You are a Game Bot:

Uncovering Game Bots in MMORPGs via Self-similarity in the Wild

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Contents

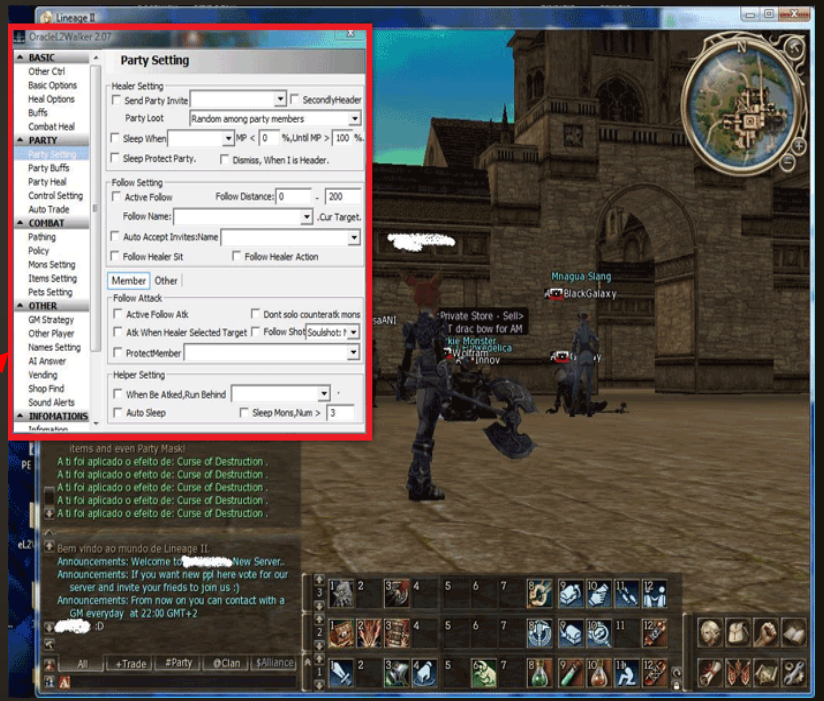
Introduction

Introduction

Game BOT

- Program that plays a game autonomously (instead of human users)

Bot configurations



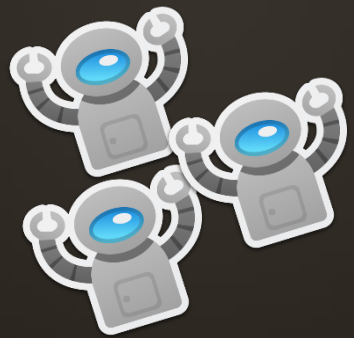
Introduction

Real Money Trading (RMT)

- Collect valuable items and monetize it by trading item to others

Game World

Virtual Assets



Virtual Assets

Real Money

Introduction

Gold Farming Group (GFG)

Introduction

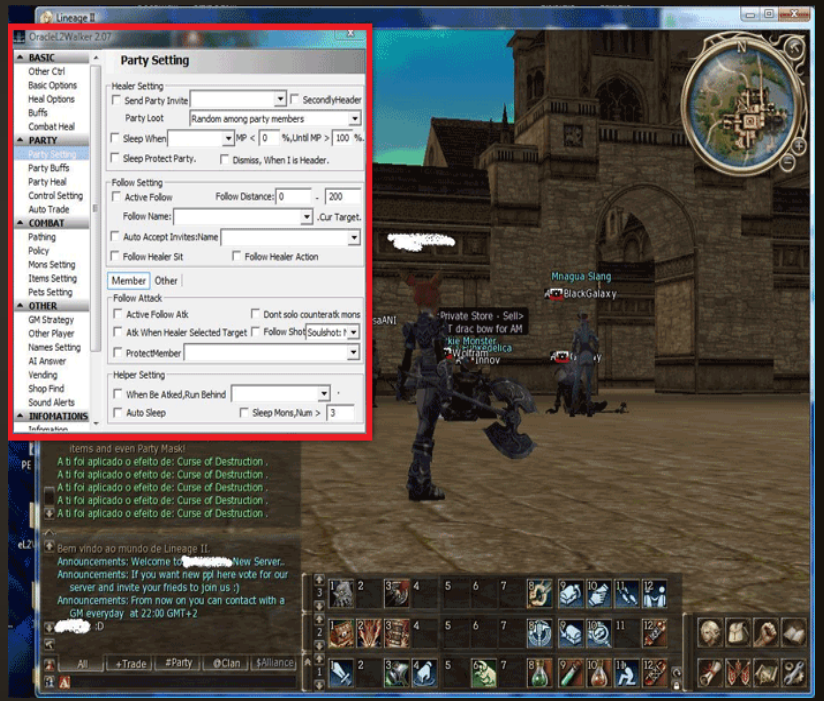
Game BOT

https://www.youtube.com/watch?v=k6tk8_R2w08

Introduction

Game BOT

- Widespread cheating in online games
  - Collapse of an in-game economy
  - Cause a human users' churn
  - Reduce the revenue



Introduction

Countermeasures

- Client-side
  - Bot process detection using anti-malware programs
- Server-side
  - **Bot classification using game log analysis**

Introduction

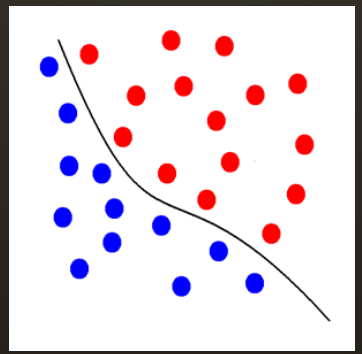
Machine Learning-based Approach

Game Logs

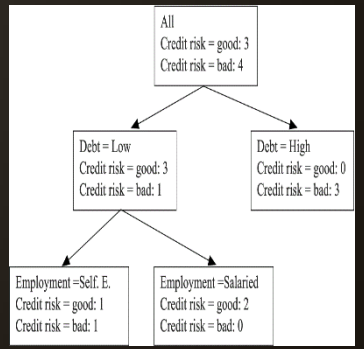
Feature Selection

Character ID	T1	T2	T3	Response
686042	0	0	0	0
854209	1	1	1	3
1032131	0	0	0	0
1049483	1	1	1	3
1340479	0	0	0	0
1352850	0	0	0	0
1771815	1	1	1	3
1832497	0	0	0	0
1884884	1	1	1	3
2130576	1	1	1	3
2445903	1	0	0	1

