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Specialization: Information Systems
MASTER THESIS

Development of a web-interface and web service API to support process mining techniques.

Ilias Merkoureas
Mcse19006

Supervisor:
Dr Georgios Miaoulis, Professor

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Examination Committee:

Georgios Miaoulis, Professor
Nikolaos Vasilas, Professor
Athanasios Voulodimos, Assistant Professor

Examination Date 09/04/2021

Georgios Miaoulis
Digitally signed by Georgios Miaoulis
DN: c=GR, l=Athens, o=University of West Attica, ou=Class B - Private Key created and stored in software CSP, sn=Miaoulis, givenName=Georgios, serialNumber=3179983822, cn=Georgios Miaoulis, email=gmiaoul@uniwa.gr
Date: 2021.04.15 21:48:48 +03'00'

Nikolaos Vasilas
Digitally signed by Nikolaos Vasilas
Date: 2021.04.17 23:08:05 +03'00'

Athanasios Voulodimos
Digitally signed by Athanasios Voulodimos
Date: 2021.04.16 02:30:56 +03'00'

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Violation of my above academic responsibility is an essential reason for the revocation of my degree».
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The Declarant

SPECIAL THANKS

This master thesis was completed after persistent efforts, in an interesting subject, such as process mining. This effort was supported by my supervising teacher, whom I would like to thank.

I would also like to thank Mrs. Georgia Theodoropoulou for her valuable advice.

ABSTRACT

This master thesis deals with the development of a web service application (web API) which will use the functions of process mining that have already been implemented in python with library pm4py. A web interface was also developed which calls with http requests the web service in which the user can apply process mining techniques online. In this environment there is the possibility of selecting event logs and applying multiple process automatic retrieval algorithms by selecting various parameters based on the algorithm. The interface allows the user to select parameters for the corresponding procedures.

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CHAPTER 1

Introduction

1.1 Introduction

The field of process mining provides tools and techniques to increase the overall knowledge of a (business) process, by means of analyzing the event data stored during the execution of the process. Process mining received a lot of attention from both academia and industry, which led to the development of several commercial and open-source process mining tools. The majority of these tools supports process discovery, i.e., discovering a process model that accurately describes the process under study, as captured within the analyzed event data. However, process mining also comprises conformance checking, i.e., checking to what degree a given process model is accurately describing event data, and process enhancement, i.e., techniques that enhance process models by projecting interesting information, e.g., case flow and/or performance measures, on top of a model. The support of such types of process mining analysis is typically limited to open source, academic process mining tools such as the ProM Framework, Apromore, Disco, Celonis and others [1].

The purpose of this master thesis was to develop a system in order to help a user to apply process mining techniques online. There are already systems that serve this need offline. This system is implemented in two levels:

- the level of the API, which helps the user to receive data after data mining techniques so he can view or analyze them in his own way
- the level of the web, at which the user can use it from any device he wants and doesn't need to have a system on his computer

Both the API and the interface provide the user data such as the events, the start events and the end events and how many times they appear in the file (in absolute value and as a percentage), the transitions and places in order to construct a petri net, conformance checking results and evaluation data (log fitness, precision, generalization, simplicity). Also, the project provides functions to help the users view and convert the file they want to use.

Finally, this master thesis deals with the user's need to change the petri net that the process mining techniques produce. This thesis website does not provide a static image of a petri net, but an html element of the petri net to help the user zoom in/out and also to give him the ability of drag every transition and place so he can get a clear result of the process discovery.

1.2 Theoretical Background

1.2.1 XES Standard

The XES standard defines a grammar for a tag-based language whose aim is to provide designers of information systems with a unified and extensible methodology for capturing systems behaviors by means of event logs and event streams is defined in the XES standard. An XML Schema describing the structure of an XES event log/stream and a XML Schema describing the structure of an extension of such a log/stream are included in this standard. Moreover, a basic collection of so-called XES extension prototypes that provide semantics to certain attributes as recorded in the event log/stream is included in this standard [2].

Several formats have been proposed during the years for the standard storage of event logs in process mining. The IEEE standard is XES, for which different implementations exist in the ProM6 process mining framework. Among noticeable implementations, we can cite XES Lite, that provides a memory-efficient handling of event logs, while supports the XES standard on relational databases, albeit with a performance deficit, and DBXES that use relational databases to support some intermediate calculations. OpyenXES took XES in an open-source Python implementation and the PM4Py Python process mining library followed obtaining a full certification [3].

1.2.2 Event Logs

We assume the existence of an event log where each event refers to a case, an activity, and a point in time. An event log can be seen as a collection of cases. A case can be seen as a trace/sequence of events.

Event data may come from

- a database system (e.g., patient data in a hospital),
- a comma-separated values (CSV) file or spreadsheet,
- a transaction log (e.g., a trading system),
- a business suite/ERP system (SAP, Oracle, etc.),
- a message log (e.g., from IBM middleware),
- an open API providing data from websites or social media and others [4]

Events are listed together with their attributes in an event log. Attributes that are typically listed are the case ID, the time stamps of the start and end times, and other attributes of the event recorded by the IT system. An event log can also be the documentation of several related business processes [5].

1.2.3 Process Mining for Python (PM4PY)

Pm4py provides a process mining software which is easily extendable, allows for algorithmic customization and allows user to easily conduct large scale experiments.

The data science world, both for classic data science and for cutting-edge machine learning research is heavily using Python. Other libraries, albeit with a lower number of features, exist already for the Python language. The bupaR library supports process mining in the statistical language R, that is widely used in data science. The main focal points of the novel PM4Py library are:

- Lowering the barrier for algorithmic development and customization when performing a process mining analysis compared to existing academic tools such as ProM, RAPIdProM and Apromore.
- Allow for the easy integration of process mining algorithms with algorithms from other data science fields, implemented in various state-of-the-art Python packages.
- Create a collaborative eco-system that easily allows researchers and practitioners to share valuable code and results with the process mining world.
- Provide accurate user-support by means of a rich body of documentation on the process mining techniques made available in the library.
- Algorithmic stability by means of rigorous testing. [1]

1.2.4 Architecture and features

In order to maximize the possibility to understand and re-use the code, and to be able to execute large-scale experiments, the following architectural guidelines have been adopted on the development of PM4Py:

- A strict separation between objects, algorithms (Alpha Miner, Inductive Miner, alignments) and visualizations in different packages. In the pm4py.object package, classes to import/export and to store the information related to the objects are provided, along with some utilities to convert objects (e.g. process trees into Petri nets); while in the pm4py.algo package, algorithms to discover, perform conformance checking, enhancement and evaluation are provided. All visualizations of objects are provided in the pm4py.visualization package.
- Most functionality in PM4Py has been realized through factory methods. These factory methods provide a single access point for each algorithm, with a standardized set of input objects, e.g., event data and a parameters object. Consider the factory method of the Alpha Miner. Factory methods allow for the extension of existing algorithms whilst ensuring backward-compatibility. The factory methods typically accept the name of the variant

of the algorithm to use, and some parameters (shared among variants, or variant-specific). [1]

1.2.5 Object management

Within process mining, the main source of data are event data, often referred to as an event log. Such an event log, represents a collection of events, describing what activities have been performed for different instances of the process under study. PM4Py provides support for different types of event data structures:

- Event logs, i.e., representing a list of traces. Each trace, in turn, is a list of events. The events are structured as key-value maps.
- Event Streams representing one list of events (again represented as key-value maps) that are not (yet) organized in cases.

Conversion utilities are provided to convert event data objects from one format to the other. Furthermore, PM4Py supports the use of pandas data frames, which are efficient in case of using larger event data. Other objects currently supported by PM4Py include: heuristic nets, accepting Petri nets, process trees and transition systems. [1]

1.2.6 Algorithms

The PM4Py library provides several mainstream process mining techniques, including:

- Process discovery: Alpha (+) Miner and Inductive Miner.
- Conformance Checking: Token-based replay and alignments.
- Measurement of fitness, precision, generalization and simplicity of process models.
- Filtering based on time-frame, case performance, trace endpoints, trace variants, attributes, and paths.
- Case management: statistics on variants and cases.
- Graphs: case duration, events per time, distribution of a numeric attribute’s values.
- Social Network Analysis: handover of work, working together, subcontracting and similar activities networks.[1]

1.3 Process Discovery

Process Discovery algorithms want to find a suitable process model that describes the order of events/activities that are executed during a process execution. [6]

1.3.1 Alpha Miner

The alpha miner is one of the most known Process Discovery algorithm and is able to find:

- A Petri net model where all the transitions are visible and unique and correspond to classified events (for example, to activities).
- An initial marking that describes the status of the Petri net model when a execution starts.
- A final marking that describes the status of the Petri net model when a execution ends.

Although this algorithm has the following disadvantage:

- Cannot handle loops of length one and length two
- Invisible and duplicated tasks cannot be discovered
- Discovered model might not be sound
- Weak against noise [6]

1.3.2 Inductive Miner

The basic idea of Inductive Miner is about detecting a 'cut' in the log (e.g. sequential cut, parallel cut, concurrent cut and loop cut) and then recur on sublogs, which were found applying the cut, until a base case is found. The Directly-Follows variant avoids the recursion on the sublogs but uses the Directly Follows graph.

Inductive miner models usually make extensive use of hidden transitions, especially for skipping/looping on a portion on the model. Furthermore, each visible transition has a unique label (there are no transitions in the model that share the same label).

Two process models can be derived: Petri Net and Process Tree.

Some advantages of this algorithm are:

- Can handle invisible tasks
- Model is sound
- Most used process mining algorithm [6]

1.3.3 Heuristic Miner

Heuristics Miner is an algorithm that acts on the Directly-Follows Graph, providing way to handle with noise and to find common constructs (dependency between two activities, AND). The output of the Heuristics Miner is a Heuristics Net, so an object that contains the activities and the relationships between them. The Heuristics Net can be then converted into a Petri net.

