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|| 산업 빅데이터 분석 실제 – 프로젝트 최종 발표 ||

대규모 그리드 컴퓨팅 미들웨어의 에러 로그 탐지 시스템

통합과정 4학기 유현진

컴퓨터과학과 2023299008

2024.12.09(Mon)

1. 프로젝트 문제 정의

❖ **대규모 시스템에서의 방대한 로그 데이터 중, 머신러닝을 통해 <u>이상 탐지 시스템을 개발</u>하는 것**

- 목표 : 정상 / 에러 로그를 구분
- 입력 데이터 : 로그 텍스트 ➡ 미들웨어 구동하면서 출력될 로그가 <u>소스코드에</u> 명시되어 있음
  <div align="center">(https://gitlab.cern.ch/jalien/jalien)</div>
- 출력 결과 : 1(정상) / 0(에러)

정적 로그

```
logger.log(Level.WARNING, "Error encountered in the JobWrapper process");

logger.log(Level.WARNING, "Error encountered while running job: ", ex);

logger.log(Level.SEVERE, "Cannot clean up the job dir even using system commands");

logger.log(Level.INFO, "Error. Workdir for job could not be created");
```

동적 로그

```
logger.log(Level.SEVERE, "IsolCmd command" + isolCmd);

logger.log(Level.SEVERE, "Exception running " + LaunchCommand + " : ", ioe);

logger.log(Level.WARNING, "Exception parsing a line of output from pgrep: " + readArg, nfe);

logger.log(Level.INFO, "Exception running " + cmd + " : " + ioe.getMessage());
```

2. 학습 데이터 준비

❖ **1) 데이터 수집**

- 실제 운영중인 <u>시스템의 로그 데이터 수집</u> (운영 시스템 = <u>글로벌 그리드 시스템</u>)

  [KISTI 운영(한국), CERN 사용(스위스)]

시스템의 로그 위치

```
[gsdc24a01@alice-kisti-hpc alien-logs]$ ll
total 33920
drwxr-x---. 2 gsdc24a01 in0190    20480 Dec  6 00:37 2024-12-02
drwxr-x---. 2 gsdc24a01 in0190    61440 Dec  7 00:37 2024-12-03
drwxr-x---. 2 gsdc24a01 in0190   151552 Dec  8 00:37 2024-12-04
drwxr-x---. 2 gsdc24a01 in0190   155648 Dec  9 00:37 2024-12-05
drwxr-x---. 2 gsdc24a01 in0190   106496 Dec  9 10:37 2024-12-06
drwxr-x---. 2 gsdc24a01 in0190    57344 Dec  8 01:37 2024-12-07
drwxr-x---. 2 gsdc24a01 in0190   126976 Dec  9 01:37 2024-12-08
drwxr-x---. 2 gsdc24a01 in0190    69632 Dec  9 10:39 2024-12-09
-rw-r-----. 1 gsdc24a01 in0190    20767 Nov  8 16:21 access_log
-rw-r-----. 1 gsdc24a01 in0190      652 Nov  8 16:21 apmon_log
```

```
[gsdc24a01@alice-kisti-hpc 2024-12-02]$ ll
total 668
-rw-------. 1 gsdc24a01 in0190 3264 Dec  2 00:20 jobagent_40060_000217.err.gz
-rw-------. 1 gsdc24a01 in0190 2714 Dec  2 00:20 jobagent_40060_000217.out.gz
-rw-r-----. 1 gsdc24a01 in0190 3062 Dec  2 00:18 jobagent_40060_000217.sh.gz
-rw-------. 1 gsdc24a01 in0190 3321 Dec  2 00:24 jobagent_40060_000218.err.gz
-rw-------. 1 gsdc24a01 in0190 2714 Dec  2 00:24 jobagent_40060_000218.out.gz
-rw-r-----. 1 gsdc24a01 in0190 3061 Dec  2 00:22 jobagent_40060_000218.sh.gz
-rw-------. 1 gsdc24a01 in0190 3292 Dec  2 01:56 jobagent_40060_000219.err.gz
-rw-------. 1 gsdc24a01 in0190 2714 Dec  2 01:56 jobagent_40060_000219.out.gz
-rw-r-----. 1 gsdc24a01 in0190 3061 Dec  2 01:54 jobagent_40060_000219.sh.gz
-rw-------. 1 gsdc24a01 in0190 3323 Dec  2 02:30 jobagent_40060_000220.err.gz
```

로그 파일

```
[gsdc24a01@alice-kisti-hpc 2024-12-02]$ zcat jobagent_40060_000217.err.gz | head
JAliEn/1.9.5-1(10):ERROR:105: Unable to locate a modulefile for 'BASE/1.0'
(10):ERROR:105: Unable to locate a modulefile for 'JDK/12.0.1-5'
(10):ERROR:105: Unable to locate a modulefile for 'XRootD/v5.7.0-16'
JAliEn/1.9.5-1(12):ERROR:102: Tcl command execution failed: set JALIEN_ROOT $::env(BASEDI
R)/JAliEn/$version

XRootD/v5.7.0-16(11):ERROR:105: Unable to locate a modulefile for 'BASE/1.0'
XRootD/v5.7.0-16(12):ERROR:105: Unable to locate a modulefile for 'libffi/v3.2.1-alice1-2
'
XRootD/v5.7.0-16(13):ERROR:105: Unable to locate a modulefile for 'zlib/v1.2.8-12'
XRootD/v5.7.0-16(14):ERROR:105: Unable to locate a modulefile for 'FreeType/v2.10.1-15'
hdf5(15):ERROR:105: Unable to locate a modulefile for 'hdf5/1.10.9-4'
```

```
[gsdc24a01@alice-kisti-hpc 2024-12-02]$ zcat jobagent_40060_000217.err.gz | tail
INFO: Connecting to JCentral on alice-jcentral.cern.ch:8098
Dec 02, 2024 12:20:23 AM alien.api.DispatchSSLClient getInstance
INFO: Connecting with client cert: C=ch,O=AliEn2,CN=JobAgent
Dec 02, 2024 12:20:24 AM alien.api.DispatchSSLClient connectTo
INFO: Printing peer's information:
Dec 02, 2024 12:20:24 AM alien.api.DispatchSSLClient connectTo
INFO: Peer's Certificate Information:
INFO
Dec 02, 2024 12:20:25 AM alien.site.JobRunner run
INFO: JobRunner going to exit from lack of jobs
[gsdc24a01@alice-kisti-hpc 2024-12-02]$
```

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2. 학습 데이터 준비

❖ **2) 데이터 전처리**

- 수집한 로그 데이터에 <u>CSV 데이터로 변환</u> & <u>라벨링 진행</u> (1 = 정상 / 0 = 에러)

로그 파일

```
Nov 01, 2024 10:23:10 AM alien.api.DispatchSSLClient checkIdleConnection
INFO: Closing idle socket
Nov 01, 2024 10:23:21 AM alien.site.JobAgent computeTimeLeft
OFF: Still have 76725 seconds to live (1714526601850-1714516326732=10275)
Nov 01, 2024 10:23:21 AM alien.site.JobAgent computeTimeLeft
OFF: Certificate timeleft is 162435
Nov 01, 2024 10:23:23 AM alien.site.JobAgent computeTimeLeft
INFO: Still have 76723 seconds to live (1714526603919-1714516326732=10277)
Nov 01, 2024 10:23:23 AM alien.site.JobAgent computeTimeLeft
INFO: Certificate timeleft is 162433
Nov 01, 2024 10:23:23 AM alien.site.JobAgent recomputeDiskSpace
INFO: Recomputing disk space of /scratch/gsdc23a01. Starting with a free space of
7437841515282432
Nov 01, 2024 10:23:23 AM alien.site.JobAgent recomputeDiskSpace
INFO: WorkdirSize=10702722, maxSize=5242880000, recomputedDisk=7437836283105154
Nov 01, 2024 10:23:23 AM alien.site.JobRunner run
INFO: No new thread
Nov 01, 2024 10:23:41 AM alien.site.JobAgent computeTimeLeft
OFF: Still have 76705 seconds to live (1714526621982-1714516326732=10295)
Nov 01, 2024 10:23:41 AM alien.site.JobAgent computeTimeLeft
OFF: Certificate timeleft is 162415
JobID 3068977211: Nov 01, 2024 03:24:15 alien.api.DispatchSSLClient getInstance
INFO: Connecting to JCentral on alice-jcentral.cern.ch:8098
JobID 3068977211: Nov 01, 2024 03:24:15 alien.api.DispatchSSLClient getInstance
INFO: Connecting with client cert:
C=ch,O=AliEn2,CN=Jobs,CN=alitrain,OU=alitrain,OU=queueid\=3068977211/resubmission\=0
JobID 3068977211: Nov 01, 2024 03:24:16 alien.api.DispatchSSLClient connectTo
INFO: Printing peer's information:
JobID 3068977211: Nov 01, 2024 03:24:16 alien.api.DispatchSSLClient connectTo
INFO: Peer's Certificate Information:
INFO
JobID 3068977211: Nov 01, 2024 03:24:18 alien.api.DispatchSSLClient dispatchRequest
SEVERE: Exception connecting at attempt no. 0
java.io.EOFException
        at java.base/java.io.ObjectInputStream
$BlockDataInputStream.peekByte(ObjectInputStream.java:3214)
        at java.base/java.io.ObjectInputStream.readObject0(ObjectInputStream.java:1684)
        at java.base/java.io.ObjectInputStream.readObject(ObjectInputStream.java:509)
        at java.base/java.io.ObjectInputStream.readObject(ObjectInputStream.java:467)
        at alien.api.DispatchSSLClient.dispatchARequest(DispatchSSLClient.java:544)
```
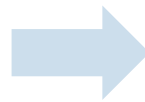
logs.csv 파일