Ground Truth



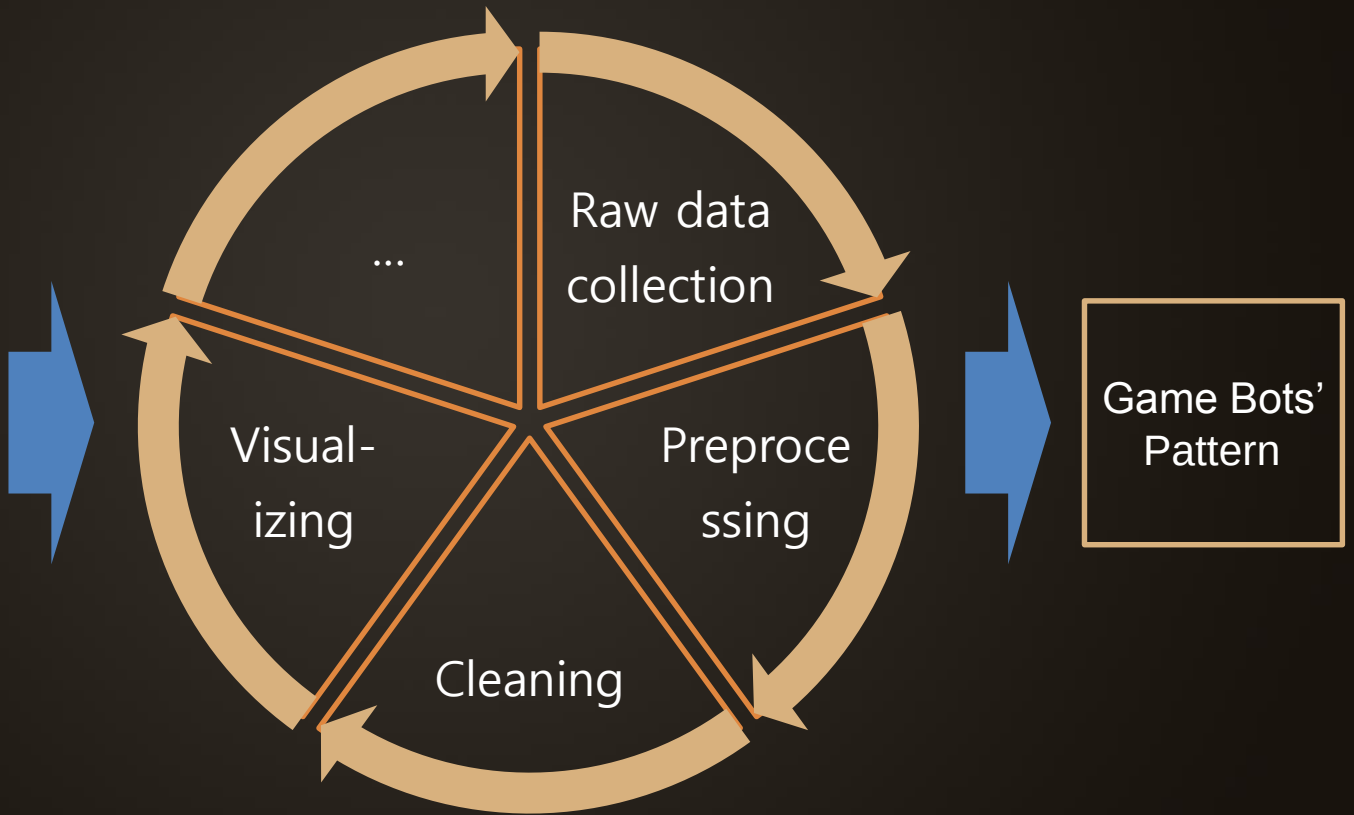
Learning Algorithm



Prediction Model

Introduction

Challenges



Introduction

Challenges

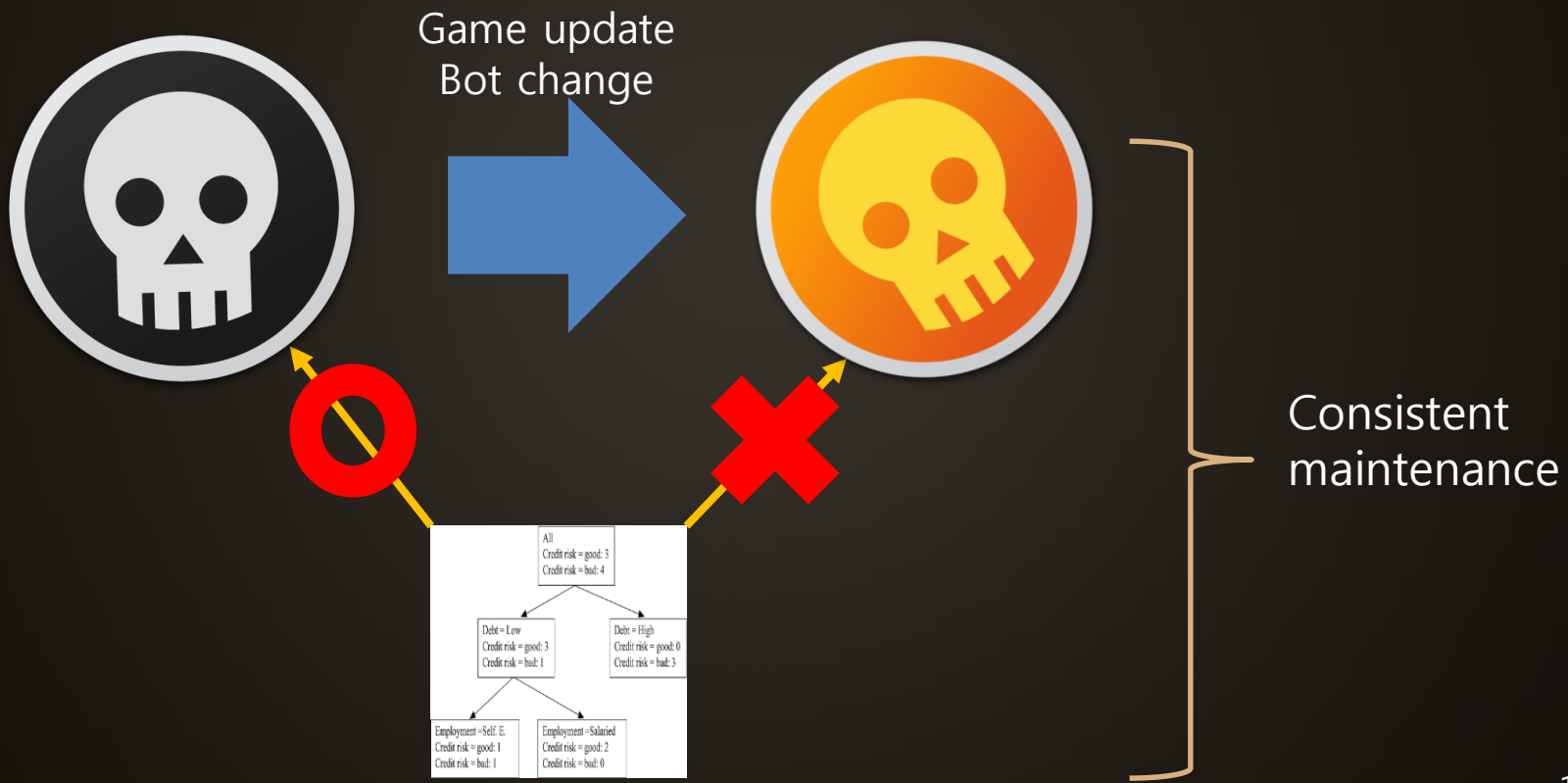
Game A Bots' Pattern

Game B Bots' Pattern

High cost
time consuming

Introduction

Challenges



Introduction

Our proposals

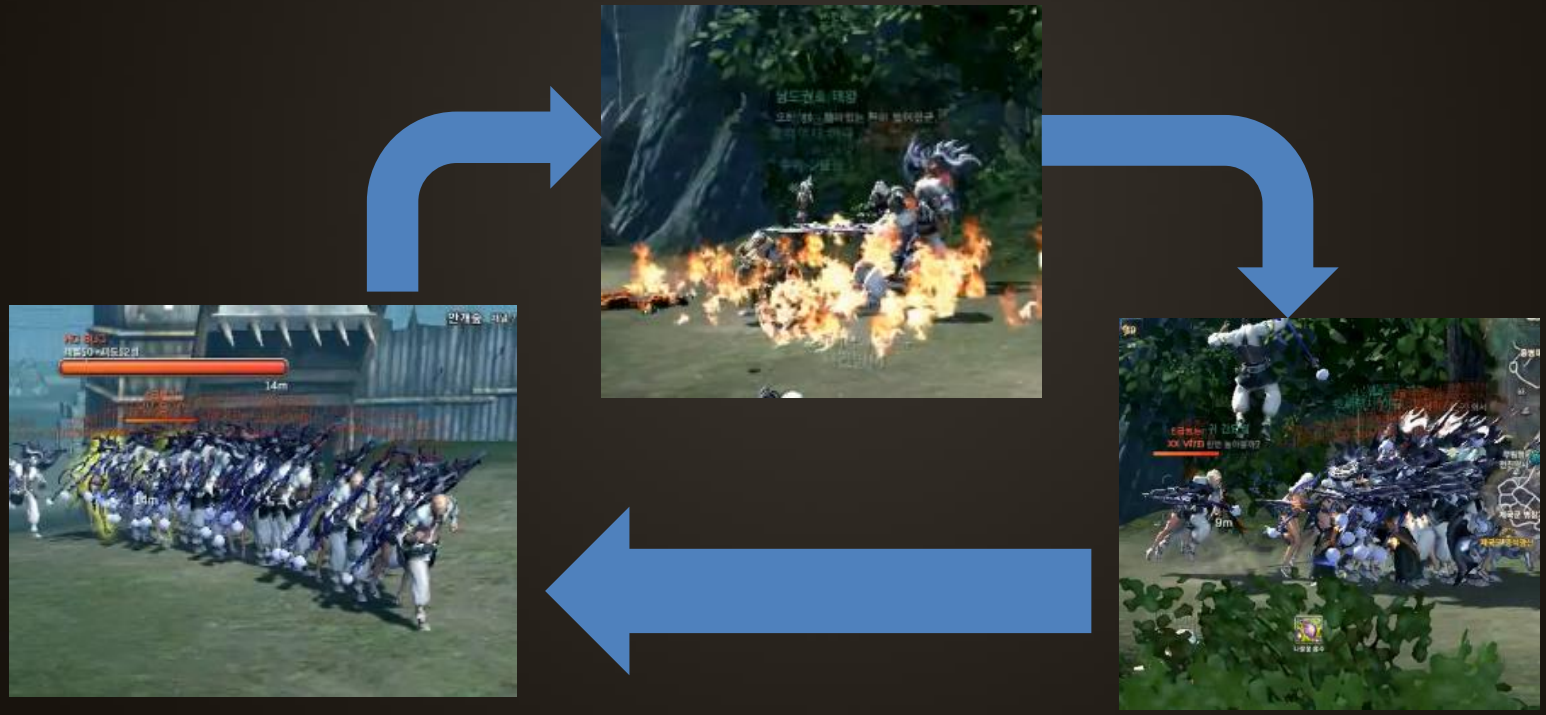
- Using self-similarity as a generic feature
  - Focus on the repetitive activities of game bots, not specific behavior
- Proposing framework to maintain a prediction model autonomously
  - Detect the change in performance of the prediction model and retrain it