It is possible to obtain a Heuristic Net and a Petri Net.

To apply the Heuristics Miner to discover a Heuristics Net, it is necessary to import a log. Then, a Heuristic Net can be found. There are also numerous possible parameters that can be inspected by clicking on the following button.

In addition, this algorithm takes frequency into account, detects short loops but does not guarantee a sound model.[6]

1.4 Conformance checking

Conformance checking is a technique to compare a process model with an event log of the same process. The goal is to check if the event log conforms to the model, and, vice versa.

In PM4Py, two fundamental techniques are implemented: token-based replay and alignments. [6]

1.4.1 Token-based replay

Token-based replay matches a trace and a Petri net model, starting from the initial place, in order to discover which transitions are executed and in which places we have remaining or missing tokens for the given process instance. Token-based replay is useful for Conformance Checking: indeed, a trace is fitting according to the model if, during its execution, the transitions can be fired without the need to insert any missing token. If the reaching of the final marking is imposed, then a trace is fitting if it reaches the final marking without any missing or remaining tokens.

In PM4Py there is an implementation of a token that is able to go across hidden transitions (calculating shortest paths between places) and can be used with any Petri net model with unique visible transitions and hidden transitions. When a visible transition needs to be fired and not all places in the preset are provided with the correct number of tokens, starting from the current marking it is checked if for some place there is a sequence of hidden transitions that could be

fired in order to enable the visible transition. The hidden transitions are then fired and a marking that permits to enable the visible transition is reached.

First, the log is loaded. Then, the Alpha Miner is applied in order to discover a Petri net. Eventually, the token-based replay is applied. The output of the token-based replay, stored in the variable **replayed_traces**, contains for each trace of the log:

- **trace_is_fit**: boolean value (True/False) that is true when the trace is according to the model.
- **activated_transitions**: list of transitions activated in the model by the token-based replay.
- **reached_marking**: marking reached at the end of the replay.
- **missing_tokens**: number of missing tokens.
- **consumed_tokens**: number of consumed tokens.
- **remaining_tokens**: number of remaining tokens.
- **produced_tokens**: number of produced tokens.

The token-based replay supports different parameters.

1.4.2 Alignments

Alignment-based replay aims to find one of the best alignment between the trace and the model. For each trace, the output of an alignment is a list of couples where the first element is an event (of the trace) or » and the second element is a transition (of the model) or ». For each couple, the following classification could be provided:

- Sync move: the classification of the event corresponds to the transition label; in this case, both the trace and the model advance in the same way during the replay.
- Move on log: for couples where the second element is », it corresponds to a replay move in the trace that is not mimicked in the model. This kind of move is unfit and signal a deviation between the trace and the model.
- Move on model: for couples where the first element is », it corresponds to a replay move in the model that is not mimicked in the trace. For moves on model, we can have the following distinction:
    - Moves on model involving hidden transitions: in this case, even if it is not a sync move, the move is fit.
    - Moves on model not involving hidden transitions: in this case, the move is unfit and signals a deviation between the trace and the model.

First, we have to import the log. Subsequently, we apply the Inductive Miner on the imported log. In addition, we compute the alignments.

With each trace, a dictionary containing among the others the following information is associated:

- **alignment**: contains the alignment (sync moves, moves on log, moves on model)
- **cost**: contains the cost of the alignment according to the provided cost function
- **fitness**: is equal to 1 if the trace is perfectly fitting

Then, a process model is computed, and alignments are also calculated. Besides, the fitness value is calculated and the resulting values are printed.

1.5 Evaluation

In PM4Py, it is possible to compare the behavior contained in the log and the behavior contained in the model, in order to see if and how they match. Four different dimensions exist in process mining, including the measurement of replay fitness, the measurement of precision, the measurement of generalization, the measurement of simplicity.[6]

1.5.1 Replay Fitness

The quality dimension of replay fitness describes the fraction of the behavior in the event log that can be replayed by the process model. Several different measures exist for this quality dimension. Some measures consider traces of behavior as whole, checking if the whole trace can be replayed by the process model. Other measures consider the more detailed level of events within a trace and try to get a more fine-grained idea of where the deviations are. Another important difference between existing measures is that some enforce a process model to be in an accepted end state when the whole trace is replayed. Others ignore this and allow the process model to remain in an active state when the trace ends. The most recent and robust technique uses a cost-based alignment between the traces in the event log and the most optimal execution of the process model. This allows for more flexibility and distinction between more and less important activities by changing the costs [7].

1.5.2 Precision

Precision is estimated by confronting model and log behavior: imprecisions between the model and the log (i.e., situations where the model allows more behavior than the one reflected in the log) are detected by juxtaposing behavior allowed by the log and the one allowed by the model. This juxtaposition is done in

terms of an automaton: first, an automaton is built from the alignments. Then, the automaton is enhanced with behavioral information of the model. Finally, the enhanced automaton is used to compute the precision [8].

1.5.3 Generalization

Replay fitness and precision only consider the relationship between the event log and the process model. However, the event log only contains a part of all the possible behavior that is allowed by the system. Generalization therefore should indicate if the process model is not “overfit-ting” to the behavior seen in the event log and describes the actual system. Another explanation for generalization is the likelihood that the process model is able to describe yet unseen behavior of the observed system. To date only few measures for generalization exist [7].

1.5.4 Simplicity

The simplicity dimension evaluates how simple the process model is to understand for a human. This dimension is therefore not directly related to the observed behavior but can consider the process model solitarily. Since there are different ways to describe the same behavior using different process models, choosing the simplest one is obviously best. This is also expressed by Occam’s razor: “one should not increase, beyond what is necessary, the number of entities required to explain anything”. However, sometimes a complex process model can only be simplified by changing the behavior, hence influencing the other quality dimensions. Several measures exist to measure how simple a process model is, for an overview we refer to. However, research has also shown that size is the main complexity indicator [7].

CHAPTER 2

APPLICATION PROGRAMMING INTERFACE

2.1 API Definition

API stands for Application Programming Interface. A Web API is an application programming interface for the Web. A Browser API can extend the functionality of a web browser. A Server API can extend the functionality of a web server [9].

2.2 REST

The REST architecture was introduced in the year 2000, by Thomas Fielding, and is based on the principles that support the World Wide Web. In summary, according to the REST principles, REST interfaces rely exclusively on Uniform Resource Identifiers (URI) for resource detection and interaction, and usually on the Hypertext Trans-fer Protocol (HTTP) for message transfer. A REST service URI only provides location and name of the resource, which serves as a unique resource identifier. The predefined HTTP verbs are used to define the type of operation that should be performed on the selected resource (e.g., GET to retrieve, DELETE to remove a resource).

Possibly due to HTTP's features (which fit the REST architecture rather well), long-term presence, and general understandability, REST has become a de facto standard way for offering a service on the Web. Despite this, REST is merely an architectural style, provided without standard specifications. This implies that several decisions have to be made by developers when exposing service APIs, which may result in diverse APIs and, in some cases, in poor design decisions (e.g., using a single HTTP verb for retrieving or deleting a resource) [10].

2.3 Project's API

For this project an API was developed so the user can get various data such as petri nets, event dictionaries and others on his browser with a GET method and also return this data to a website with a POST method. This master thesis API was developed in python because it is a powerful language for data analysis and provides many ready-made and useful libraries. For the development of this API flask was used (https://flask.palletsprojects.com/en/1.1.x/).

Flask is a micro web framework written in Python. It is classified as a microframework because it does not require particular tools or libraries. It has no database abstraction layer, form validation, or any other components where pre-existing third-party libraries provide common functions. However, Flask supports extensions that can add application features as if they were implemented in Flask itself. Extensions exist for object-relational mappers, form validation, upload handling, various open authentication technologies and several common framework related tools [11].

When we run flask web application with the command python API.py. A local IP address is return. In this case it is http://127.0.0.1:5000/. This IP is our endpoint. We can call this endpoint with two ways POST and GET.