20241101 Nov 01, 2024 10:23:10 AM alien.api.DispatchSSLClient checkIdleConnection	1
20241101 INFO: Closing idle socket	1
20241101 Nov 01, 2024 10:23:21 AM alien.site.JobAgent computeTimeLeft	1
20241101 INFO: Still have 76725 seconds to live (1714526601850-1714516326732=10275)	1
20241101 Nov 01, 2024 10:23:21 AM alien.site.JobAgent computeTimeLeft	1
20241101 INFO: Certificate timeleft is 162435	1
20241101 Nov 01, 2024 10:23:23 AM alien.site.JobAgent computeTimeLeft	1
20241101 INFO: Still have 76723 seconds to live (1714526603919-1714516326732=10277)	1
20241101 Nov 01, 2024 10:23:23 AM alien.site.JobAgent computeTimeLeft	1
20241101 INFO: Certificate timeleft is 162433	1
20241101 Nov 01, 2024 10:23:23 AM alien.site.JobAgent recomputeDiskSpace	1
20241101 INFO: Recomputing disk space of /scratch/gsdc23a01. Starting with a free spa...	1
20241101 Nov 01, 2024 10:23:23 AM alien.site.JobAgent recomputeDiskSpace	1
20241101 INFO: WorkdirSize=10702722, maxSize=5242880000, recomputedDisk=743783...	1
20241101 Nov 01, 2024 10:23:23 AM alien.site.JobRunner run	1
20241101 INFO: No new thread	1
20241101 Nov 01, 2024 10:23:41 AM alien.site.JobAgent computeTimeLeft	1
20241101 INFO: Still have 76705 seconds to live (1714526621982-1714516326732=10295)	1
20241101 Nov 01, 2024 10:23:41 AM alien.site.JobAgent computeTimeLeft	1
20241101 INFO: Certificate timeleft is 162415	1
20241101 JobID 3068977211: Nov 01, 2024 03:24:15 alien.api.DispatchSSLClient getInstan...	1
20241101 INFO: Connecting to JCentral on alice-jcentral.cern.ch:8098	1
20241101 JobID 3068977211: Nov 01, 2024 03:24:15 alien.api.DispatchSSLClient getInstan...	1
20241101 INFO: Connecting with client cert: C=ch,O=AliEn2,CN=Jobs,CN=alitrain,OU=al...	1
20241101 JobID 3068977211: Nov 01, 2024 03:24:16 alien.api.DispatchSSLClient connectT...	1
20241101 INFO: Printing peer's information:	1
20241101 JobID 3068977211: Nov 01, 2024 03:24:16 alien.api.DispatchSSLClient connectT...	1
20241101 INFO: Peer's Certificate Information:	1
20241101 INFO	1
20241101 JobID 3068977211: Nov 01, 2024 03:24:18 alien.api.DispatchSSLClient dispatchR...	1
20241101 SEVERE: Exception connecting at attempt no. 0	0
20241101 java.io.EOFException	0
20241101 at java.base/java.io.ObjectInputStream$BlockDataInputStream.peekByte(Object...	0
20241101 at java.base/java.io.ObjectInputStream.readObject0(ObjectInputStream.java:168...	0
20241101 at java.base/java.io.ObjectInputStream.readObject(ObjectInputStream.java:509)	0
20241101 at java.base/java.io.ObjectInputStream.readObject(ObjectInputStream.java:467)	0

2. 학습 데이터 준비

❖ **3) 로그 데이터 추가 수집**

- " 운영 시스템에서 추출한 로그로는 학습할 에러 로그의 개수가 적음 " *(정상 90%, 에러 10%)*

  - 미들웨어 소스코드에서 샘플 에러 로그를 추가 수집 *그리드 컴퓨팅 환경에서 자주 사용하는 소스코드를 중점으로 추출*
    (jalien/src/main/java/alien/site 디렉터리)

수집 기준

- 각각의 소스코드를 직접 확인
- logger.log 라인 중,
  - Level.SEVERE
  - Level.WARNING
  - Level.INFO 중 에러
    메세지에 해당

2. 학습 데이터 준비

❖ **4) 추가 수집 데이터 전처리**

최종적으로 정상 60%, 에러 40%

- 동적 로그가 다수 존재하여, <u>임의의 데이터 삽입하는 과정 진행</u>

  - <> = 5 ~ 8자리 숫자(num) / [] = 임의의 파일 경로(path) / [[]] = 10 ~ 30자리의 문자열(str)

- <u>'INFO 레벨 + 에러 로그'</u> 인 경우를 잘 학습시키기 위해, <u>해당 로그의 비율을 높임</u> *(실제로 사람이 자주 놓치는 케이스)*

```
"SEVERE: Could not fetch machine's idle CPU"
"WARNING: JobRunner main loop caught an exception"
"SEVERE: Could not get the node's memory to set up the oversubscription pool"
"WARNING: Error creating top cgroup:"
"WARNING: Exception moving <> to cgroup <>"
"WARNING: Exception moving <> to cgroup <>"
"WARNING: Exception moving <> to cgroup <>"
"WARNING: Exception setting low memory <> to cgroup <>"
"WARNING: Exception setting low memory <> to cgroup <>"
"WARNING: Exception setting max memory <> to pid <>"
"WARNING: Exception killing process inferred from []"
"WARNING: Exception cleaning cgroups of pid <>"
"WARNING: Exception getting the CPU cores in cgroup []"
"WARNING: Exception assigning CPU cores [[]] to cgroup []"
"WARNING: Exception setting CPU quota <> to cgroup []"
"SEVERE: Problem in construction of ComputingElement: "
"SEVERE: Unable to fetch config for \"host_host\""
"WARNING: Could not create a pidfile in: /scratch/gsdc24a01/ALICE/alien-log/CE.pid"
"SEVERE: Exception reloading the identity: [[]]"
"WARNING: Error syncing with LDAP: [[]]"
"SEVERE: Exception checking the identity: [[]]"
"SEVERE: Can't send parameter to ML (getNumberFreeSlots): [[]]"
"INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagent-<>-<>.sh"
"INFO: Agent Startup file not found: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagent-<>-<>.sh"
"INFO: Getting JobAgent TokenCertificate failed: [[]]"
"WARNING: Exception writing token to"
"WARNING: Getting JobAgent TokenCertificate failed"
"SEVERE: Cannot find class for type: "
"SEVERE: Cannot find class for ceConfig:"
"SEVERE: Cannot instantiate queue class for type: PBS.java"
"SEVERE: Could not obtain AliEn jar path:"
"WARNING: Problem with getting logger:"
"WARNING: Problem with the monitoring objects IO Exception: "
"WARNING: Problem with the monitoring objects ApMon Exception: "
"WARNING: Unknown exception: "
"WARNING: Unable to check for AVX support"
"WARNING: Another exception matching the job"
"ERROR: Unable to handle job"
"SEVERE: Could not generate JobWrapper launch command "
"SEVERE: Exception running [[]] :"
"SEREVE: Could not run debug for launchCommand:"
"WARNING: Error encountered while running job: "
```