Feature Selection and Modeling

Self-similarity

Definition

- Measurement of the similarity of periodic actions per user



Self-similarity

Motivation and consideration

- Intrinsic attributes
  - Bot programs **repeat routines** using predetermined settings
  - Human users may exhibit similar behavior, but **not for long period of time**
- Stability
  - **Little effect** of game update or bot program changes
  - Considering **various actions** rather than a single action
- Computing efficiency
  - Easy to apply distributed algorithms (i.e. **MapReduce**) for log processing

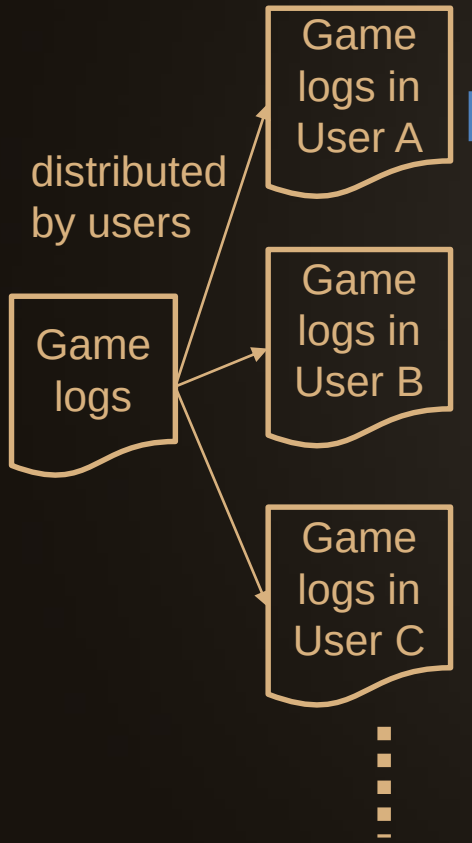
Self-similarity

Detailed process

- Generating log vectors
- Measuring cosine similarity
- Measuring self-similarity

Self-similarity

Generating log vectors

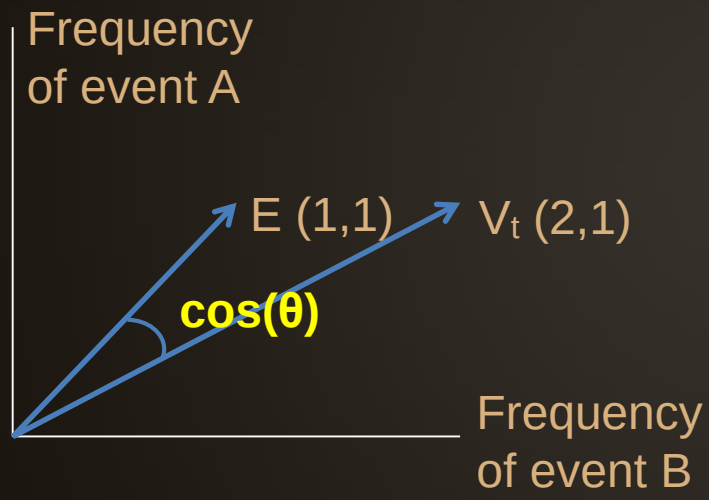


time	Event id	Character info.	Other info.
15/08/13 12:00:12.131	1205	AAA, 34	N/A
15/08/13 12:00:14.237	1204	AAA, 34	N/A
15/08/13 12:00:59.436	1208	AAA, 34	Ogre
15/08/13 12:00:59:436	1208	AAA, 34	Ogre
15/08/13 12:00:59.857	1208	AAA, 34	Troll
15/08/13 12:01:17.019	1022	AAA, 34	Ring
15/08/13 12:01:21.341	1022	AAA, 34	Sword
15/08/13 12:01:23.151	1205	AAA, 34	N/A
15/08/13 12:01:54.354	1204	AAA, 34	N/A
15/08/13 12:01:56.445	1208	AAA, 34	Wolf
15/08/13 12:02:07.351	1205	AAA, 34	N/A
15/08/13 12:02:41.847	1204	AAA, 34	N/A
15/08/13 12:02:47.650	1208	AAA, 34	Ogre
15/08/13 12:03:09.353	1208	AAA, 34	Ogre

Time period (hour:min)	Log count per event id			
	1022	1204	1205	1208
12:00	0	1	1	3
12:01	2	1	1	1
12:02	0	1	1	1
12:03	0	0	0	1

Self-similarity

Measuring the cosine similarity between log vector(V_t) and unit vector(E)



$$\cos(\theta) = \frac{A \cdot B}{||A||||B||} = \frac{\sum A_i \times B_i}{\sqrt{\sum (A_i)^2} \times \sqrt{\sum (B_i)^2}}$$

$$= \frac{(2\times1 + 1\times1)}{\sqrt{2\times2+1\times1} \times \sqrt{1\times1+1\times1}}$$

$$= \frac{3}{\sqrt{5} \times \sqrt{2}}$$

$$\fallingdotseq 0.948$$

Self-similarity

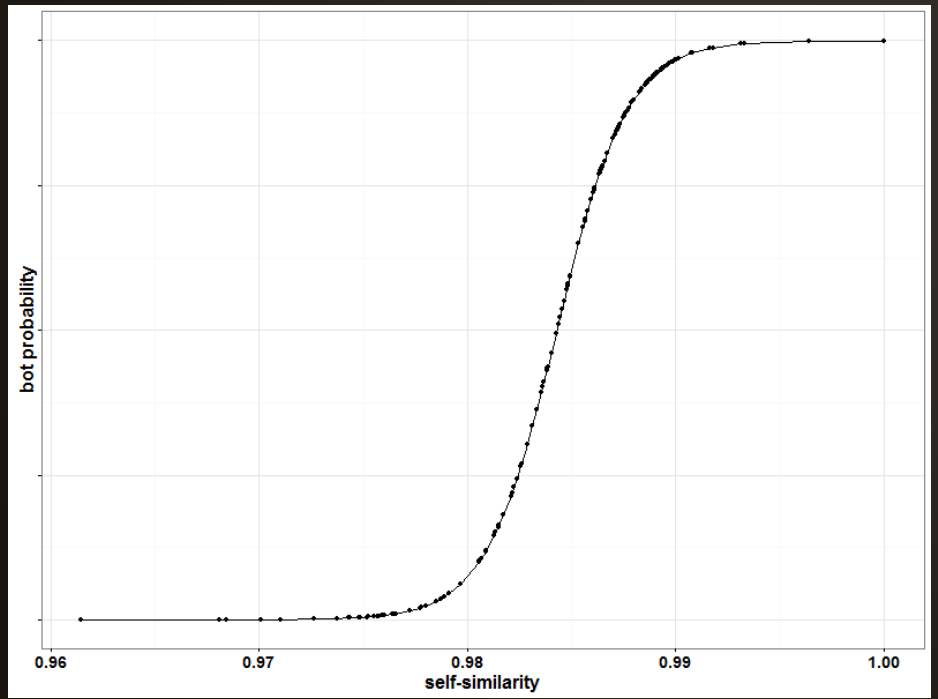
Measuring self-similarity

- Measuring std. of cosine similarity and transforming using the following model
  - $H = 1 - \frac{1}{2}\sigma, (0.5 \leq H \leq 1, \sigma: std.deviation\ of\ cosine\ similarity)$