Below there is an example of output when a user starts the API:

```
 * Serving Flask app "api" (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deployment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Restarting with windowsapi reloader
 * Debugger is active!
 * Debugger PIN: 282-941-890
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

Bellow there is a UML example of Web Interface communication with the API and a diagram for the web Interface.

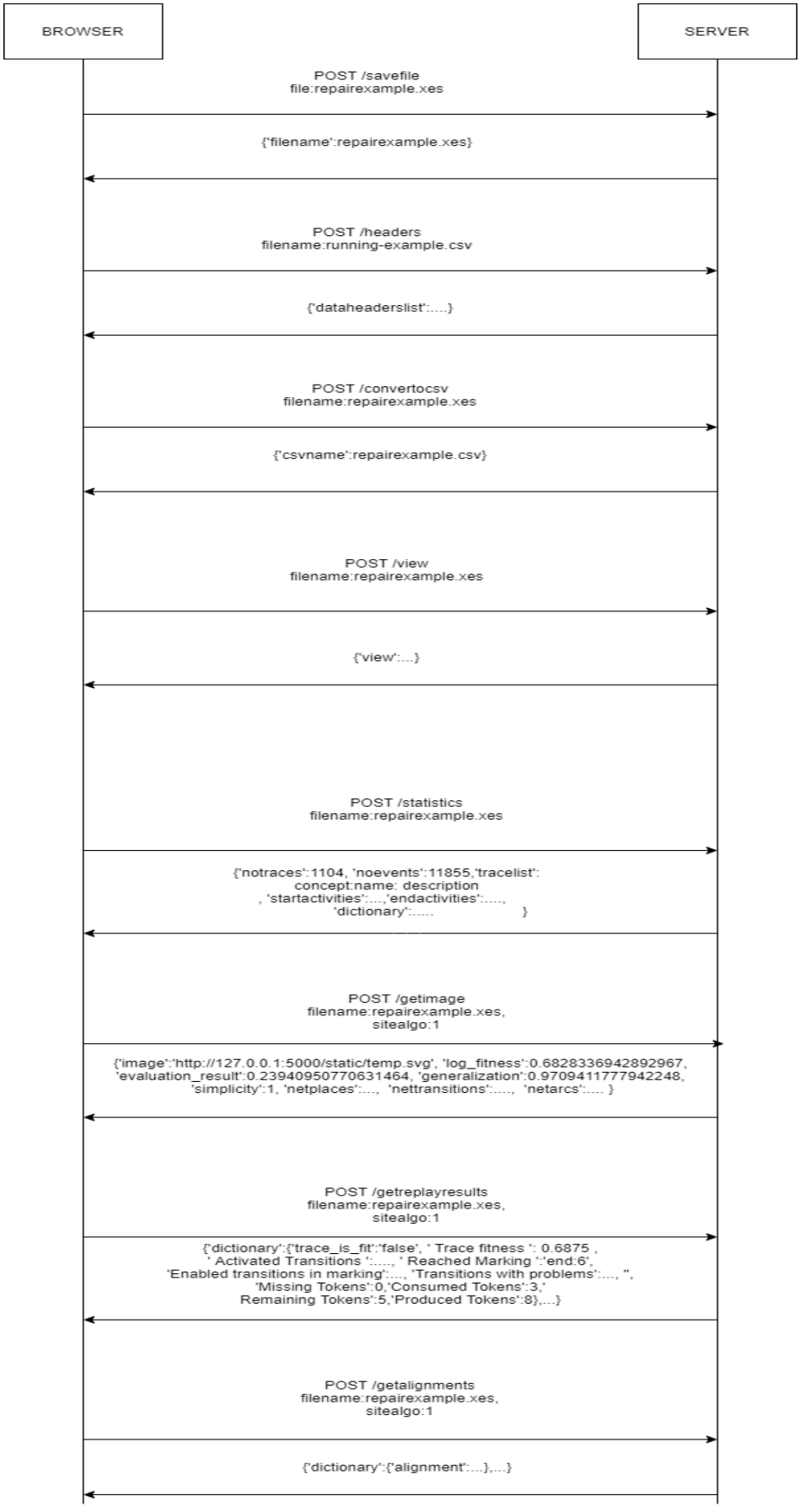


Image 2.1: Browser Server Communication

And an image with the architecture of the system.

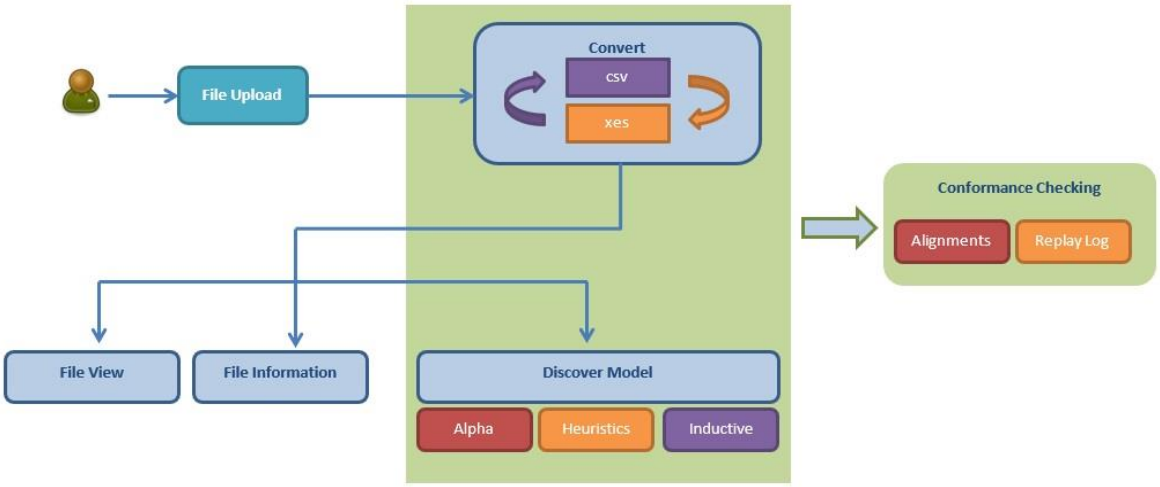


Image 2.2: System Architecture

Next, I'll display some examples of this thesis endpoint.

2.3.1.1 Convert xes files to csv

The user can convert his uploaded .xes files to .csv, on the server side of this application. The user has to call the endpoint: http://127.0.0.1:5000/convertocsv?filename=(name_of_file).xes.

With the help of Swagger Inspector [13] below there is a definition of the specific endpoint of the API:

```
get:
    description: Auto generated using Swagger Inspector
    parameters:
      - name: filename
        in: query
        schema:
          type: string
        example: repairexample.xes
    responses:
```

```
'200':
  description: Auto generated using Swagger Inspector
  content:
    application/json:
      schema:
        type: object
        properties: {}
      examples:
        '0':
          value: |
            [
              {
                "csvname": "repairexample.csv"
              }
            ]
```

2.3.1.2 Convert csv files to xes

The user can convert his uploaded .csv files to xes, on the server side of this application. The user has to call the endpoint: http://127.0.0.1:5000/convertocsv?filename=(name_of_file).csv&seperator=(csv_column_separtor)&caseconcept=(the_column to rename)&conceptname=(the_column to rename)&timestamp=(the_column to rename)&startevent=(the_column to rename)

```
get:
  description: Auto generated using Swagger Inspector
  parameters:
    - name: caseconcept
      in: query
      schema:
        type: string
      example: Case%20ID
    - name: filename
      in: query
      schema:
        type: string
      example: running-example.csv
    - name: startevent
      in: query
```

```
      schema:
        type: string
      example: Costs
    - name: conceptname
      in: query
      schema:
        type: string
      example: Activity
    - name: seperator
      in: query
      schema:
        type: string
      example: ;
    - name: timestamp
      in: query
      schema:
        type: string
      example: 'dd-MM-yyyy:HH.mm'
responses:
    '200':
      description: Auto generated using Swagger Inspector
      content:
        application/json:
          schema:
            type: object
            properties: {}
          examples:
            '0':
              value: |
                [
                  {
                    "xesname": "running-example.xes"
                  }
                ]
```

2.3.2.1 View xes file content

The user can view the content of his uploaded .xes file. The user has to call the endpoint: http://127.0.0.1:5000/view?filename=(name_of_file).csv.

The following screenshot is an example with the contents of running-example.xes file.

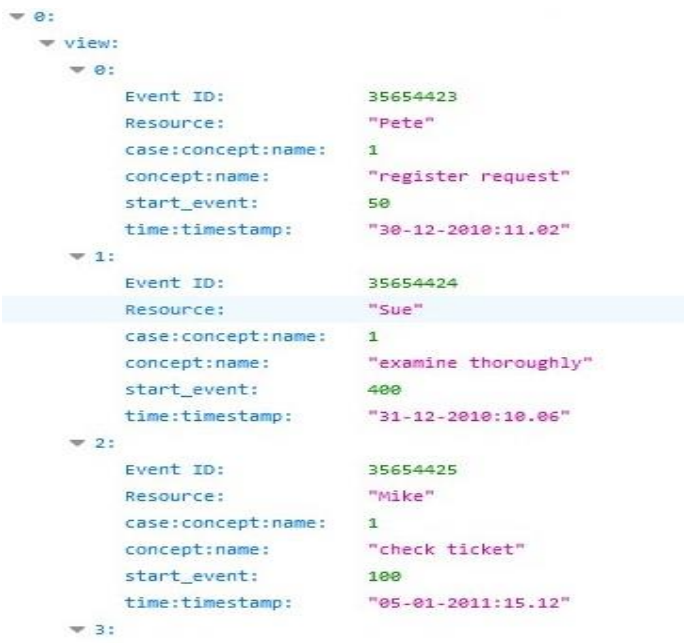


Image 2.3: Xes File Contents