추가 로그 데이터

```
20241104 "WARNING: Unknown exception: "                                                          0
20241104 "INFO: Did not get any OOM error from dmesg"                                            0
20241104 "WARNING: Data list format not understood: [/abs/path/to/random/file_pcqwc]"           0
20241104 "INFO: Unable to kill the JobWrapper"                                                   0
20241104 "SEVERE: Error. Could not receive data from JobAgent: "                                 0
20241104 "INFO: .alienValidation.trace does not exist."                                          0
20241104 "INFO: There is not enough space left: 81633530MB"                                      0
20241104 "INFO: Can not set NUMA architecture aware cpuIsolation"                                0
20241104 "WARNING: Invalid containerizer: "                                                      0
20241104 "INFO: Could not parse memory limit from proc file"                                     0
20241104 "WARNING: Exception saving content to file"                                             0
20241104 "INFO: Error reading /abs/path/to/random/file_pmphr"                                    0
20241104 "WARNING: Problem with the monitoring objects IO Exception: "                           0
20241104 "INFO: There is not enough space left: 70359905MB"                                      0
20241104 "INFO: Exception running [/abs/path/to/random/file_vwyhz] : [/abs/path/to/random/file_dpqwe]"  0
20241104 "INFO: Error reading /abs/path/to/random/file_arcmu"                                    0
20241104 "INFO: Error reading /abs/path/to/random/file_xrtco"                                    0
20241104 "WARNING: An error occurred while registering [/abs/path/to/random/file_pldvt]. Bad connection?"  0
20241104 "WARNING: Can't upload output file [/abs/path/to/random/file_tiqgk], does not exist or has zero size."  0
20241104 "INFO: Did not change pinning of cgroup "                                               0
20241104 "INFO: Did not change pinning of cgroup "                                               0
20241104 "INFO: Format error on getting NUMA range"                                              0
20241104 "SEVERE: Failed to get Site sonar probe list for node node95343443 in [/abs/path/to/random/file_qdqbd]"  0
20241104 "INFO: Failed getting or inserting host in getNumberFreeSlots"                          0
20241104 "INFO: No probes returned from Site Sonar. Skipping ..."                                0
20241104 "INFO: Failed getting or inserting host in getNumberFreeSlots"                          0
20241104 "INFO: There is not enough space left: 30027389MB"                                      0
20241104 "WARNING: Exception creating temporary file"                                            0
20241104 "WARNING: Problem with getting logger:"                                                 0
20241104 "WARNING: Could  notcreate process list: "                                              0
20241104 "WARNING: Could not access [/abs/path/to/random/file_weihr] "                           0
20241104 "WARNING: Error deleting the job workdir, using system commands instead"                0
20241104 "SEVERE: IO Error in calling the url [/abs/path/to/random/file_lwjja] for node node5006437 in [/abs/path/to/  0
20241104 "SEVERE: Error installing [/abs/path/to/random/file_xpzen]"                             0
20241104 "INFO: Unable to kill the JobWrapper"                                                   0
```
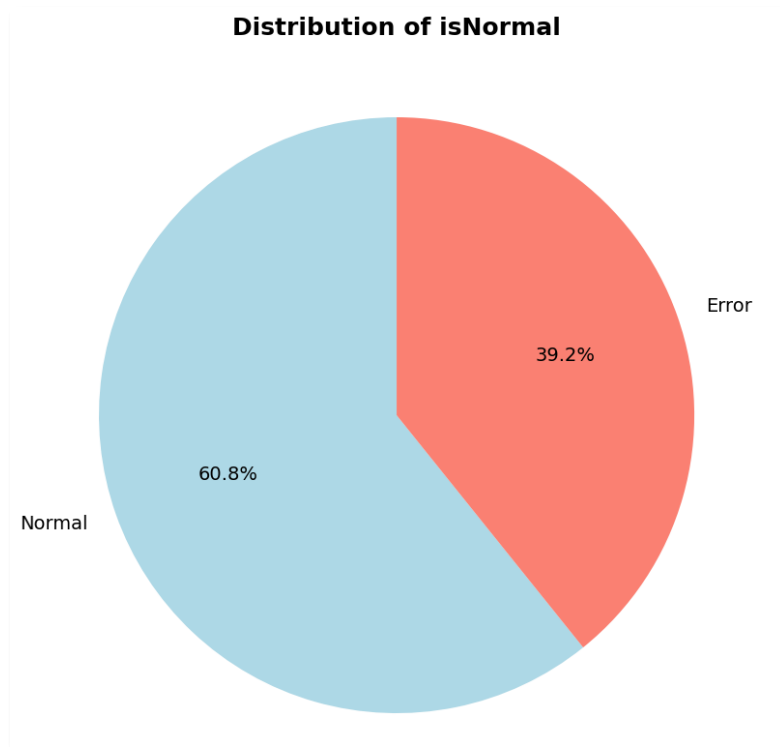
최종 logs.csv

2. 학습 데이터 준비

```
RangeIndex: 27459 entries, 0 to 27458
Data columns (total 3 columns):
 #   Column   Non-Null Count  Dtype
---  ------   --------------  -----
 0   Date     27459 non-null  int64
 1   Msg      27459 non-null  object
 2   isError  27459 non-null  int64
dtypes: int64(2), object(1)
```

❖ 2) 데이터 분석 (에러 로그 비율, 날짜별 로그 비율)

Distribution of isNormal

Error 39.2%

Normal 60.8%

Logs Distribution by Date

20241104 12.8%

20241103 20.2%

20241101 28.0%

20241102 39.0%

```
총 행 수: 27459
'1' 값 비율: 60.78% (16689/27459)
'0' 값 비율: 39.22% (10770/27459)
```

```
총 행 수: 27459
Date 값 비율:
'20241101': 27.98% (7684/27459)
'20241102': 39.04% (10719/27459)
'20241103': 20.16% (5535/27459)
'20241104': 12.82% (3521/27459)
```
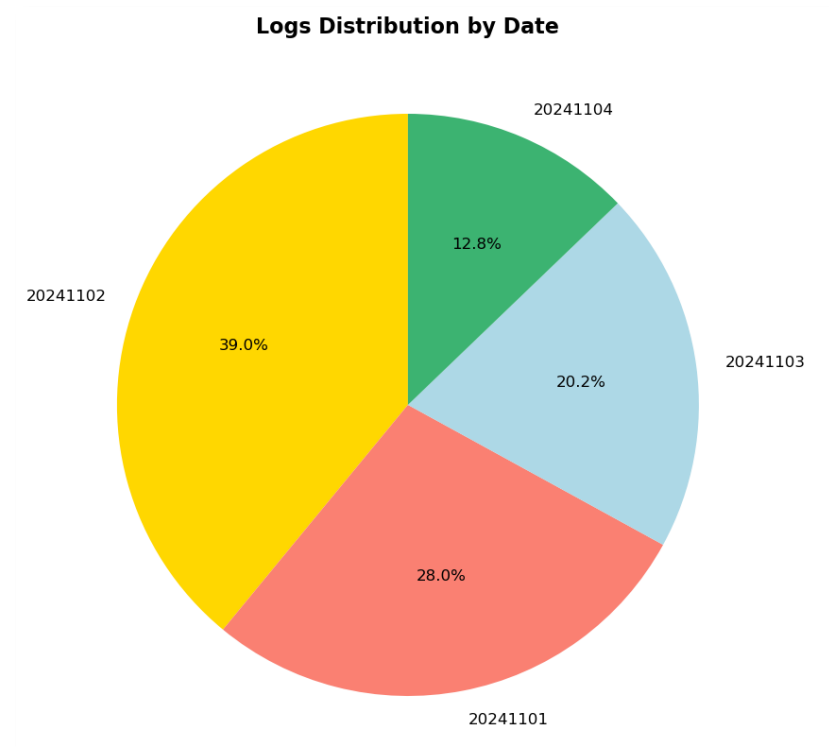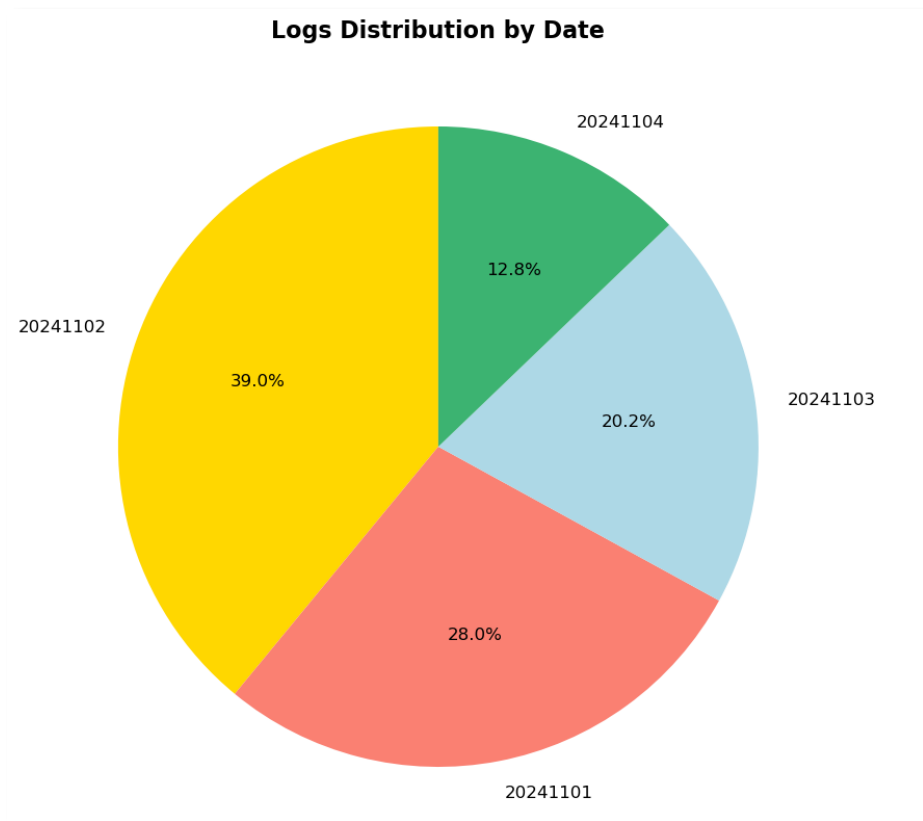
2. 학습 데이터 준비