Modeling and Evaluation

Modeling

- Logistic regression
  - Calculating the probability of a character being a game bot



Experiments

Experiments

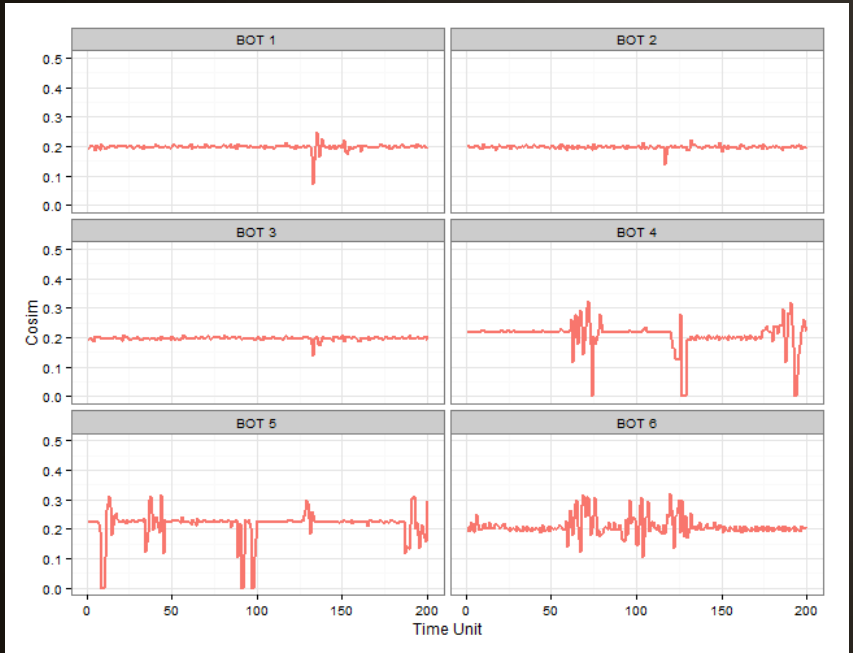
Datasets

	Lineage	Aion	B&S
Release year	1997	2008	2012
Daily active users	**300K**	**200K**	**100K**
Concurrent users	150K	80K	50K

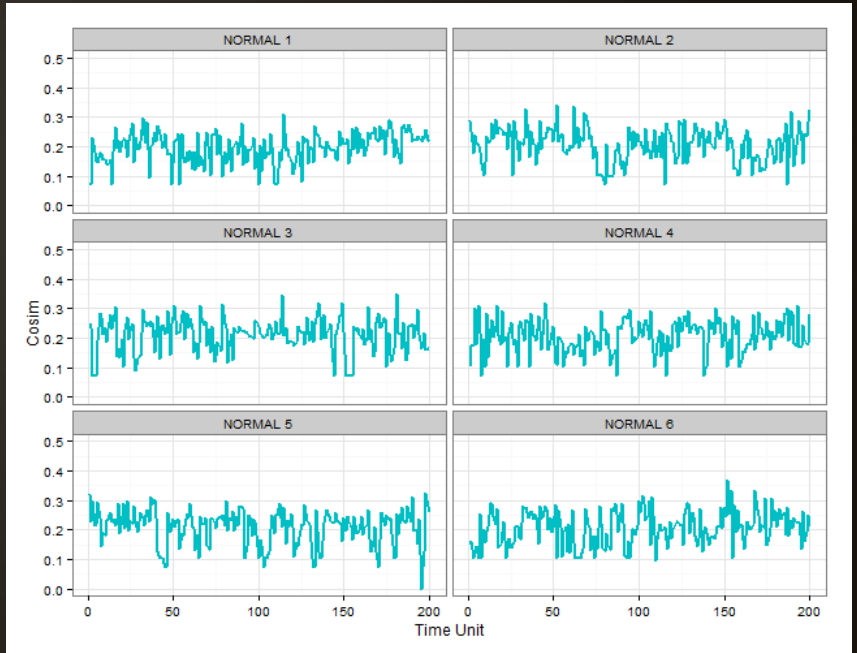
Experiments

Cosine similarities

- Bots have cosine similarities with fewer variations than human users



Bots

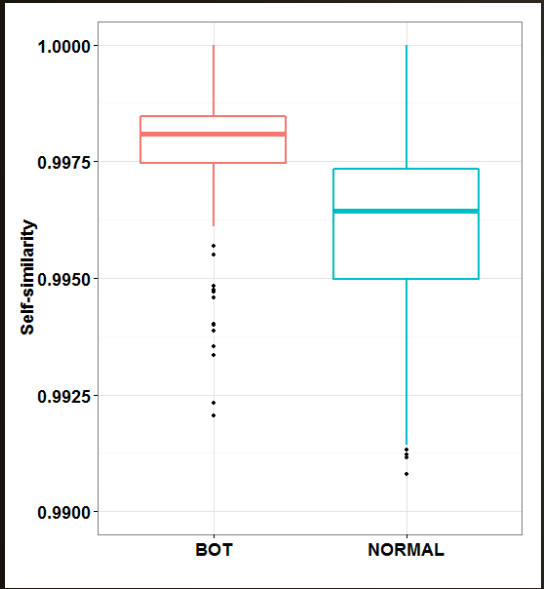


Humans

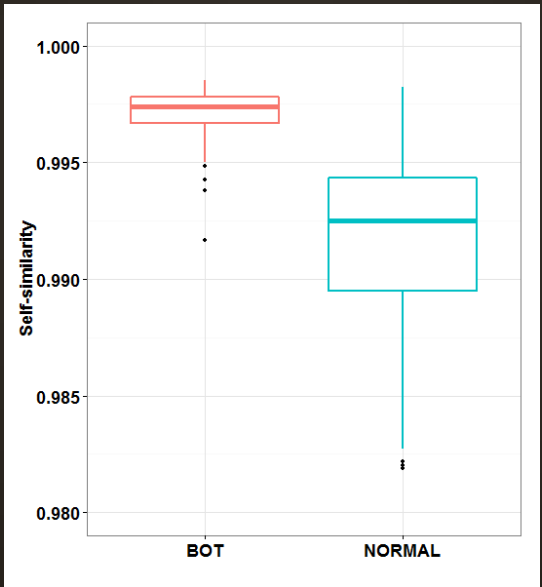
Experiments

Self-similarity

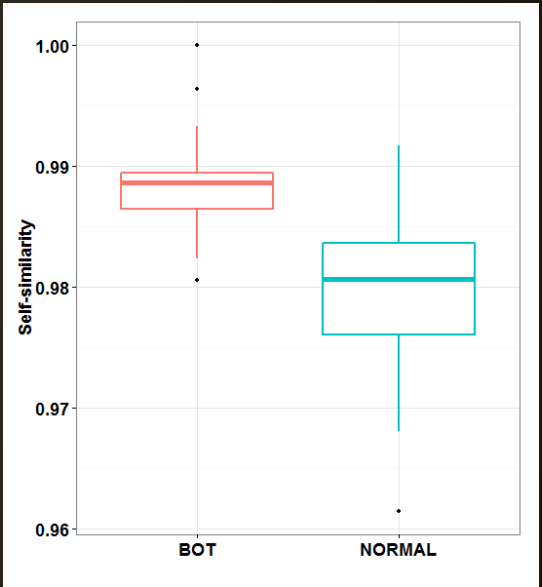
- Almost bots have higher values than human users