```
get:
    description: Auto generated using Swagger Inspector
    parameters:
      - name: filename
        in: query
        schema:
          type: string
        example: repairexample.xes
```

2.3.2.2 View csv file content

The user can view the content of his uploaded .csv file. The user has to call the endpoint:

http://127.0.0.1:5000/viewcsv?filename=(name_of_file).csv&seperator=(insert_string).

The following screenshot is an example with the contents of running-example.csv file.

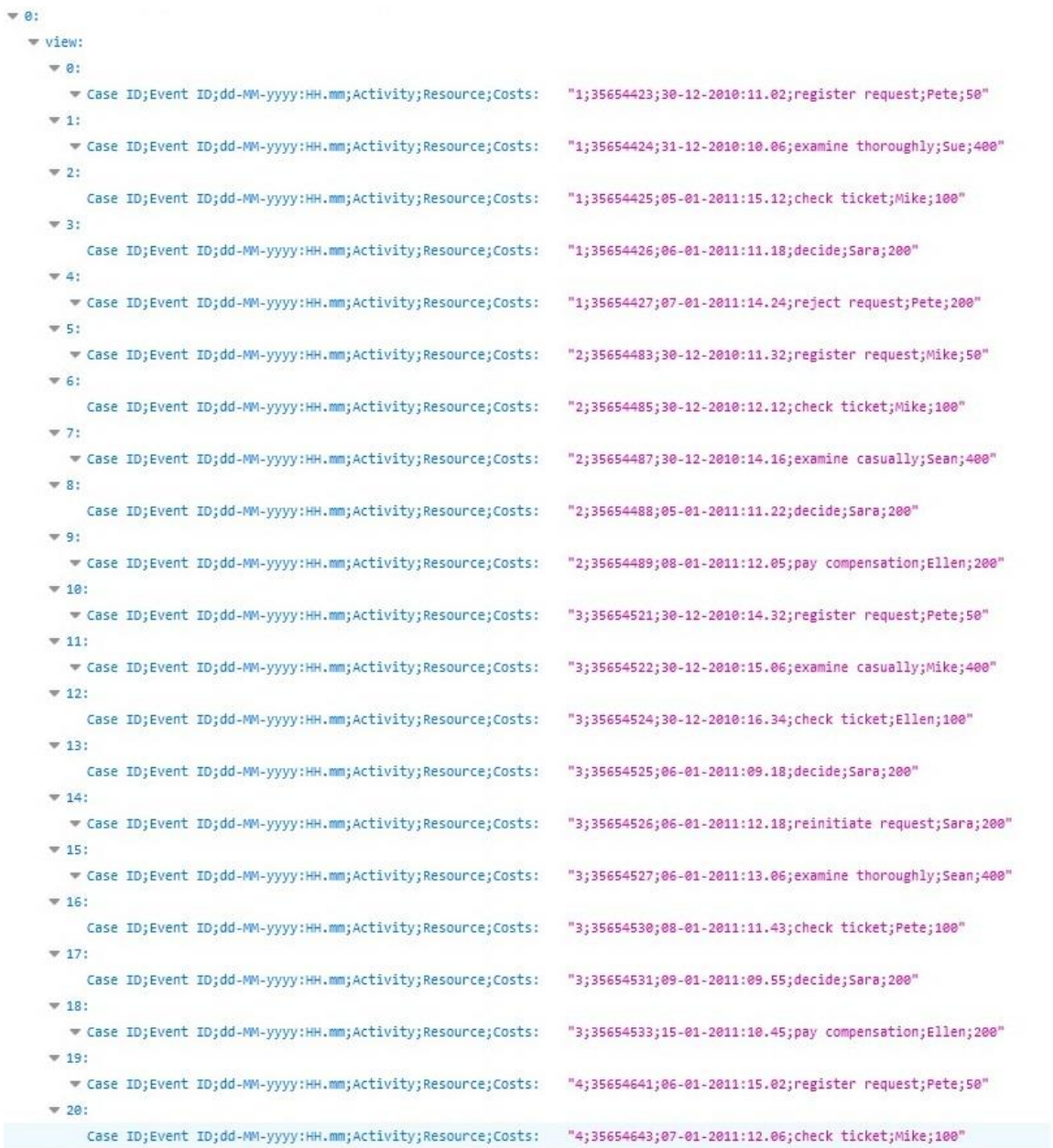


Image 2.4: Csv File Contents

```
get:
  description: Auto generated using Swagger Inspector
  parameters:
   - name: caseconcept
     in: query
     schema:
       type: string
     example: Case%20ID
   - name: filename
     in: query
     schema:
       type: string
     example: running-example.csv
   - name: startevent
     in: query
     schema:
       type: string
     example: Costs
   - name: conceptname
     in: query
     schema:
       type: string
     example: Activity
   - name: seperator
     in: query
     schema:
       type: string
     example: ;
   - name: timestamp
     in: query
     schema:
       type: string
     example: 'dd-MM-yyyy:HH.mm'
```

2.3.3.1 View information of xes file

The user can view the content of his uploaded .xes file. The user has to call the endpoint:

http://127.0.0.1:5000/statistics?filename=(name_of_file).xes.

The following screenshot is an example with the contents of repair-example.csv file.

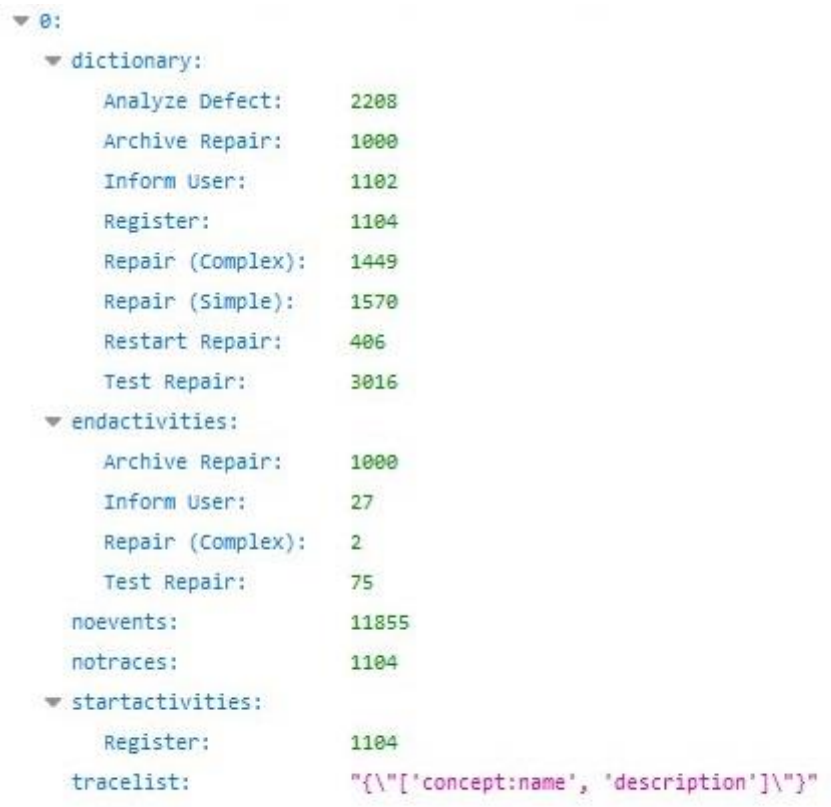


Image 2.5: Xes File Statistics

Dictionary key has value all the activities. Activities key has value all the end activities. Start activities key has value all the start activities. Noevents key has value the number of all the events. Notraces key has value the number of traces.

```
get:
 description: Auto generated using Swagger Inspector
 parameters:
  - name: filename
    in: query
    schema:
      type: string
    example: repairexample.xes
 responses:
  '200':
```

```
description: Auto generated using Swagger Inspector
content:
  application/json:
    schema:
      type: object
      properties: {}
    examples:
      '0':
        value: |
          [
            {
              "dictionary": {
                "Analyze Defect": 2208,
                "Archive Repair": 1000,
                "Inform User": 1102,
                "Register": 1104,
                "Repair (Complex)": 1449,
                "Repair (Simple)": 1570,
                "Restart Repair": 406,
                "Test Repair": 3016
              },
              "endactivities": {
                "Archive Repair": 1000,
                "Inform User": 27,
                "Repair (Complex)": 2,
                "Test Repair": 75
              },
              "noevents": 11855,
              "notraces": 1104,
              "startactivities": {
                "Register": 1104
              },
              "tracelist": "{\"['concept:name', 'description']\"}"
            }
          ]
```

2.3.3.2 View information of csv file

The user can view the content of his uploaded .csv file. The user has to call the endpoint:

http://127.0.0.1:5000/csvstatistics?filename=(name_of_file).csv&seperator=(csv_column_separtor)&caseconcept=(the_column to rename)&conceptname=(the_column to rename)&timestamp=(the_column to rename)&startevent=(the_column to rename).

The following screenshot is an example with the contents of repair-example.csv file.

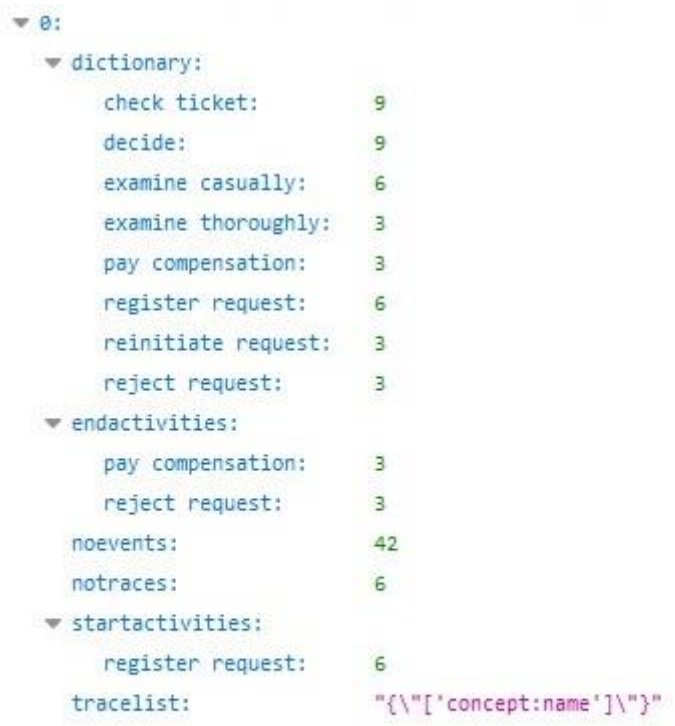


Image 2.6: Csv File Statistics

Test scenarios

get:

description: Auto generated using Swagger Inspector

parameters:

```
  - name: caseconcept
    in: query
    schema:
      type: string
    example: Case%20ID
  - name: filename
    in: query
    schema:
      type: string
    example: running-example.csv
  - name: startevent
    in: query
    schema:
      type: string
    example: Costs
  - name: conceptname
    in: query
    schema:
      type: string
    example: Activity
  - name: seperator
    in: query
    schema:
      type: string
    example: ;
  - name: timestamp
    in: query
    schema:
      type: string
    example: 'dd-MM-yyyy:HH.mm'
responses:
  '200':
    description: Auto generated using Swagger Inspector
    content:
      application/json:
        schema:
          type: object
          properties: {}
        examples:
          '0':
```

```
value: |
 [
  {
   "dictionary": {
    "check ticket": 9,
    "decide": 9,
    "examine casually": 6,
    "examine thoroughly": 3,
    "pay compensation": 3,
    "register request": 6,
    "reinitiate request": 3,
    "reject request": 3
   },
   "endactivities": {
    "pay compensation": 3,
    "reject request": 3
   },
   "noevents": 42,
   "notraces": 6,
   "startactivities": {
    "register request": 6
   },
   "tracelist": "{\"['concept:name']\"}"
  }
 ]
```

2.3.4.1 Discovery Algorithms for xes files

The web API is using the same endpoint for all three of algorithms (Alpha, Heuristics, Inductive Miner). Although, you should provide different parameters for each algorithm. For the Alpha Miner algorithm, the user has to call the endpoint:

http://127.0.0.1:5000/getimage?filename=(name_of_xesfile)&algorithm=1