RangeIndex: 27459 entries, 0 to 27458
Data columns (total 3 columns):
 #   Column   Non-Null Count Dtype
--- ------   -------------- -----
 0   Date   27459 non-null int64
 1   Msg   27459 non-null object
 2   isError 27459 non-null int64
dtypes: int64(2), object(1)

❖ 2) 데이터 분석 (에러 로그 타입)

Logs Distribution by Date


```
Log Counts and Proportions (isNormal = 0):
WARNING: 29.07% (3131/10770)
SEVERE: 8.53% (919/10770)
INFO: 48.97% (5274/10770)
OTHER: 13.43% (1446/10770)
```

Type	Date	Message	
WARNING	20241103	"WARNING: Found exception while processing cgroups exploration "	0
	20241103	"WARNING: Site Sonar probe [/abs/path/to/random/file_jpicq] didn't	0
	20241103	"WARNING: JobInfo or DiskInfo monitor null"	0
	20241103	"WARNING: Exception assigning CPU cores [/abs/path/to/random/file	0
SEVERE	20241103	"SEVERE: Could not fetch machine's idle CPU"	0
	20241103	"SEVERE: Monitor has detected an error: [/abs/path/to/random/file_u	0
INFO	20241103	"INFO: There is not enough space left: 73276140MB"	0
	20241103	"INFO: Did not change pinning of cgroup "	0
	20241103	"INFO: Switching to core check using shell instead"	0
	20241103	"INFO: Can not set NUMA architecture aware cpuIsolation"	0
	20241103	"INFO: Can not set NUMA architecture aware cpuIsolation"	0
OTHER	20241101	java.lang.NullPointerException: Cannot invoke "java.lang.Long.lo	0
	20241101	at alien.site.JobRunner.lambda$static$0(JobRunner.java:39)	0
	20241101	at alien.monitoring.Monitor.callMonitoringObjects(Monitor.java:	0
	20241101	at alien.monitoring.Monitor.run(Monitor.java:340)	0
	20241101	at java.base/java.util.concurrent.Executors$RunnableAdapter.call	0
	20241101	at java.base/java.util.concurrent.FutureTask.runAndReset(FutureT	0
	20241101	at java.base/java.util.concurrent.ScheduledThreadPoolExecutor$	0
	20241101	at java.base/java.util.concurrent.ThreadPoolExecutor.runWorker(	0
	20241101	at java.base/java.util.concurrent.ThreadPoolExecutor$Worker.run	0
	20241101	at java.base/java.lang.Thread.run(Thread.java:833)	0

보통 JAVA Exception Message에 해당

3. 모델 선택 및 학습

❖ <u>지도 학습 / 비지도 학습 방법을 모두 사용</u>하여, 해당 로그에 적합한 학습 방법 선택

- 1) 지도 학습 (라벨이 있는 경우)
  - SVM : 데이터를 특정 카테고리로 분류하는데 유용

```
Classification Report:
              precision    recall  f1-score   support

           0       0.98      1.00      0.99      2125
           1       1.00      0.99      0.99      3367

    accuracy                           0.99      5492
   macro avg       0.99      0.99      0.99      5492
weighted avg       0.99      0.99      0.99      5492
```


Confusion Matrix for SVC

Learning Curve
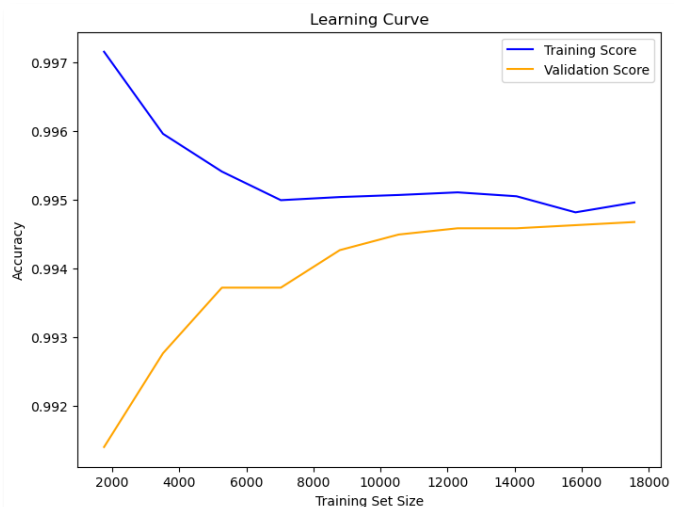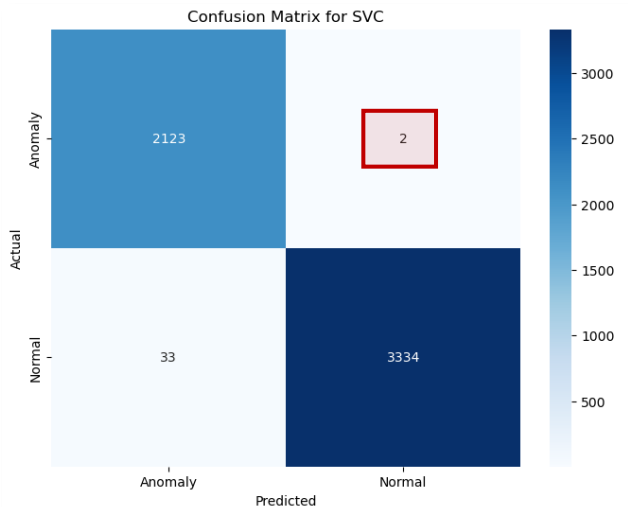
```python
import pandas as pd
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.svm import SVC
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report, confusion_matrix
import matplotlib.pyplot as plt
import seaborn as sns

# 1. 데이터 로드
file_path = 'data/logs.csv'  # CSV 파일 경로
data = pd.read_csv(file_path)

# 주요 열 확인
if 'Msg' not in data.columns or 'isNormal' not in data.columns:
    raise ValueError("CSV 파일에 'Msg' 또는 'isNormal' 열이 없습니다.")

# 2. 텍스트 데이터 및 레이블 준비
texts = data['Msg']  # 텍스트 데이터
labels = data['isNormal']  # 레이블 (1: 정상, 0: 비정상)

# 3. TF-IDF 벡터화
vectorizer = TfidfVectorizer(max_features=5000)
X = vectorizer.fit_transform(texts)  # 텍스트 데이터 벡터화

# 4. 데이터 분할 (훈련/테스트)
X_train, X_test, y_train, y_test = train_test_split(X, labels, test_size=0.2, random_state=42)

# 출력 확인
print(f"TF-IDF 행렬 크기: {X.shape}")
print(f"훈련 데이터 크기: {X_train.shape}")
print(f"테스트 데이터 크기: {X_test.shape}")

# 5. SVC 모델 학습
model = SVC(kernel='rbf', gamma='scale', C=1.0, probability=True)
model.fit(X_train, y_train)

# 6. 모델 평가
y_pred = model.predict(X_test)

# 7. 성능 보고
print("Classification Report:")
print(classification_report(y_test, y_pred))
```
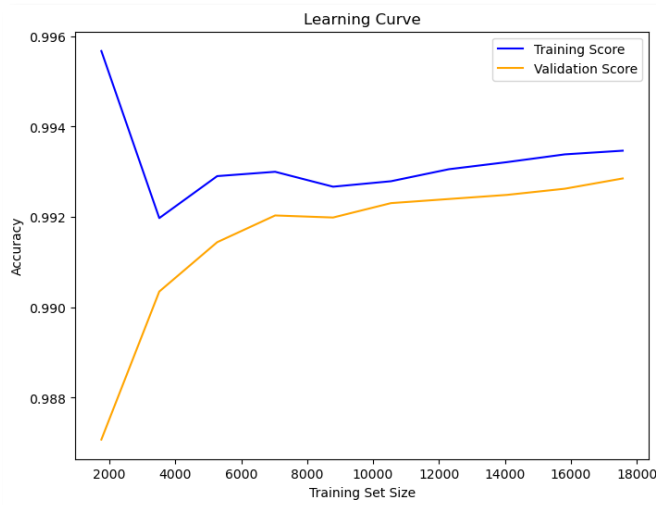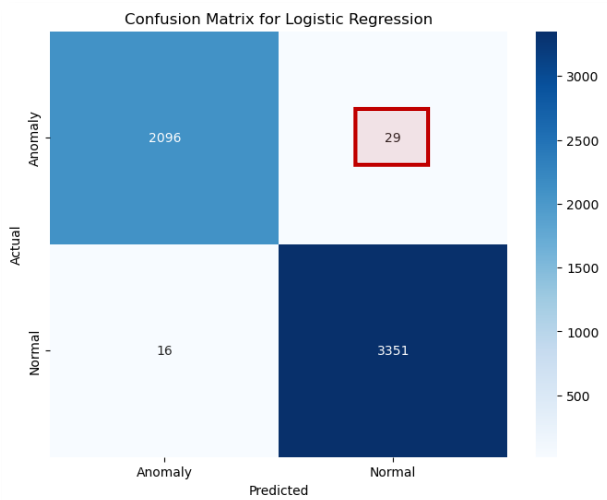
3. 모델 선택 및 학습