Lineage



Aion



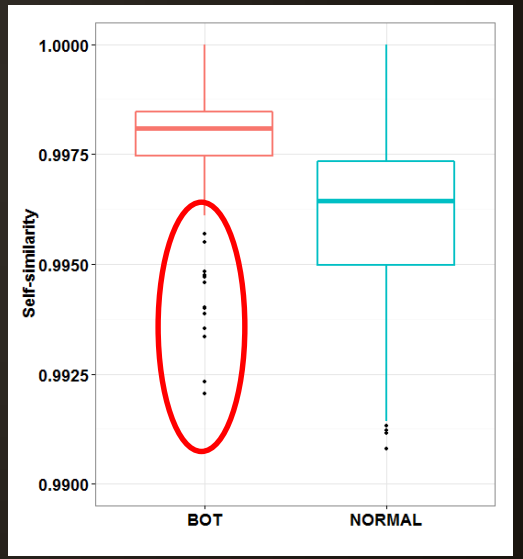
B&S

Feature selection

Additional feature selection

- Exceptional cases – short time playing or no activities over long time
- Outliers

No.	Field name	Description
1	self_sim	Self-similarity
2	cosim_count	Count of a set of log vectors
3	cosim_uniq_count	Unique count of a set of log vectors
4	cosim_zero_count	Count of data in which cosine similarity is zero
5	cosim_mode	Count of data that appears most often in a set of log vectors
6	total_log_count	Total count of logs generated by user
7	main_char_level	Character level
8	total_use_time_min	Play time during certain period per user
9	npc_kill_count	NPC kill count
10	trade_get_count	Count of trade in which user takes item
11	trade_give_count	Count of trade in which user gives items
12	retrieve_count	Count of activity in which user retrieve items from warehouse
13	deposit_count	Count of activity in which user deposits items to warehouse
14	log_count_per_min	Average count of logs are generated per minute

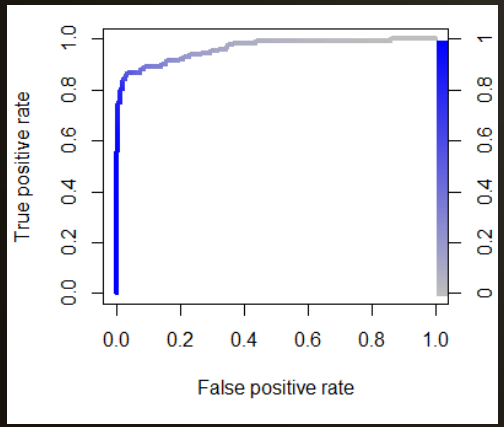


Experiments

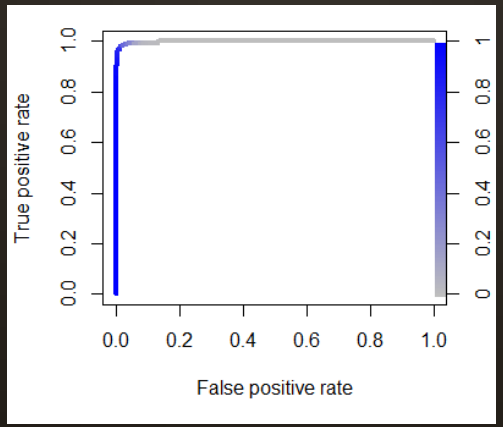
Performance evaluation

- Model1: using only self-similarity. Model2: using all features

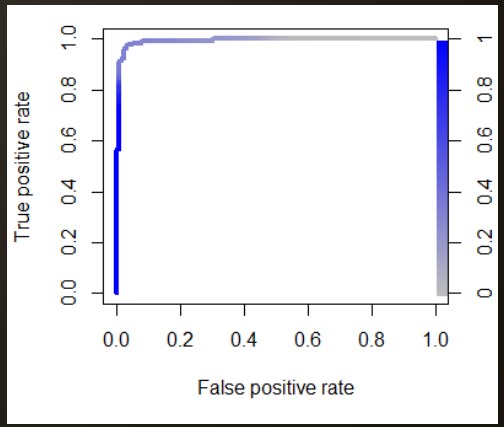
Game	BOT	Human	AUC (model 1)	AUC (model 2)
Lineage	128	149	0.8967	**0.9455**
Aion	186	160	0.9557	**0.9942**
B&S	131	129	0.8280	**0.9399**



Lineage



Aion



B&S

Model Maintenance

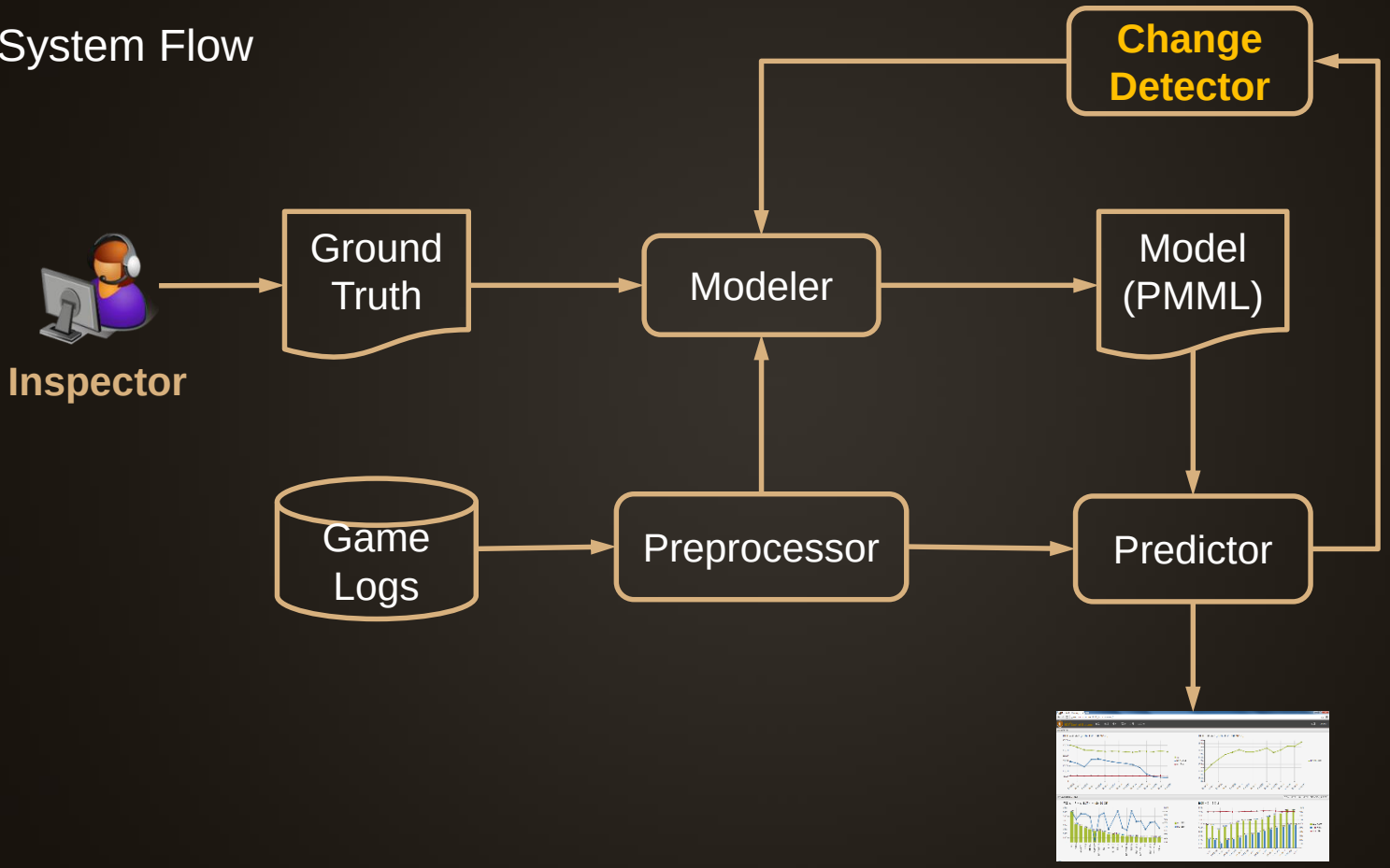
Model maintenance

Motivation and consideration

- How to optimize the time for retraining
  - Too often -> high cost
  - Too rare -> obsolete model
- How to retrain a model autonomously