```
▼ 0:
    evaluation_result:    0.23940950770631464
    generalization:       0.9709411777942248
    image:                "http://127.0.0.1:5000/static/temp.svg"
    log_fitness:          0.6828336942892967
  ▼ netarcs:
      0:                  "(t)Archive Repair->(p)end"
      1:                  "(p)start->(t)Register"
      2:                  "(t)Inform User->(p)end"
      3:                  "(t)Repair (Complex)->(p)end"
    ▼ 4:                  "(t)Inform User->(p)({'Inform User'}, {'Archive Repair'})"
      5:                  "(t)Test Repair->(p)end"
    ▼ 6:                  "(p)({'Inform User'}, {'Archive Repair'})->(t)Archive Repair
  ▼ netplaces:
      0:                  "end"
      1:                  "({'Inform User'}, {'Archive Repair'})"
      2:                  "start"
  ▼ nettransitions:
      0:                  "Analyze Defect"
      1:                  "Restart Repair"
      2:                  "Test Repair"
      3:                  "Repair (Complex)"
      4:                  "Repair (Simple)"
      5:                  "Inform User"
      6:                  "Register"
      7:                  "Archive Repair"
    simplicity:           1
```


Image 2.7: API Alpha Miner

For the Inductive Miner algorithm, the user has to call the endpoint:

http://127.0.0.1:5000/getimage?filename=(name_of_xesfile)&algorithm=2


```
▼ 0:
    evaluation_result:    0.3709219143576826
    generalization:       0.8939312853835611
    image:                "http://127.0.0.1:5000/static/temp.svg"
    log_fitness:          1
  ▼ netarcs:
      0:                  "(p)p_14->(t)tauJoin_6"
      1:                  "(t)Test Repair->(p)p_20"
      2:                  "(t)skip_20->(p)p_13"
      3:                  "(t)skip_17->(p)p_16"
      4:                  "(p)p_5->(t)Analyze Defect"
      5:                  "(t)init_loop_10->(p)p_15"
      6:                  "(p)p_18->(t)Restart Repair"
      7:                  "(t)Analyze Defect->(p)p_6"
      8:                  "(p)p_20->(t)skip_15"
      9:                  "(p)p_10->(t)tauJoin_6"
      10:                 "(t)Restart Repair->(p)p_16"
      11:                 "(p)p_13->(t)init_loop_10"
      12:                 "(t)skip_7->(p)p_10"
      13:                 "(p)p_15->(t)Repair (Complex)"
      14:                 "(p)p_6->(t)skip_3"
      15:                 "(t)Repair (Complex)->(p)p_17"
      16:                 "(p)p_20->(t)skip_16"
      17:                 "(p)p_8->(t)skip_22"
      18:                 "(p)p_9->(t)Inform User"
      19:                 "(t)skip_12->(p)p_18"
      20:                 "(t)init_loop_13->(p)p_19"
      21:                 "(t)skip_3->(p)p_5"
      22:                 "(p)p_9->(t)skip_7"
      23:                 "(p)p_16->(t)skip_18"
      24:                 "(p)p_6->(t)skip_4"
      25:                 "(p)p_15->(t)Repair (Simple)"
      26:                 "(p)p_8->(t)Archive Repair"
      27:                 "(t)skip_16->(p)p_18"
      28:                 "(t)skip_22->(p)sink"
      29:                 "(p)p_16->(t)skip_19"
      30:                 "(p)p_17->(t)init_loop_13"
      31:                 "(t)Register->(p)p_5"
      32:                 "(t)skip_19->(p)p_14"
      33:                 "(p)p_17->(t)skip_12"
      34:                 "(p)source->(t)Register"
```


Image 2.8: API Inductive Miner

For the Heuristic Miner algorithm, the user has to call the endpoint:

http://127.0.0.1:5000/getimage?filename=(name_of_xesfile)&algorithm=3


```
▼ 0:
    evaluation_result:    0.5073613986657465
    generalization:       0.9224983618335266
    image:                "http://127.0.0.1:5000/static/temp.svg"
    log_fitness:          0.9445528689593501
  ▼ netarcs:
      0:                  "(p)intplace_Test Repair->(t)hid_42"
      1:                  "(p)intplace_Test Repair->(t)hid_43"
      2:                  "(p)pre_Repair (Complex)->(t)Repair (Complex)"
      3:                  "(t)hid_43->(p)sink0"
      4:                  "(t)Restart Repair->(p)intplace_Restart Repair"
      5:                  "(p)intplace_Restart Repair->(t)hid_44"
      6:                  "(p)intplace_Restart Repair->(t)hid_45"
      7:                  "(t)hid_28->(p)pre_Test Repair"
      8:                  "(t)hid_23->(p)pre_Repair (Simple)"
      9:                  "(t)hid_26->(p)pre_Inform User"
      10:                 "(t)hid_32->(p)pre_Test Repair"
      11:                 "(t)hid_22->(p)pre_Repair (Complex)"
      12:                 "(t)hid_35->(p)pre_Repair (Simple)"
      13:                 "(t)hid_30->(p)pre_Inform User"
      14:                 "(p)pre_Repair (Simple)->(t)Repair (Simple)"
      15:                 "(t)hid_42->(p)pre_Test Repair"
      16:                 "(t)hid_34->(p)pre_Repair (Complex)"
      17:                 "(t)hid_31->(p)pre_Repair (Simple)"
      18:                 "(t)hid_40->(p)pre_Inform User"
      19:                 "(t)hid_27->(p)pre_Repair (Complex)"
      20:                 "(t)hid_45->(p)pre_Repair (Simple)"
      21:                 "(t)hid_21->(p)pre_Analyze Defect"
      22:                 "(t)hid_44->(p)pre_Repair (Complex)"
      23:                 "(t)hid_37->(p)pre_Test Repair"
      24:                 "(p)intplace_Inform User->(t)Restart Repair"
      25:                 "(p)pre_Analyze Defect->(t)Analyze Defect"
      26:                 "(p)intplace_Test Repair->(t)Restart Repair"
      27:                 "(p)source0->(t)Register"
      28:                 "(p)intplace_Inform User->(t)Archive Repair"
      29:                 "(p)intplace_Test Repair->(t)Archive Repair"
      30:                 "(p)pre_Inform User->(t)Inform User"
      31:                 "(p)intplace_Repair (Complex)->(t)hid_29"
      32:                 "(t)hid_29->(p)sink0"
      33:                 "(t)hid_11->(p)pre_Inform User"
      34:                 "(t)Repair (Simple)->(p)intplace_Repair (Simple)"
      35:                 "(p)splace_in_Inform User_0->(t)hid_11"
      36:                 "(p)intplace_Repair (Simple)->(t)hid_30"
```


Image 2.9: API heuristic miner

The endpoint returns log_fitness, precision, generalization, simplicity for the specific algorithm and log file. Next, it returns a petri net as svg file (the endpoint saves the petri net on server side), netplaces a list of places of petri net,

nettransitions a list of transitions of petrinet and netarcs a list of all the arcs between places and transitions.

```
parameters:
    - name: filename
      in: query
      schema:
        type: string
      example: repairexample.xes
    - name: algorithm
      in: query
      schema:
        type: string
      example: '3'
  responses:
    '200':
      description: Auto generated using Swagger Inspector
      content:
        application/json:
          schema:
            type: object
            properties: {}
          examples:
            '0':
              value: |
                [
                  {
                    "evaluation_result": 0.5073613986657465,
                    "generalization": 0.9224983618335266,
                    "image": "http://127.0.0.1:5000/static/temp.svg",
                    "log_fitness": 0.9445528689593501,
                    "netarcs": [
                      "(t)Register->(p)pre_Analyze Defect",
                      "(t)hid_23->(p)pre_Repair (Simple)",
                      "(t)hid_42->(p)pre_Test Repair",
                      "(t)hid_30->(p)pre_Inform User",
                      "(t)hid_35->(p)pre_Repair (Simple)",
                      "(p)intplace_Inform User->(t)Restart Repair",
                      "(p)intplace_Test Repair->(t)Archive Repair",
                      "(p)intplace_Inform User->(t)Archive Repair",
```

"(p)intplace_Test Repair->(t)Restart Repair",
"(p)pre_Analyze Defect->(t)Analyze Defect",
"(p)source0->(t)Register",
"(p)pre_Repair (Complex)->(t)Repair (Complex)",
"(p)intplace_Analyze Defect->(t)hid_22",
"(p)intplace_Analyze Defect->(t)hid_23",
"(t)hid_22->(p)splace_in_Inform User_0",
"(p)intplace_Inform User->(t)hid_37",
"(p)pre_Test Repair->(t)Test Repair",
"(t)hid_23->(p)splace_in_Inform User_0",
"(p)intplace_Inform User->(t)hid_38",
"(t)hid_38->(p)sink0",
"(t)Test Repair->(p)intplace_Test Repair",
"(t)Archive Repair->(p)sink0",
"(t)Repair (Complex)->(p)intplace_Repair (Complex)",
"(p)intplace_Test Repair->(t)hid_40",
"(p)intplace_Repair (Complex)->(t)hid_26",
"(p)pre_Repair (Simple)->(t)Repair (Simple)",
"(p)intplace_Repair (Complex)->(t)hid_27",
"(p)intplace_Test Repair->(t)hid_42",
"(p)intplace_Repair (Complex)->(t)hid_28",
"(p)intplace_Test Repair->(t)hid_43",
"(p)intplace_Repair (Complex)->(t)hid_29",
"(t)hid_43->(p)sink0",
"(t)hid_22->(p)pre_Repair (Complex)",
"(t)hid_29->(p)sink0",
"(p)intplace_Analyze Defect->(t)hid_21",
"(t)Restart Repair->(p)intplace_Restart Repair",
"(t)Repair (Simple)->(p)intplace_Repair (Simple)",
"(p)intplace_Repair (Simple)->(t)hid_30",
"(p)intplace_Restart Repair->(t)hid_44",
"(p)intplace_Repair (Simple)->(t)hid_31",
"(p)intplace_Restart Repair->(t)hid_45",
"(p)pre_Inform User->(t)Inform User",
"(t)hid_40->(p)pre_Inform User",
"(p)intplace_Repair (Simple)->(t)hid_32",
"(t)Analyze Defect->(p)intplace_Analyze Defect",
"(t)hid_31->(p)pre_Repair (Simple)",
"(t)hid_11->(p)pre_Inform User",
"(t)hid_34->(p)pre_Repair (Complex)",