❖ **지도 학습 / 비지도 학습 방법을 모두 사용**하여, 해당 로그에 적합한 학습 방법 선택

- 1) 지도 학습 (라벨이 있는 경우)

  - Logistic Regression : 다양한 데이터 요소를 기반으로 값을 예측하는 데 유용

	precision	recall	f1-score	support
0	0.99	0.99	0.99	2125
1	0.99	1.00	0.99	3367
accuracy			0.99	5492
macro avg	0.99	0.99	0.99	5492
weighted avg	0.99	0.99	0.99	5492

Confusion Matrix for Logistic Regression

Learning Curve

```python
import pandas as pd
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report

# CSV 파일 경로
file_path = 'data/logs.csv'

# 데이터 로드
data = pd.read_csv(file_path)

# 주요 열 확인 (Msg와 isError 열을 사용한다고 가정)
if 'Msg' not in data.columns or 'isNormal' not in data.columns:
    raise ValueError("CSV 파일에 'Msg' 또는 'isNormal' 열이 없습니다.")

# 1. 텍스트 데이터와 타깃 데이터 준비
texts = data['Msg']  # 텍스트 데이터
labels = data['isNormal']  # 타깃 데이터

# 2. TF-IDF 벡터화
vectorizer = TfidfVectorizer(max_features=5000)  # 최대 5000개의 피처로 제한
X = vectorizer.fit_transform(texts)  # TF-IDF 벡터화

# 3. 데이터 분할 (훈련 세트와 테스트 세트)
X_train, X_test, y_train, y_test = train_test_split(X, labels, test_size=0.2, random_state=42)

# 출력 확인
print(f"TF-IDF 행렬 크기: {X.shape}")
print(f"훈련 데이터 크기: {X_train.shape}")
print(f"테스트 데이터 크기: {X_test.shape}")

# 4. 모델 학습
model = LogisticRegression()
model.fit(X_train, y_train)

# 5. 테스트 데이터 평가
y_pred = model.predict(X_test)
print(classification_report(y_test, y_pred))
```

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❖ **지도 학습 / 비지도 학습 방법을 모두 사용**하여, 해당 로그에 적합한 학습 방법 선택

- 2) 비지도 학습 (라벨이 없는 경우)

  - DBSCAN : 라벨이 없는 데이터를 유사성 또는
    차이점에 따라 그룹화하는 기술

```
Adjusted Rand Index (ARI): 0.181
Homogeneity: 0.891
Completeness: 0.166
V-Measure: 0.280

Classification Report:
              precision    recall  f1-score   support

           0       0.99      0.95      0.97     10770
           1       0.97      0.99      0.98     16689

    accuracy                           0.98     27459
   macro avg       0.98      0.97      0.98     27459
weighted avg       0.98      0.98      0.98     27459
```


DBSCAN Clustering Visualization (2D PCA)
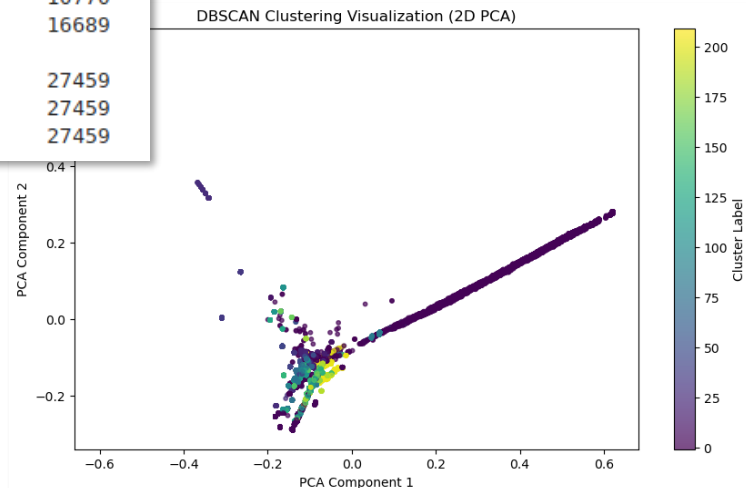
```python
import pandas as pd
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.cluster import DBSCAN
from sklearn.metrics import classification_report, adjusted_rand_score


# 1. 데이터 로드
file_path = 'data/logs.csv'  # CSV 파일 경로
data = pd.read_csv(file_path)

# 주요 열 확인
if 'Msg' not in data.columns or 'isNormal' not in data.columns:
    raise ValueError("CSV 파일에 'Msg' 또는 'isNormal' 열이 없습니다.")

# 2. 텍스트 데이터 및 레이블 준비
texts = data['Msg']  # 텍스트 데이터
labels = data['isNormal']  # 레이블 (1: 정상, 0: 비정상)

# 3. TF-IDF 벡터화
vectorizer = TfidfVectorizer(max_features=5000)
X = vectorizer.fit_transform(texts).toarray()  # 벡터화 및 배열 변환

# 4. DBSCAN 모델 학습
dbscan = DBSCAN(eps=0.5, min_samples=10, metric='cosine')
clusters = dbscan.fit_predict(X)

# 5. 결과 평가
print("클러스터 레이블 분포:")
print(pd.Series(clusters).value_counts())

# DBSCAN은 비지도 학습이므로 레이블이 없지만, 기존 레이블과 비교 가능
if labels is not None:
    print("\nAdjusted Rand Index (ARI):", adjusted_rand_score(labels, clusters))
```

3. 모델 선택 및 학습

❖ <u>지도 학습 / 비지도 학습 방법을 모두 사용</u>하여, 해당 로그에 적합한 학습 방법 선택

- 2) 비지도 학습 (라벨이 없는 경우)

  - K-Means : 라벨이 없는 데이터를 유사성 또는

    차이점에 따라 그룹화하는 기술

```
Adjusted Rand Index (ARI): 0.118
Homogeneity: 0.264
Completeness: 0.296
V-Measure: 0.279

Classification Report:
              precision    recall  f1-score   support

           0       0.55      1.00      0.71     10770
           1       1.00      0.47      0.64     16689

    accuracy                           0.68     27459
   macro avg       0.77      0.73      0.67     27459
weighted avg       0.82      0.68      0.67     27459
```