Model maintenance

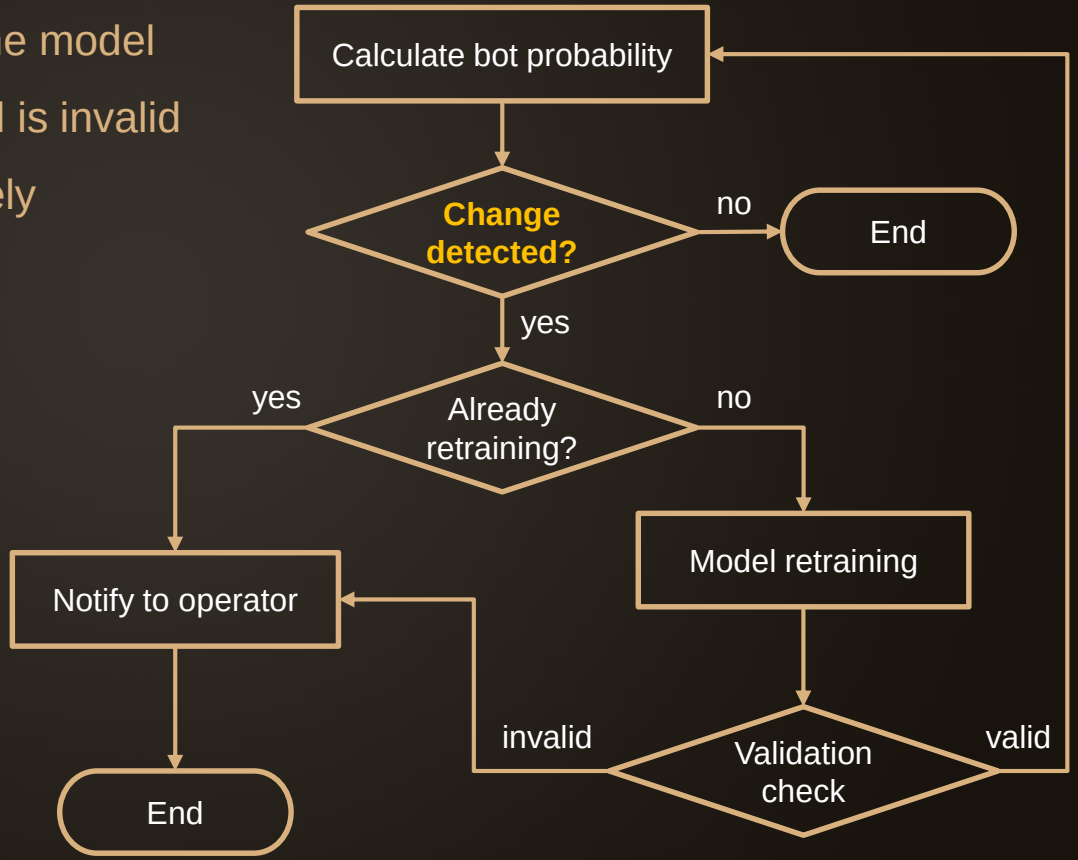
System Flow



Model maintenance

Logic Flow

- If change is detected, retraining the model
- Notifying to operator, if new model is invalid or change is detected consecutively

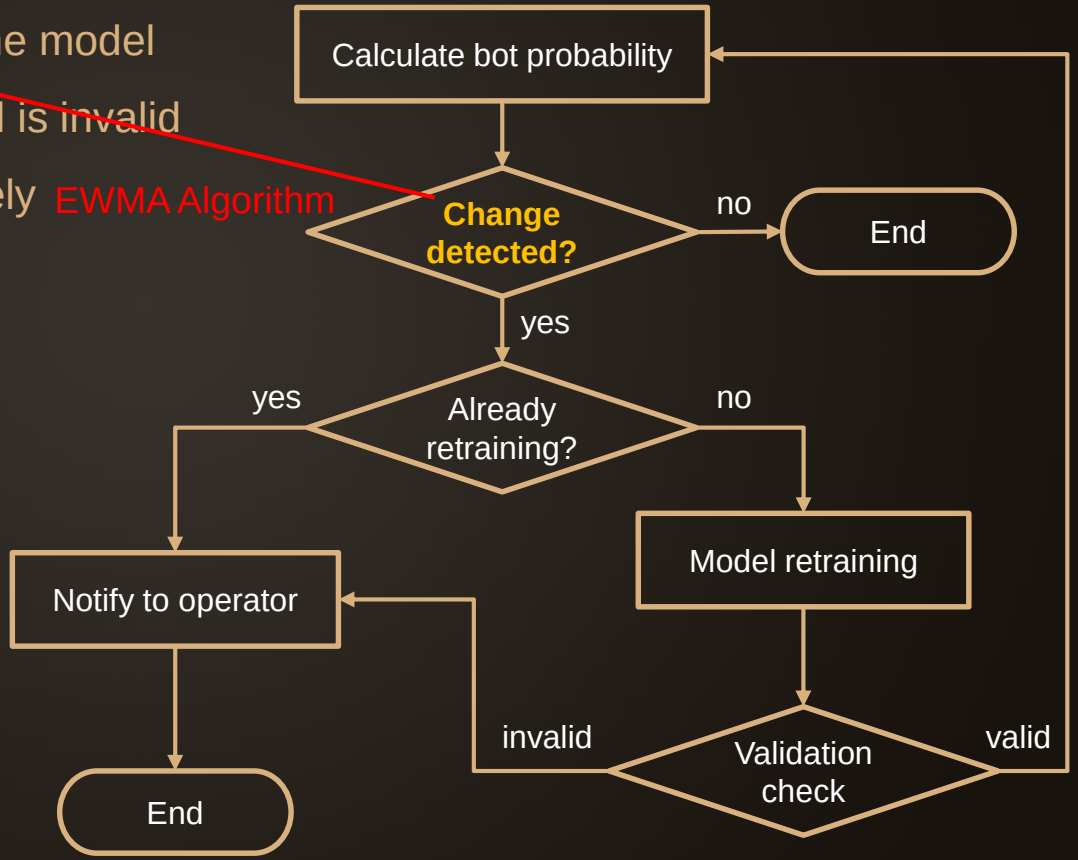


Model maintenance

Logic Flow

- If change is detected, retraining the model
- Notifying to operator, if new model is invalid or change is detected consecutively

EWMA Algorithm

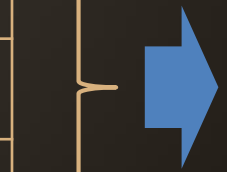


Model maintenance

EWMA algorithm

- Calculating the correlation coefficient of bot probability between time t and t-1

User	Bot probability (time t)	Bot probability (time t-1)
A	0.99	0.95
B	0.95	0.92
C	0.23	0.25
D	0.55	0.55
…	…	…



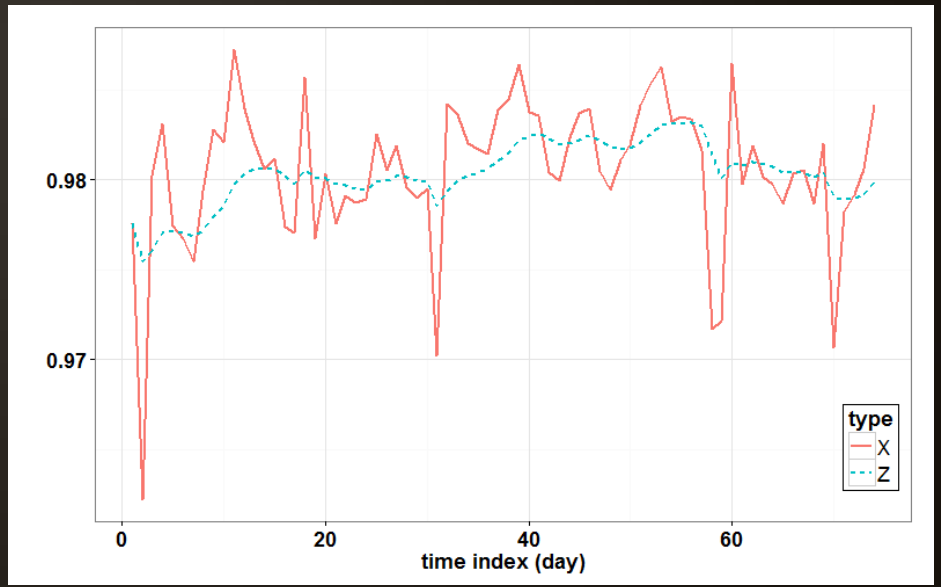
Correlation coefficient

Model maintenance

EWMA algorithm

- Calculating the correlation coefficient of bot probability between time t and t-1