```
    "(t)Inform User->(p)intplace_Inform User",
    "(t)hid_45->(p)pre_Repair (Simple)",
    "(p)splace_in_Inform User_0->(t)hid_11",
    "(t)hid_37->(p)pre_Test Repair",
    "(t)hid_27->(p)pre_Repair (Complex)",
    "(p)intplace_Inform User->(t)hid_35",
    "(t)hid_28->(p)pre_Test Repair",
    "(t)hid_44->(p)pre_Repair (Complex)",
    "(p)intplace_Inform User->(t)hid_34",
    "(t)hid_21->(p)pre_Analyze Defect",
    "(t)hid_32->(p)pre_Test Repair",
    "(t)hid_26->(p)pre_Inform User"
  ],
  "netplaces": [
    "pre_Repair (Simple)",
    "source0",
    "intplace_Restart Repair",
    "sink0",
    "intplace_Test Repair",
    "pre_Repair (Complex)",
    "pre_Test Repair",
    "pre_Analyze Defect",
    "splace_in_Inform User_0",
    "intplace_Repair (Complex)",
    "intplace_Inform User",
    "intplace_Analyze Defect",
    "pre_Inform User",
    "intplace_Repair (Simple)"
  ],
  "nettransitions": [
    "hid_43",
    "hid_22",
    "hid_29",
    "Register",
    "hid_37",
    "hid_30",
    "hid_44",
    "Analyze Defect",
    "Repair (Complex)",
    "hid_38",
```

```
      "Repair (Simple)",
      "Inform User",
      "Test Repair",
      "hid_31",
      "Archive Repair",
      "hid_45",
      "Restart Repair",
      "hid_32",
      "hid_11",
      "hid_40",
      "hid_26",
      "hid_23",
      "hid_27",
      "hid_34",
      "hid_21",
      "hid_42",
      "hid_28",
      "hid_35"
    ],
    "simplicity": 0.5384615384615384
  }
]
```


2.3.4.2 Discovery Algorithms for csv files

The web API is using the same endpoint for all three of algorithms (Alpha, Heuristics, Inductive Miner). Although, you should provide different parameters for each algorithm. For the Alpha Miner algorithm, the user has to call the endpoint:

http://127.0.0.1:5000/getimagecsv?filename=(name_of_csvfile)&algorithm=1&seperator=(csv_column_separtor)&caseconcept=(the_column to rename)&conceptname=(the_column to rename)&timestamp=(the_column to rename)&startevent=(the_column to rename)

```
▼ 0:
    evaluation_result:    0.7530864197530864
    generalization:       0.5259294594558881
    image:                "http://127.0.0.1:5000/static/temp.svg"
    log_fitness:          1
  ▼ netarcs:
    ▼ 0:                  "(t)examine thoroughly->(p)({'examine thoroughly', 'examine casually'}, {'decide'})"
    ▼ 1:                  "(t)examine casually->(p)({'examine thoroughly', 'examine casually'}, {'decide'})"
    ▼ 2:                  "(t)register request->(p)({'reinitiate request', 'register request'}, {'check ticket'})"
    ▼ 3:                  "(t)reinitiate request->(p)({'reinitiate request', 'register request'}, {'check ticket'})"
    ▼ 4:                  "(p)({'examine thoroughly', 'examine casually'}, {'decide'})->(t)decide"
      5:                  "(p)start->(t)register request"
      6:                  "(t)check ticket->(p)({'check ticket'}, {'decide'})"
      7:                  "(t)reject request->(p)end"
      8:                  "(p)({'check ticket'}, {'decide'})->(t)decide"
    ▼ 9:                  "(t)register request->(p)({'reinitiate request', 'register request'}, {'examine thoroughly', 'examine casually'})"
    ▼ 10:                 "(p)({'decide'}, {'reject request', 'reinitiate request', 'pay compensation'})->(t)reinitiate request"
    ▼ 11:                 "(p)({'reinitiate request', 'register request'}, {'check ticket'})->(t)check ticket"
    ▼ 12:                 "(p)({'reinitiate request', 'register request'}, {'examine thoroughly', 'examine casually'})->(t)examine thoroughly"
    ▼ 13:                 "(p)({'reinitiate request', 'register request'}, {'examine thoroughly', 'examine casually'})->(t)examine casually"
    ▼ 14:                 "(p)({'decide'}, {'reject request', 'reinitiate request', 'pay compensation'})->(t)reject request"
    ▼ 15:                 "(t)decide->(p)({'decide'}, {'reject request', 'reinitiate request', 'pay compensation'})"
    ▼ 16:                 "(p)({'decide'}, {'reject request', 'reinitiate request', 'pay compensation'})->(t)pay compensation"
      17:                 "(t)pay compensation->(p)end"
    ▼ 18:                 "(t)reinitiate request->(p)({'reinitiate request', 'register request'}, {'examine thoroughly', 'examine casually'})"
  ▼ netplaces:
    ▼ 0:                  "({'reinitiate request', 'register request'}, {'check ticket'})"
    ▼ 1:                  "({'decide'}, {'reject request', 'reinitiate request', 'pay compensation'})"
    ▼ 2:                  "({'reinitiate request', 'register request'}, {'examine thoroughly', 'examine casually'})"
      3:                  "end"
    ▼ 4:                  "({'examine thoroughly', 'examine casually'}, {'decide'})"
      5:                  "({'check ticket'}, {'decide'})"
      6:                  "start"
  ▼ nettransitions:
      0:                  "examine thoroughly"
      1:                  "examine casually"
      2:                  "decide"
      3:                  "check ticket"
      4:                  "reject request"
      5:                  "register request"
      6:                  "pay compensation"
      7:                  "reinitiate request"
    simplicity:           0.6521739130434783
```


Image 2.10: API csv Alpha

For the Inductive Miner algorithm, the user has to call the endpoint:

http://127.0.0.1:5000/getimagecsv?filename=(name_of_csvfile)&algorithm=2&seperator=(csv_column_separtor)&caseconcept=(the_column to rename)&conceptname=(the_column to rename)&timestamp=(the_column to rename)&startevent=(the_column to rename)

```
▼ 0:
    evaluation_result:    0.7530864197530864
    generalization:       0.5465854051849908
    image:                "http://127.0.0.1:5000/static/temp.svg"
    log_fitness:          1
  ▼ netarcs:
      0:                  "(p)p_10->(t)examine casually"
      1:                  "(p)p_10->(t)examine thoroughly"
      2:                  "(t)examine thoroughly->(p)p_11"
      3:                  "(t)register request->(p)p_5"
      4:                  "(t)decide->(p)p_6"
      5:                  "(t)tauSplit_3->(p)p_10"
      6:                  "(t)examine casually->(p)p_11"
      7:                  "(p)p_11->(t)decide"
      8:                  "(p)p_5->(t)tauSplit_3"
      9:                  "(t)check ticket->(p)p_9"
      10:                 "(p)source->(t)register request"
      11:                 "(p)p_4->(t)reject request"
      12:                 "(t)pay compensation->(p)sink"
      13:                 "(p)p_4->(t)pay compensation"
      14:                 "(p)p_6->(t)reinitiate request"
      15:                 "(p)p_9->(t)decide"
      16:                 "(p)p_6->(t)skip_5"
      17:                 "(t)skip_5->(p)p_4"
      18:                 "(t)tauSplit_3->(p)p_8"
      19:                 "(t)reinitiate request->(p)p_5"
      20:                 "(p)p_8->(t)check ticket"
      21:                 "(t)reject request->(p)sink"
  ▼ netplaces:
      0:                  "p_5"
      1:                  "p_11"
      2:                  "source"
      3:                  "sink"
      4:                  "p_10"
      5:                  "p_4"
      6:                  "p_6"
      7:                  "p_8"
      8:                  "p_9"
  ▼ nettransitions:
      0:                  "check ticket"
      1:                  "tauSplit_3"
      2:                  "reinitiate request"
      3:                  "skip_5"
      4:                  "decide"
```


Image 2.11: API csv Inductive

For the Heuristic Miner algorithm, the user has to call the endpoint:

http://127.0.0.1:5000/getimagecsv?filename=(name_of_csvfile)&algorithm=3&seperator=(csv_column_separtor)&caseconcept=(the_column to rename)&conceptname=(the_column to rename)&timestamp=(the_column to rename)&startevent=(the_column to rename)