K-Means Clustering Visualization (2D PCA)
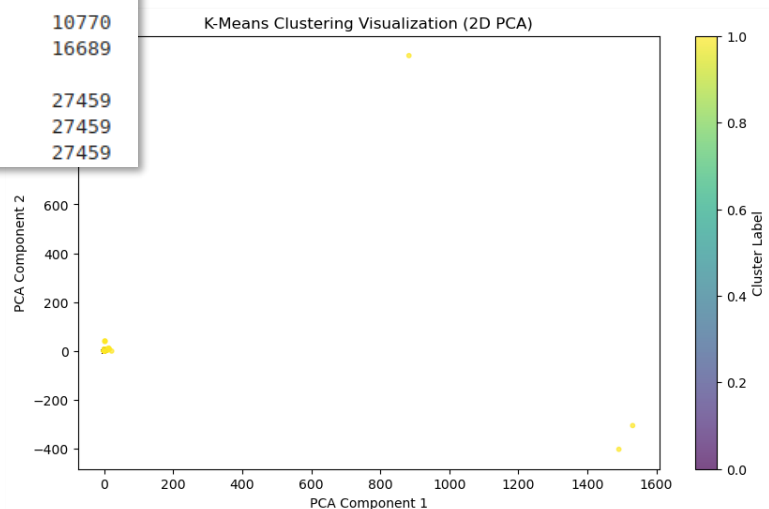
```python
import pandas as pd
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.cluster import KMeans
from sklearn.decomposition import PCA

# 1. 데이터 로드
file_path = 'data/logs.csv'  # CSV 파일 경로
data = pd.read_csv(file_path)

# 주요 열 확인
if 'Msg' not in data.columns:
    raise ValueError("CSV 파일에 'Msg' 열이 없습니다.")

# 2. 텍스트 데이터 준비
texts = data['Msg']   # 텍스트 데이터

# 3. TF-IDF 벡터화
vectorizer = TfidfVectorizer(max_features=5000)
X = vectorizer.fit_transform(texts).toarray()  # 벡터화된 데이터

# 4. K-Means 모델 학습
n_clusters = 2   # 클러스터 개수 설정
kmeans = KMeans(n_clusters=n_clusters, random_state=42, n_init=10)
kmeans.fit(X)
clusters = kmeans.labels_   # 클러스터 레이블

# 5. 실루엣 점수 평가
sil_score = silhouette_score(X, clusters)
print(f"Silhouette Score: {sil_score:.3f}")
```
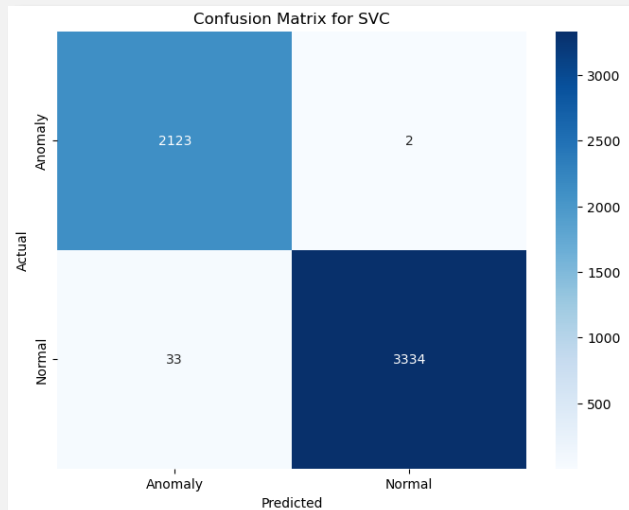
3. 모델 선택 및 학습

❖ 학습 결과 – 지도 학습 (SVM vs. Logistic Regression)

SVM

	precision	recall	f1-score	support
0	0.98	1.00	0.99	2125
1	1.00	0.99	0.99	3367
accuracy			0.99	5492
macro avg	0.99	0.99	0.99	5492
weighted avg	0.99	0.99	0.99	5492

Confusion Matrix for SVC

Logistic Regression

	precision	recall	f1-score	support
0	0.99	0.99	0.99	2125
1	0.99	1.00	0.99	3367
accuracy			0.99	5492
macro avg	0.99	0.99	0.99	5492
weighted avg	0.99	0.99	0.99	5492

Confusion Matrix for Logistic Regression
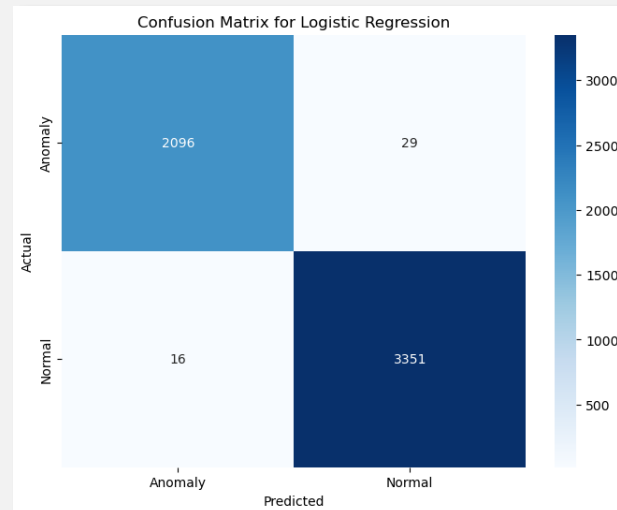
실제 Anomaly 로그를 놓칠 확률이 LR 모델보다 SVM 모델이 적음

[Confusion Matrix]
SVC's FP = 2 / LR's FP = 29

- Precision :
  0 / 1으로 예측할 때 얼마나 정확한지를 평가
- Recall :
  실제 데이터를 얼마나 잘 찾아냈는지를 평가
- F1-Score :
  Precision과 Recall 사이의 균형을 평가

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3. 모델 선택 및 학습

❖ 학습 결과 – 비지도 학습 (DBSCAN vs. K-Means)

DBSCAN

```
Adjusted Rand Index (ARI): 0.181
Homogeneity: 0.891
Completeness: 0.166
V-Measure: 0.280

Classification Report:
              precision    recall  f1-score   support

          0       0.99      0.95      0.97     10770
          1       0.97      0.99      0.98     16689

   accuracy                           0.98     27459
  macro avg       0.98      0.97      0.98     27459
weighted avg      0.98      0.98      0.98     27459
```
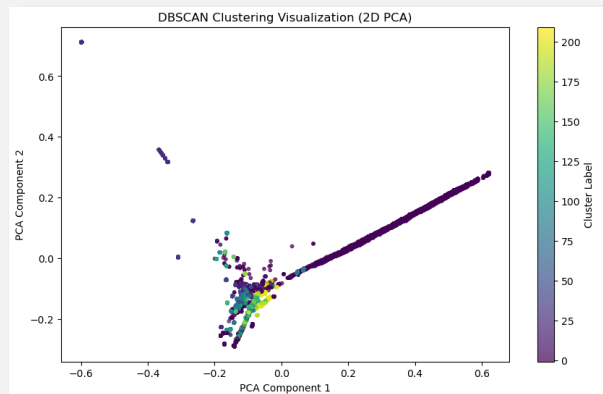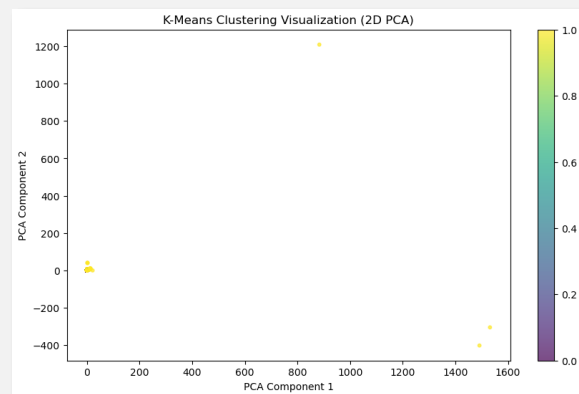

DBSCAN Clustering Visualization (2D PCA)

K-Means

```
Adjusted Rand Index (ARI): 0.118
Homogeneity: 0.264
Completeness: 0.296
V-Measure: 0.279

Classification Report:
              precision    recall  f1-score   support

          0       0.55      1.00      0.71     10770
          1       1.00      0.47      0.64     16689

   accuracy                           0.68     27459
  macro avg       0.77      0.73      0.67     27459
weighted avg      0.82      0.68      0.67     27459
```


K-Means Clustering Visualization (2D PCA)

> **전체적인 지표로는**
> **DBSCAN이 더 나은 성능을 보임**

- ARI :
  기존 레이블과 클러스터링 결과 간의 유사도
- Homogeneity :
  각 클러스터가 단일 클래스의 데이터만 포함하는지
- Completeness :
  같은 클래스의 모든 데이터가 동일한 클러스터에 포함되는지
- V-Measure :
  Homogeneity와 Completeness의 조화 평균