- Calculating the weighted moving average of coefficients

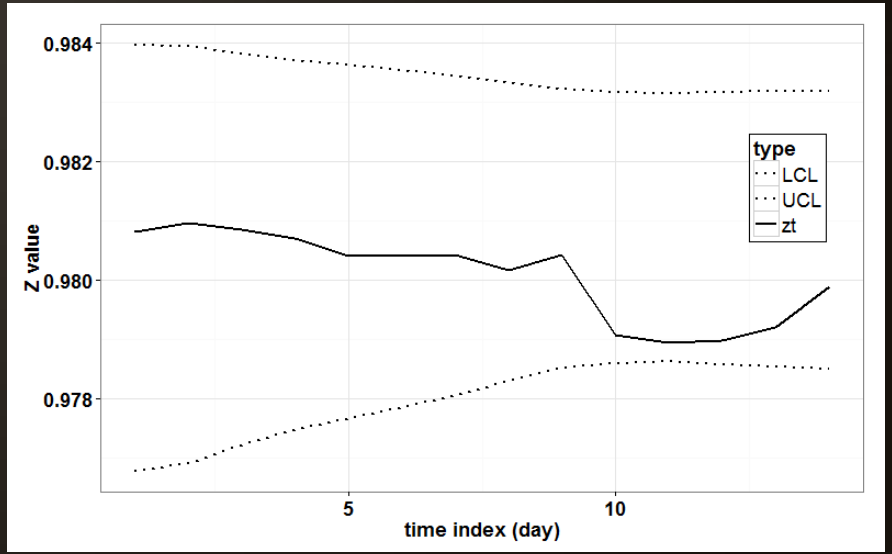


(X: coefficient, Z: moving average)

Model maintenance

EWMA algorithm

- Calculating the correlation coefficient of bot probability between time t and t-1
- Calculating the weighted moving average of coefficients
- Measuring upper an lower control limits



Model maintenance

EWMA algorithm

- Calculating the correlation coefficient of bot probability between time t and t-1

- Calculating the weighted moving average of coefficients

- Measuring upper an lower control limits

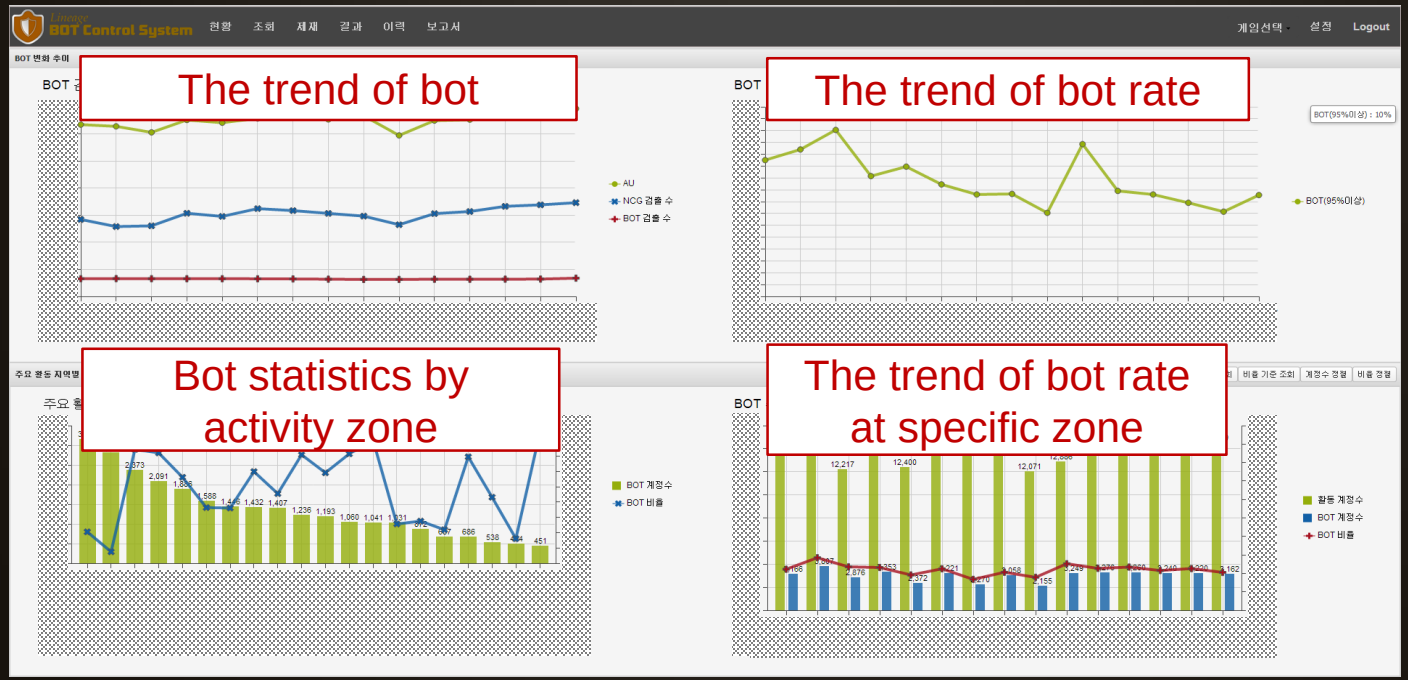
- Retraining the model, unless $LCL < Z_t < UCL$

Real-World Deployment

Real-World Deployment

BOT detection system – dashboard

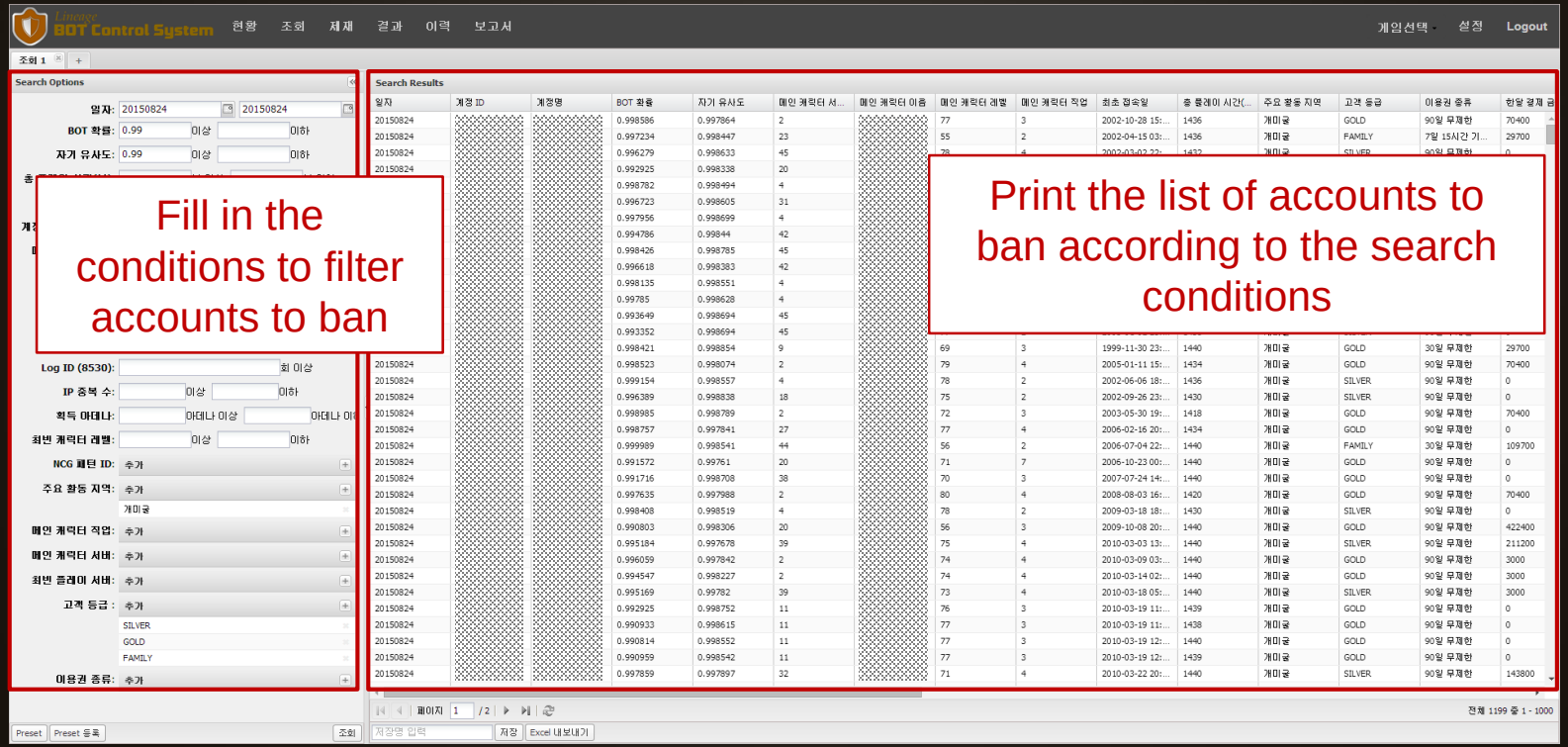
- Provide the trend of numbers or rates of BOT, and the chart of BOT statistics by main activity zone



