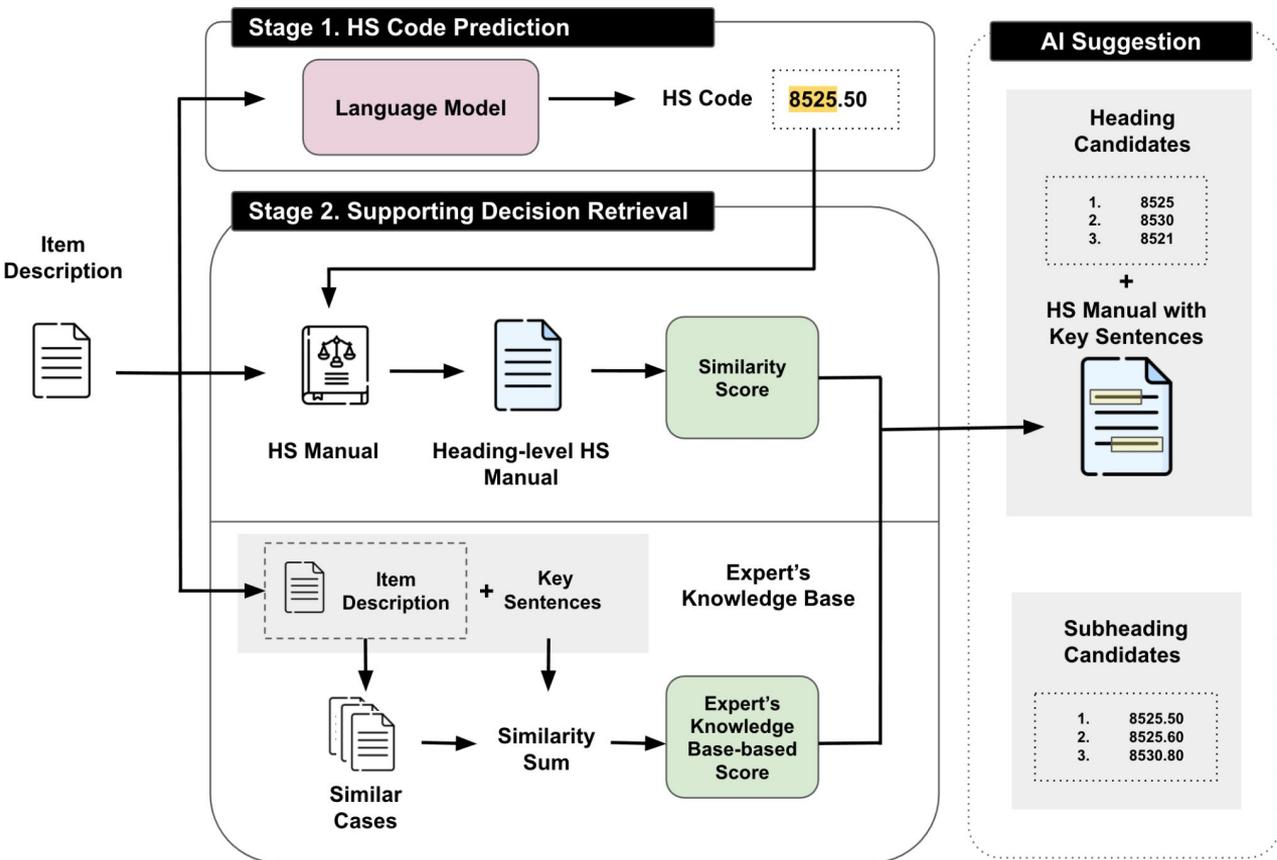
Beta Testing with Korea Customs Service

Item classification supporting model

This is the service page of the item classification supporting-AI model for Chapter 84, 85, and 90 items. If you enter the item description and press the button, you can download the PDF file with the item's predicted HS code and HS manual with highlighted supporting sentences.

Item description

ex) This application is a circular connector for electrical connection consisting of two male terminals and a metal cover, which is mainly used as a connector for connecting the signal of a coin exchanger in a city bus (voltage: 125v)

# of headings 2

# of sentences ex) 3 (number of supporting sentences in HS manual)

# of candidates ex) 3 (number of suggested HS-6 codes)

Submit https://ds.ibs.re.kr/product-classification/

"The model gave suggestions that I could have missed. I found this very helpful."

"The model helped me make quick decisions."

"Since the model shows the candidates, it can be helpful to educate new workers who have short working experience and expertise in the classification task."

Thank You

This work would not have been possible without my amazing collaborators!

Mia Yeonsoo Soyeon Etim Yu-Che Cheng-Te Karandeep Brian Ryan

Eunji Sihyeon John Katie Aitolkyn Kien Alina Jaechan

sundong@ibs.re.kr | https://sundong.kim