❖ '학습한 데이터 + 새로운 데이터' 를 통해 <u>에러 데이터 탐지가 제대로 이루어지는지 확인</u>

- 학습데이터 : 정적 + 동적 로그를 대상으로 테스트

    ⇒ 동적 에러 로그를 잘 탐지하는지 확인하는 것이 목표

```
INFO: [ NTPDate ] Initial NTP sync finished. Status:
Nov 01, 2024 8:23:11 AM alien.api.DispatchSSLClient checkIdleConnection
WARNING: Exception filling the values for resource_status / null
WARNING: Exception moving 87184252 to cgroup 1923
SEVERE: Problem in construction of ComputingElement:
SEVERE: Exception checking the identity: /home01/gsdc24a01/test/
INFO: Exception while waiting for release of CPU pinning lock
INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagent-4231-00039.sh
```

- 새로운 데이터 : 학습하지 않은 정상 + 에러 로그를 대상으로 테스트

    ⇒ 에러 로그에서 보이는 패턴을 잘 학습했는지 확인하는 것이 목표 (not, null, cannot, exception, unable ...)

```
INFO: We have jobs that might be optimised (TTL)
INFO: Printing client information:
INFO: Running JCentral with host cert:
WARNING: HTTP port is defined but not as a number for
WARNING: Exception accepting a client
WARNING: Cannot setSoTimeout for the initial communication
SEVERE: No TTL optimizations could be applied. Errors while parsing the entries.
SEVERE:Host certificate is not valid any more, please renew it and restart the service
INFO: Queue is not open! Check queueinfo
INFO: Did not shutdown gracefully
INFO: Can't instantiate JobOptimizer!
INFO: Can not instantiate JobOptimizer!
```

❖ **에러 로그 탐지 시스템 구조**

학습된 모델 / 모델별 TF-IDF

- dbscan_model.pkl
- dbscan_tfidf_vectorizer.pkl
- kmeans_model.pkl
- kmeans_tfidf_vectorizer.pkl
- lr_model.pkl
- lr_tfidf_vectorizer.pkl
- svc_model.pkl
- svc_tfidf_vectorizer.pkl

탐지할 로그 데이터

```
INFO: [ NTPDate ] Initial NTP sync finished. Status: 0
Nov 01, 2024 8:23:11 AM alien.api.DispatchSSLClient checkIdleConnection
WARNING: Exception filling the values for resource_status / null
WARNING: Exception moving 87184252 to cgroup 1923
SEVERE: Problem in construction of ComputingElement:
SEVERE: Exception checking the identity: /home01/gsdc24a01/test/
INFO: Exception while waiting for release of CPU pinning lock
INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-
log/2024-11-02/jobagent-4231-00039.sh
INFO: We have jobs that might be optimised (TTL)
INFO: Printing client information:
INFO: Running JCentral with host cert:
WARNING: HTTP port is defined but not as a number for
WARNING: Exception accepting a client
WARNING: Cannot setSoTimeout for the initial communication
SEVERE: No TTL optimizations could be applied. Errors while parsing the entries.
SEVERE:Host certificate is not valid any more, please renew it and restart the service
INFO: Queue is not open! Check queueinfo
INFO: Did not shutdown gracefully
INFO: Can't instantiate JobOptimizer!
INFO: Can not instantiate JobOptimizer!
```

탐지 시스템

```python
import joblib  # SVC 모델 로드

# 1. SVC 모델 및 TF-IDF 벡터화 로드
model_path = 'trained-model/svc_model.pkl'  # SVM 모델 경로
vectorizer_path = 'trained-model/svc_tfidf_vectorizer.pkl'  # TF-IDF 벡터화 모델 경로

svc_model = joblib.load(model_path)  # SVM 모델 로드
tfidf_vectorizer = joblib.load(vectorizer_path)  # TF-IDF 벡터화 모델 로드

# 2. 에러 로그 판단 함수
def predict_log(log_message):
    """
    주어진 로그 메시지가 에러 로그인지 판단.
    :param log_message: str, 로그 메시지
    :return: str, "Error Log" 또는 "Normal Log"
    """
    if not log_message.strip():
        return "Empty log message."

    # TF-IDF 변환
    transformed_message = tfidf_vectorizer.transform([log_message])

    # SVM 예측
    prediction = svc_model.predict(transformed_message)

    # 결과 반환
    return "Error Log" if prediction[0] == 0 else "Normal Log"

# 3. 입력 파일에서 로그 판단
def process_input_file(input_file):
    try:
        with open(input_file, 'r') as infile:
            lines = infile.readlines()
    except FileNotFoundError:
        print(f"Error: File '{input_file}' not found.")
        return

    results = []
    for idx, line in enumerate(lines, start=1):
        log_message = line.strip()
        if log_message:  # 빈 줄 무시
            prediction = predict_log(log_message)
            results.append((idx, log_message, prediction))

    # 결과 출력
    for idx, log_message, prediction in results:
        print(f"[Line {idx}] {log_message} \n >> {prediction}")

# 4. 실행
if __name__ == "__main__":
    input_file = 'data/logs-input.txt'  # 입력 파일 경로

    print("[Log Detection with SVC]")
    process_input_file(input_file)
```

Prediction
(SVM, Logistic Regression)

Clustering
(DBSCAN, K-Means)

"Normal Log"

"Error Log"

SVM

```
[Log Detection with SVC]
[Line 1] INFO: [ NTPDate ] Initial NTP sync finished. Status: 0
 >> Normal Log
[Line 2] Nov 01, 2024 8:23:11 AM alien.api.DispatchSSLClient checkIdleConnection
 >> Normal Log
[Line 3] WARNING: Exception filling the values for resource_status / null
 >> Error Log
[Line 4] WARNING: Exception moving 87184252 to cgroup 1923
 >> Error Log
[Line 5] SEVERE: Problem in construction of ComputingElement:
 >> Error Log
[Line 6] SEVERE: Exception checking the identity: /home01/gsdc24a01/test/
 >> Error Log
[Line 7] INFO: Exception while waiting for release of CPU pinning lock
 >> Error Log
[Line 8] INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagen
t-4231-00039.sh
 >> Error Log
[Line 9] INFO: We have jobs that might be optimised (TTL)
 >> Normal Log
[Line 10] INFO: Printing client information:
 >> Normal Log
[Line 11] INFO: Running JCentral with host cert:
 >> Normal Log
[Line 12] WARNING: HTTP port is defined but not as a number for
 >> Error Log
[Line 13] WARNING: Exception accepting a client
 >> Error Log
[Line 14] WARNING: Cannot setSoTimeout for the initial communication
 >> Error Log
[Line 15] SEVERE: No TTL optimizations could be applied. Errors while parsing the entries.
 >> Error Log
[Line 16] SEVERE:Host certificate is not valid any more, please renew it and restart the service
 >> Error Log
[Line 17] INFO: Queue is not open! Check queueinfo
 >> Error Log
[Line 18] INFO: Did not shutdown gracefully
 >> Error Log
[Line 19] INFO: Can't instantiate JobOptimizer!
 >> Normal Log
[Line 20] INFO: Can not instantiate JobOptimizer!
 >> Error Log
```

*Can't 가 포함된
로그를 학습하지
않아 발생한 문제로
보임*

Logistic Regression

```
[Log Detection with Logistic Regression]
[Line 1] INFO: [ NTPDate ] Initial NTP sync finished. Status: 0
 >> Normal Log
[Line 2] Nov 01, 2024 8:23:11 AM alien.api.DispatchSSLClient checkIdleConnection
 >> Normal Log
[Line 3] WARNING: Exception filling the values for resource_status / null
 >> Error Log
[Line 4] WARNING: Exception moving 87184252 to cgroup 1923
 >> Error Log
[Line 5] SEVERE: Problem in construction of ComputingElement:
 >> Error Log
[Line 6] SEVERE: Exception checking the identity: /home01/gsdc24a01/test/
 >> Error Log
[Line 7] INFO: Exception while waiting for release of CPU pinning lock
 >> Error Log
[Line 8] INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagen
t-4231-00039.sh
 >> Error Log
[Line 9] INFO: We have jobs that might be optimised (TTL)
 >> Normal Log
[Line 10] INFO: Printing client information:
 >> Normal Log
[Line 11] INFO: Running JCentral with host cert:
 >> Normal Log
[Line 12] WARNING: HTTP port is defined but not as a number for
 >> Error Log
[Line 13] WARNING: Exception accepting a client
 >> Error Log
[Line 14] WARNING: Cannot setSoTimeout for the initial communication
 >> Error Log
[Line 15] SEVERE: No TTL optimizations could be applied. Errors while parsing the entries.
 >> Error Log
[Line 16] SEVERE:Host certificate is not valid any more, please renew it and restart the service
 >> Error Log
[Line 17] INFO: Queue is not open! Check queueinfo
 >> Error Log
[Line 18] INFO: Did not shutdown gracefully
 >> Error Log
[Line 19] INFO: Can't instantiate JobOptimizer!
 >> Normal Log
[Line 20] INFO: Can not instantiate JobOptimizer!
 >> Error Log
```