Real-World Deployment

BOT detection system – search and filter

- Search and filter the list of accounts to ban



Conclusion

Conclusion

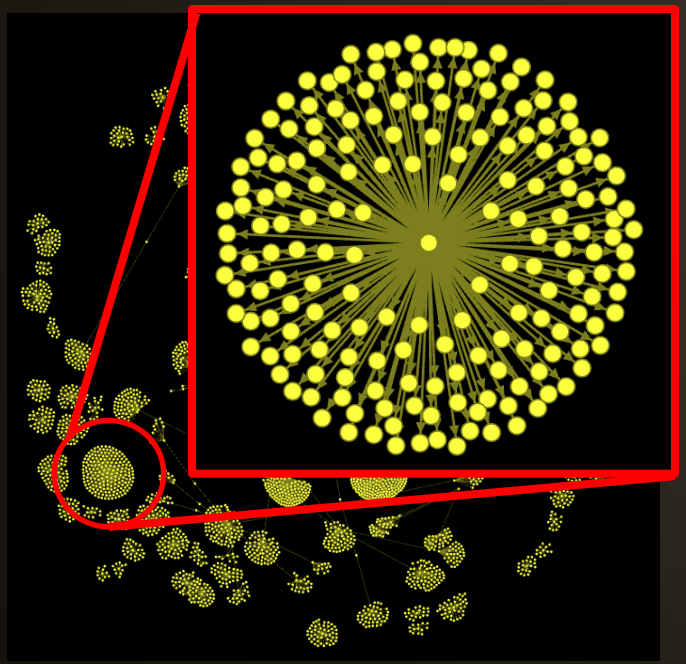
Contributions

- We proposed self-similarity as a feature and demonstrated its effectiveness **with real datasets**
- We proposed a bot detection framework that includes a detection model **maintenance process**
- We implemented the proposed framework and **utilized it for live MMORPGs**

Conclusion

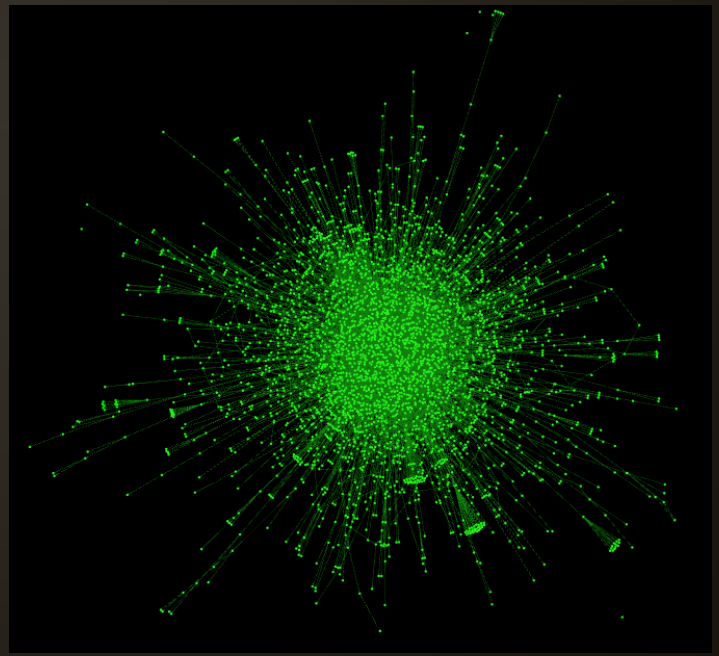
Future works – short-time playing bot

- Undetected massive number of bots playing for less than 10 hours per week
- Star-shaped trading network structure



Short-time playing BOT

VS

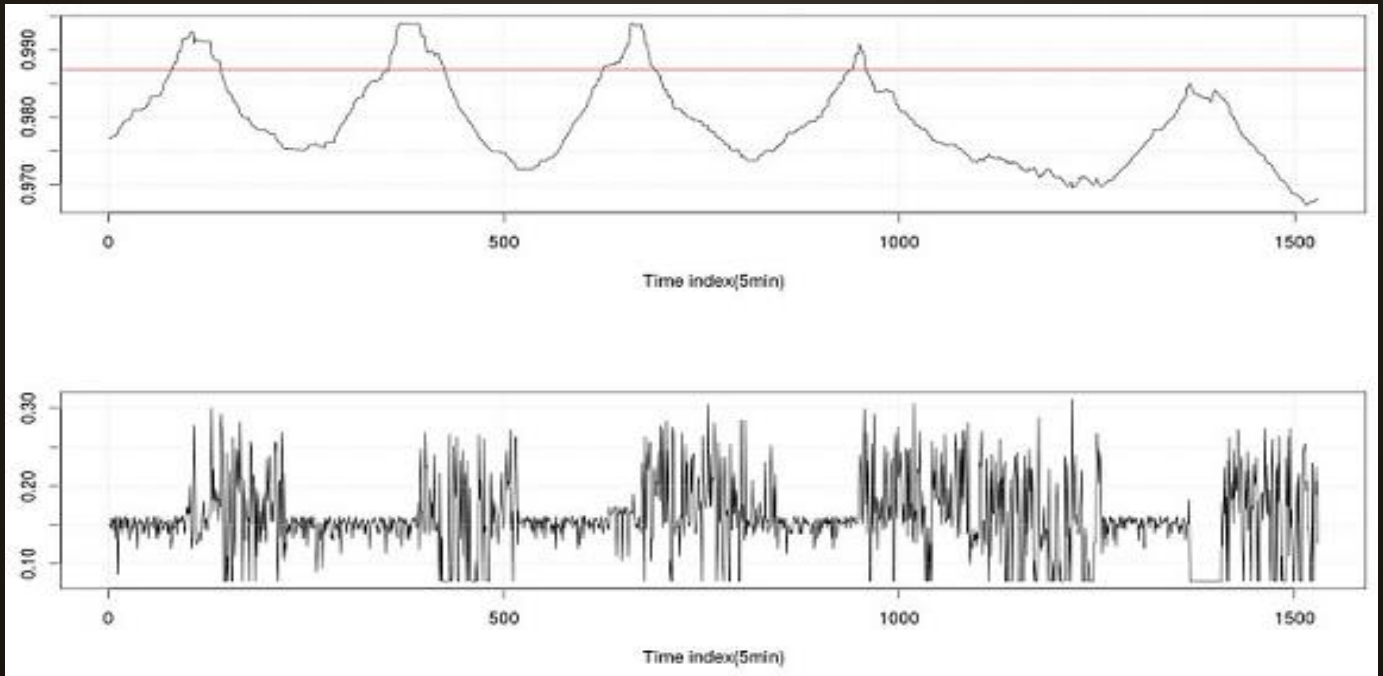


Human users

Conclusion

Future works – occasional bot users

- Human players playing for hours and then turning on a bot for a few hours
- Self-similarities have pulse, if we use short period of time for aggregation



Questions and Answers