4. 학습 모델 활용

DBSCAN	정상 로그도 에러 로그로 판단 (모델의 학습 상태가 나쁨)	K-Means	에러 로그를 정상 로그로 판단 (모델의 학습 상태가 나쁨)

```
[Log Detection with DBSCAN]
[Line 1] INFO: [ NTPDate ] Initial NTP sync finished. Status: 0
 >> Error Log
[Line 2] Nov 01, 2024 8:23:11 AM alien.api.DispatchSSLClient checkIdleConnection
 >> Error Log
[Line 3] WARNING: Exception filling the values for resource_status / null
 >> Error Log
[Line 4] WARNING: Exception moving 87184252 to cgroup 1923
 >> Error Log
[Line 5] SEVERE: Problem in construction of ComputingElement:
 >> Error Log
[Line 6] SEVERE: Exception checking the identity: /home01/gsdc24a01/test/
 >> Error Log
[Line 7] INFO: Exception while waiting for release of CPU pinning lock
 >> Error Log
[Line 8] INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagen
t-4231-00039.sh
 >> Error Log
[Line 9] INFO: We have jobs that might be optimised (TTL)
 >> Error Log
[Line 10] INFO: Printing client information:
 >> Error Log
[Line 11] INFO: Running JCentral with host cert:
 >> Error Log
[Line 12] WARNING: HTTP port is defined but not as a number for
 >> Error Log
[Line 13] WARNING: Exception accepting a client
 >> Error Log
[Line 14] WARNING: Cannot setSoTimeout for the initial communication
 >> Error Log
[Line 15] SEVERE: No TTL optimizations could be applied. Errors while parsing the entries.
 >> Error Log
[Line 16] SEVERE:Host certificate is not valid any more, please renew it and restart the service
 >> Error Log
[Line 17] INFO: Queue is not open! Check queueinfo
 >> Error Log
[Line 18] INFO: Did not shutdown gracefully
 >> Error Log
[Line 19] INFO: Can't instantiate JobOptimizer!
 >> Error Log
[Line 20] INFO: Can not instantiate JobOptimizer!
 >> Error Log
```
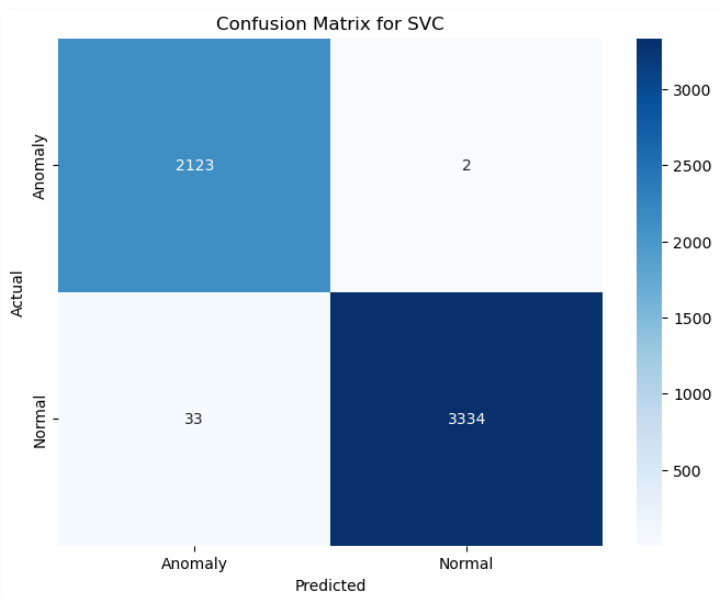
```
[Log Detection with K-Means]
[Line 1] INFO: [ NTPDate ] Initial NTP sync finished. Status: 0
 >> Normal Log
[Line 2] Nov 01, 2024 8:23:11 AM alien.api.DispatchSSLClient checkIdleConnection
 >> Error Log
[Line 3] WARNING: Exception filling the values for resource_status / null
 >> Normal Log
[Line 4] WARNING: Exception moving 87184252 to cgroup 1923
 >> Normal Log
[Line 5] SEVERE: Problem in construction of ComputingElement:
 >> Normal Log
[Line 6] SEVERE: Exception checking the identity: /home01/gsdc24a01/test/
 >> Normal Log
[Line 7] INFO: Exception while waiting for release of CPU pinning lock
 >> Normal Log
[Line 8] INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagen
t-4231-00039.sh
 >> Normal Log
[Line 9] INFO: We have jobs that might be optimised (TTL)
 >> Normal Log
[Line 10] INFO: Printing client information:
 >> Normal Log
[Line 11] INFO: Running JCentral with host cert:
 >> Normal Log
[Line 12] WARNING: HTTP port is defined but not as a number for
 >> Normal Log
[Line 13] WARNING: Exception accepting a client
 >> Normal Log
[Line 14] WARNING: Cannot setSoTimeout for the initial communication
 >> Normal Log
[Line 15] SEVERE: No TTL optimizations could be applied. Errors while parsing the entries.
 >> Normal Log
[Line 16] SEVERE:Host certificate is not valid any more, please renew it and restart the service
 >> Normal Log
[Line 17] INFO: Queue is not open! Check queueinfo
 >> Normal Log
[Line 18] INFO: Did not shutdown gracefully
 >> Normal Log
[Line 19] INFO: Can't instantiate JobOptimizer!
 >> Normal Log
[Line 20] INFO: Can not instantiate JobOptimizer!
 >> Normal Log
```

❖ 모델 학습 결과 + 새로운 데이터에 대한 에러 탐지 결과 ⇒ [Best] SVM

```
Classification Report:
              precision    recall  f1-score   support

           0       0.98      1.00      0.99      2125
           1       1.00      0.99      0.99      3367

    accuracy                           0.99      5492
   macro avg       0.99      0.99      0.99      5492
weighted avg       0.99      0.99      0.99      5492
```

Confusion Matrix for SVC


```
[Log Detection with SVC]
[Line 1] INFO: [ NTPDate ] Initial NTP sync finished. Status: 0
 >> Normal Log
[Line 2] Nov 01, 2024 8:23:11 AM alien.api.DispatchSSLClient checkIdleConnection
 >> Normal Log
[Line 3] WARNING: Exception filling the values for resource_status / null
 >> Error Log
[Line 4] WARNING: Exception moving 87184252 to cgroup 1923
 >> Error Log
[Line 5] SEVERE: Problem in construction of ComputingElement:
 >> Error Log
[Line 6] SEVERE: Exception checking the identity: /home01/gsdc24a01/test/
 >> Error Log
[Line 7] INFO: Exception while waiting for release of CPU pinning lock
 >> Error Log
[Line 8] INFO: Error creating Agent Startup file: /scratch/gsdc24a01/ALICE/alien-log/2024-11-02/jobagen
t-4231-00039.sh
 >> Error Log
[Line 9] INFO: We have jobs that might be optimised (TTL)
 >> Normal Log
[Line 10] INFO: Printing client information:
 >> Normal Log
[Line 11] INFO: Running JCentral with host cert:
 >> Normal Log
[Line 12] WARNING: HTTP port is defined but not as a number for
 >> Error Log
[Line 13] WARNING: Exception accepting a client
 >> Error Log
[Line 14] WARNING: Cannot setSoTimeout for the initial communication
 >> Error Log
[Line 15] SEVERE: No TTL optimizations could be applied. Errors while parsing the entries.
 >> Error Log
[Line 16] SEVERE:Host certificate is not valid any more, please renew it and restart the service
 >> Error Log
[Line 17] INFO: Queue is not open! Check queueinfo
 >> Error Log
[Line 18] INFO: Did not shutdown gracefully
 >> Error Log
[Line 19] INFO: Can't instantiate JobOptimizer!
 >> Normal Log
[Line 20] INFO: Can not instantiate JobOptimizer!
 >> Error Log
```