```
▼ 0:
    evaluation_result:    0.75
    generalization:       0.46345210039759677
    image:                "http://127.0.0.1:5000/static/temp.svg"
    log_fitness:          0.9688983855650523
  ▼ netarcs:
      0:                  "(t)hid_16->(p)splace_in_check ticket_1"
    ▼ 1:                  "(t)check ticket->(p)splace_in_decide_check ticket_0"
      2:                  "(t)examine thoroughly->(p)pre_decide"
      3:                  "(t)hid_9->(p)pre_examine thoroughly"
      4:                  "(p)intplace_reinitiate request->(t)hid_16"
      5:                  "(p)intplace_decide->(t)pay compensation"
      6:                  "(p)intplace_decide->(t)reinitiate request"
      7:                  "(t)pay compensation->(p)sink0"
      8:                  "(t)register request->(p)intplace_register request"
      9:                  "(t)reject request->(p)sink0"
      10:                 "(t)hid_3->(p)pre_check ticket"
      11:                 "(p)intplace_reinitiate request->(t)hid_17"
      12:                 "(t)hid_7->(p)pre_decide"
      13:                 "(t)hid_16->(p)pre_examine thoroughly"
      14:                 "(p)splace_in_decide_examine casually_0->(t)hid_7"
      15:                 "(p)splace_in_check ticket_1->(t)hid_4"
    ▼ 16:                 "(t)examine casually->(p)splace_in_decide_examine casually_0"
      17:                 "(p)pre_examine thoroughly->(t)examine thoroughly"
      18:                 "(t)hid_10->(p)pre_examine casually"
      19:                 "(p)intplace_register request->(t)hid_10"
      20:                 "(p)splace_in_decide_check ticket_0->(t)hid_7"
      21:                 "(p)pre_check ticket->(t)check ticket"
      22:                 "(p)source0->(t)register request"
      23:                 "(t)decide->(p)intplace_decide"
      24:                 "(t)hid_4->(p)pre_check ticket"
      25:                 "(t)hid_10->(p)splace_in_check ticket_0"
      26:                 "(p)splace_in_check ticket_0->(t)hid_3"
      27:                 "(t)hid_17->(p)splace_in_check ticket_1"
    ▼ 28:                 "(t)reinitiate request->(p)intplace_reinitiate request"
      29:                 "(p)pre_examine casually->(t)examine casually"
      30:                 "(p)intplace_register request->(t)hid_9"
      31:                 "(t)hid_9->(p)splace_in_check ticket_0"
      32:                 "(p)pre_decide->(t)decide"
      33:                 "(p)intplace_decide->(t)reject request"
      34:                 "(t)hid_17->(p)pre_examine casually"
  ▼ netplaces:
      0:                  "pre_check ticket"
      1:                  "sink0"
```


Image 2.12: API csv Heuristic

```
get:
 description: Auto generated using Swagger Inspector
 parameters:
   - name: caseconcept
     in: query
     schema:
       type: string
     example: Case%20ID
   - name: filename
     in: query
     schema:
       type: string
     example: running-example.csv
   - name: startevent
     in: query
     schema:
       type: string
     example: Costs
   - name: conceptname
     in: query
     schema:
       type: string
     example: Activity
   - name: seperator
     in: query
     schema:
       type: string
     example: ;
   - name: timestamp
     in: query
     schema:
       type: string
     example: 'dd-MM-yyyy:HH.mm'
   - name: algorithm
     in: query
     schema:
       type: string
     example: '3'
 responses:
```

```
'200':
  description: Auto generated using Swagger Inspector
  content:
    application/json:
      schema:
        type: object
        properties: {}
      examples:
        '0':
          value: |
            [
              {
                "evaluation_result": 0.75,
                "generalization": 0.46345210039759677,
                "image": "http://127.0.0.1:5000/static/temp.svg",
                "log_fitness": 0.9688983855650523,
                "netarcs": [
                  "(t)reinitiate request->(p)intplace_reinitiate request",
                  "(p)source0->(t)register request",
                  "(t)register request->(p)intplace_register request",
                  "(t)examine casually->(p)splace_in_decide_examine casually_0",
                  "(p)intplace_decide->(t)reject request",
                  "(t)reject request->(p)sink0",
                  "(p)pre_examine thoroughly->(t)examine thoroughly",
                  "(p)intplace_decide->(t)pay compensation",
                  "(p)splace_in_decide_examine casually_0->(t)hid_7",
                  "(t)pay compensation->(p)sink0",
                  "(t)hid_10->(p)pre_examine casually",
                  "(p)intplace_register request->(t)hid_9",
                  "(p)splace_in_check ticket_0->(t)hid_3",
                  "(p)pre_examine casually->(t)examine casually",
                  "(t)hid_10->(p)splace_in_check ticket_0",
                  "(t)decide->(p)intplace_decide",
                  "(t)hid_9->(p)pre_examine thoroughly",
                  "(t)hid_4->(p)pre_check ticket",
                  "(t)examine thoroughly->(p)pre_decide",
                  "(t)check ticket->(p)splace_in_decide_check ticket_0",
                  "(t)hid_16->(p)pre_examine thoroughly",
                  "(t)hid_17->(p)splace_in_check ticket_1",
                  "(p)intplace_decide->(t)reinitiate request",
```

```
    "(p)intplace_reinitiate request->(t)hid_17",
    "(t)hid_17->(p)pre_examine casually",
    "(p)splace_in_check ticket_1->(t)hid_4",
    "(t)hid_3->(p)pre_check ticket",
    "(p)intplace_reinitiate request->(t)hid_16",
    "(p)splace_in_decide_check ticket_0->(t)hid_7",
    "(t)hid_9->(p)splace_in_check ticket_0",
    "(p)intplace_register request->(t)hid_10",
    "(t)hid_16->(p)splace_in_check ticket_1",
    "(p)pre_check ticket->(t)check ticket",
    "(p)pre_decide->(t)decide",
    "(t)hid_7->(p)pre_decide"
  ],
  "netplaces": [
    "splace_in_decide_check ticket_0",
    "pre_check ticket",
    "pre_examine casually",
    "intplace_register request",
    "splace_in_decide_examine casually_0",
    "source0",
    "pre_examine thoroughly",
    "intplace_reinitiate request",
    "pre_decide",
    "intplace_decide",
    "splace_in_check ticket_1",
    "splace_in_check ticket_0",
    "sink0"
  ],
  "nettransitions": [
    "hid_7",
    "hid_10",
    "hid_9",
    "hid_3",
    "hid_16",
    "register request",
    "hid_4",
    "reject request",
    "pay compensation",
    "hid_17",
    "decide",
```

```
      "reinitiate request",
      "examine casually",
      "examine thoroughly",
      "check ticket"
    ],
    "simplicity": 0.6666666666666666
  }
]
```

2.3.5.1 Replay results for xes files

For the replay results, the user has to call the endpoint:

http://127.0.0.1:5000/getreplayresults?filename=(name_of_csvfile)&algorithm=(exactly_the same numbers as discover process)

Image 2.13: API replay results

get:

description: Auto generated using Swagger Inspector

parameters:

- name: filename

```
      in: query
      schema:
        type: string
      example: repairexample.xes
    - name: algorithm
      in: query
      schema:
        type: string
      example: '3'
```

2.3.5.1 Replay results for csv files

For the replay results for csv files, the user has to call the endpoint:

http://127.0.0.1:5000/getreplayresultscsv?filename=(name_of_csvfile)&sitealgo=(exactly_the same numbers as discover process)&seperator=(csv_column_separtor)&caseconcept=(the_column to rename)&conceptname=(the_column to rename)&timestamp=(the_column to rename)&startevent=(the_column to rename)

Image 2.14: API csv replay results

get:

description: Auto generated using Swagger Inspector

parameters:

- name: caseconcept

in: query

schema:

type: string

```
    example: Case%20ID
  - name: filename
    in: query
    schema:
      type: string
    example: running-example.csv
  - name: startevent
    in: query
    schema:
      type: string
    example: Costs
  - name: conceptname
    in: query
    schema:
      type: string
    example: Activity
  - name: seperator
    in: query
    schema:
      type: string
    example: ;
  - name: sitealgo
    in: query
    schema:
      type: string
    example: '3'
  - name: timestamp
    in: query
    schema:
      type: string
    example: 'dd-MM-yyyy:HH.mm'
```

2.3.6.1 Get alignments for xes files

For the alignments, the user has to call the endpoint:

http://127.0.0.1:5000/getalignments?filename=(name_of_csvfile)&algorithm=(exactly_the same numbers as discover process)

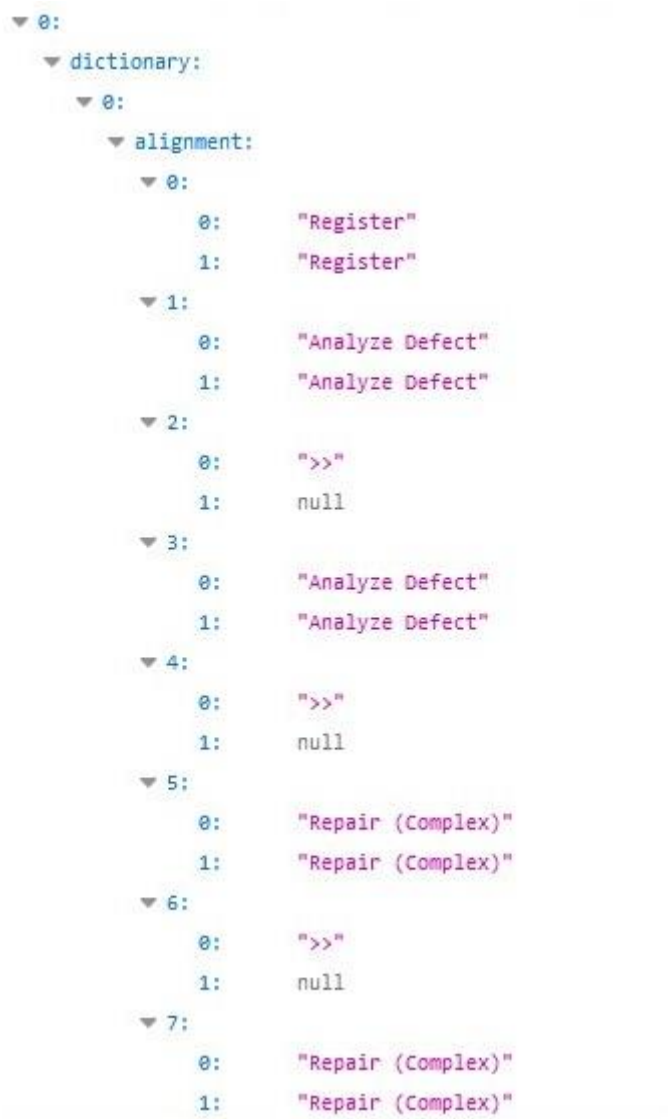


Image 2.15: API alignments

get:
  description: Auto generated using Swagger Inspector
  parameters:
    - name: filename
      in: query
      schema:

```
      type: string
    example: repairexample.xes
  - name: algorithm
    in: query
    schema:
      type: string
    example: '3'
```

2.3.6.2 Get alignments for csv files

For the alignments of csv files, the user has to call the endpoint:

http://127.0.0.1:5000/getalignmentscsv?filename=(name_of_csvfile)&sitealgo=(exactly_the same numbers as discover process)&seperator=(csv_column_separtor)&caseconcept=(the_column to rename)&conceptname=(the_column to rename)&timestamp=(the_column to rename)&startevent=(the_column to rename)

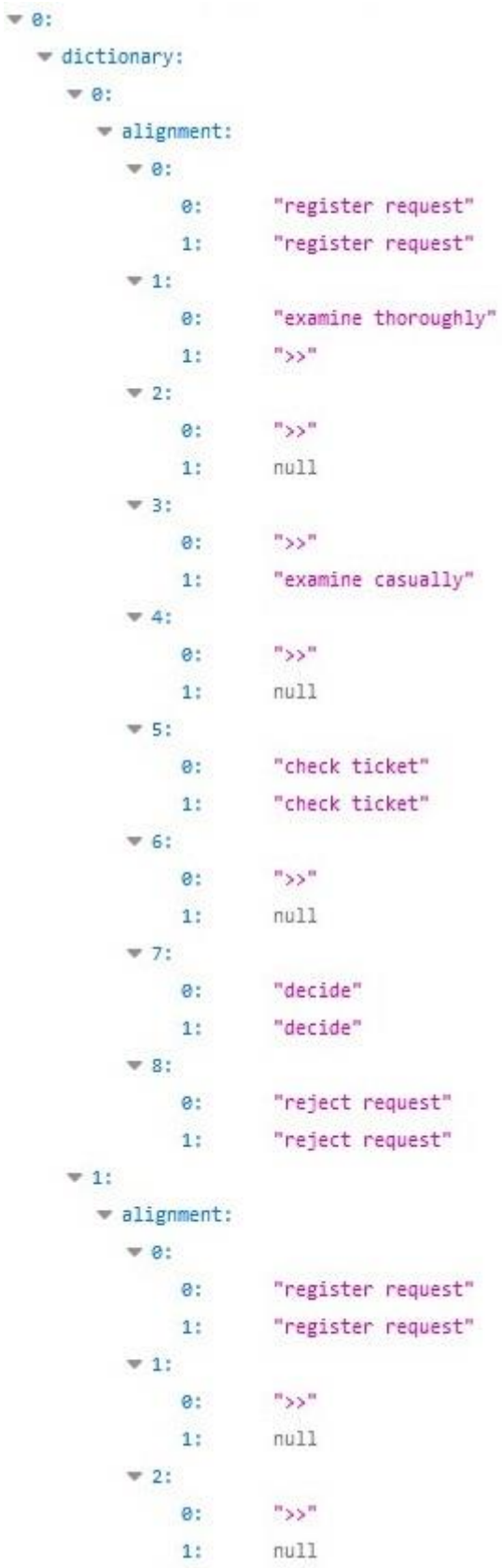


Image 2.16: API csv alignments

```
get:
    description: Auto generated using Swagger Inspector
    parameters:
      - name: caseconcept
        in: query
        schema:
          type: string
        example: Case%20ID
      - name: filename
        in: query
        schema:
          type: string
        example: running-example.csv
      - name: startevent
        in: query
        schema:
          type: string
        example: Costs
      - name: conceptname
        in: query
        schema:
          type: string
        example: Activity
      - name: seperator
        in: query
        schema:
          type: string
        example: ;
      - name: sitealgo
        in: query
        schema:
          type: string
        example: '3'
      - name: timestamp
        in: query
        schema:
          type: string
        example: 'dd-MM-yyyy:HH.mm'
```

CHAPTER 3

WEB INTERFACE

3.1 React Js

React JS is a JavaScript library for building user interfaces.

The reasons why React Js was chosen to build the interface are:

- React makes it painless to create interactive UIs. Design simple views for each state in your application, and React will efficiently update and render just the right components when your data changes. Declarative views make your code more predictable and easier to debug.

- Build encapsulated components that manage their own state, then compose them to make complex UIs. Since component logic is written in JavaScript instead of templates, the user can easily pass rich data through the app and keep state out of the DOM.

- The user can develop new features in React without rewriting existing code [12].

- It is easy to make POST calls to the API and retrieve returning JSON objects.

- Thanks to react flow library (https://reactflow.dev/) the developer can create a petri net, in which the user can zoom in/out and also move around its elements, places and transitions.

- Also, thanks to react loader spinner (https://www.npmjs.com/package/react-loader-spinner) the developer can create a customized loader to let the user know that the API is processing data.

3.2 React Js and Flask

The API has two responsibilities. The first is to respond to post or get request made to this endpoint and the second is to response web interface requests.

Next, we need to install the flask-cors [14] with the pip install flask-cors command. Flask-cors is looking for requests for a different application.

Functions that are available on server side:

- savefile: @app.route('/savefile', methods=['POST']).

It is used only from web interface so the user can upload his xes or csv files and then save them to server.

- headers: @app.route('/headers', methods=['POST'])

It is used only from web interface to return the headers of files.

- convertocsv: @app.route('/convertocsv', methods=['POST', 'GET']).

The user can convert a selected xes file to csv.

- convertoxes: @app.route('/convertoxes', methods=['POST', 'GET']).

The user can convert a selected csv file to xes.

- view: @app.route('/view', methods=['POST', 'GET']).

API returns the header and each row of xes file.

- viewcsv: @app.route('/viewcsv', methods=['POST', 'GET']).

API returns the header and each row of csv file.

- statistics: @app.route('/ statistics, methods=['POST', 'GET']).

API returns statistics of xes file, such as number of traces, events, start events, end events.

- csvstatistics: @app.route('/csvstatistics', methods=['POST', 'GET']).

API returns statistics of csv file, such as number of traces, events, start events, end events.

- getimage: @app.route('/getimage', methods=['POST', 'GET']).

API returns list of places, transitions and edges of petri net importing a xes file and also evalution results (log_fitness, precision, simplicity, generalization).

- getimagecsv: @app.route('/getimagecsv', methods=['POST', 'GET']).

API returns list of places, transitions and edges of petri net importing a csv file and also evalution results (log_fitness, precision, simplicity, generalization).

- getreplayresults: @app.route('/getreplayresults', methods=['POST', 'GET']).

API returns an array with data such as: Trace is fit, Trace fitness, Activated Transitions, Reached Marking, Enabled transitions in marking, Transitions with problems, Missing Tokens, Consumed tokens, Remaining Tokens και Produced tokens for the selected xes file.

- getreplayresultscsv: @app.route('/getreplayresultscsv', methods=['POST', 'GET']).

API returns an array with data such as: Trace is fit, Trace fitness, Activated Transitions, Reached Marking, Enabled transitions in marking, Transitions with problems, Missing Tokens, Consumed tokens, Remaining Tokens και Produced tokens for the selected csv file.

- getalignments: @app.route('/getalignments', methods=['POST', 'GET'])

API returns a lot of arrays with two rows in purpose of conformance checking of imported xes file.

- getalignmentscsv: @app.route('/getalignmentscsv', methods=['POST', 'GET'])

API returns a lot of arrays with two rows in purpose of conformance checking of imported csv file.

3.3 Web pages

3.3.1 First Page

Image 3.1: First Page

Xes and csv files are stored at server. There is not a session management and when you press refresh the application redirects you to this page.

When user hovers File from menu there is only one option upload. The reason is that he has not upload any file so he can do any other action. When the user presses the upload option the next page is showed up:

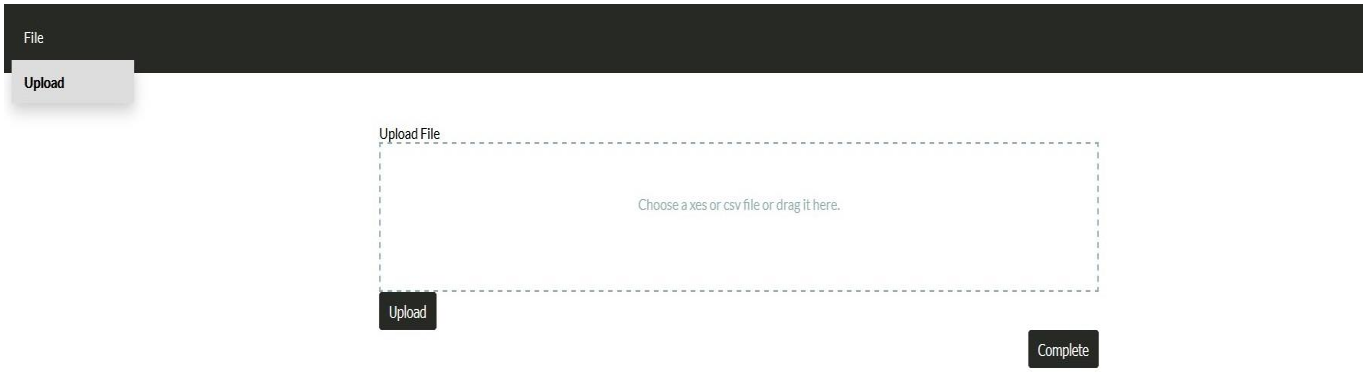


Image 3.2: File Upload

The user can upload any xes or csv file by pressing one click on the box and then choose the file from windows browser or with drag and drop. In case the file is csv or xes the image will change to this:

Image 3.3: File Upload Complete

When the user presses the complete button, web interface redirects to the main screen.

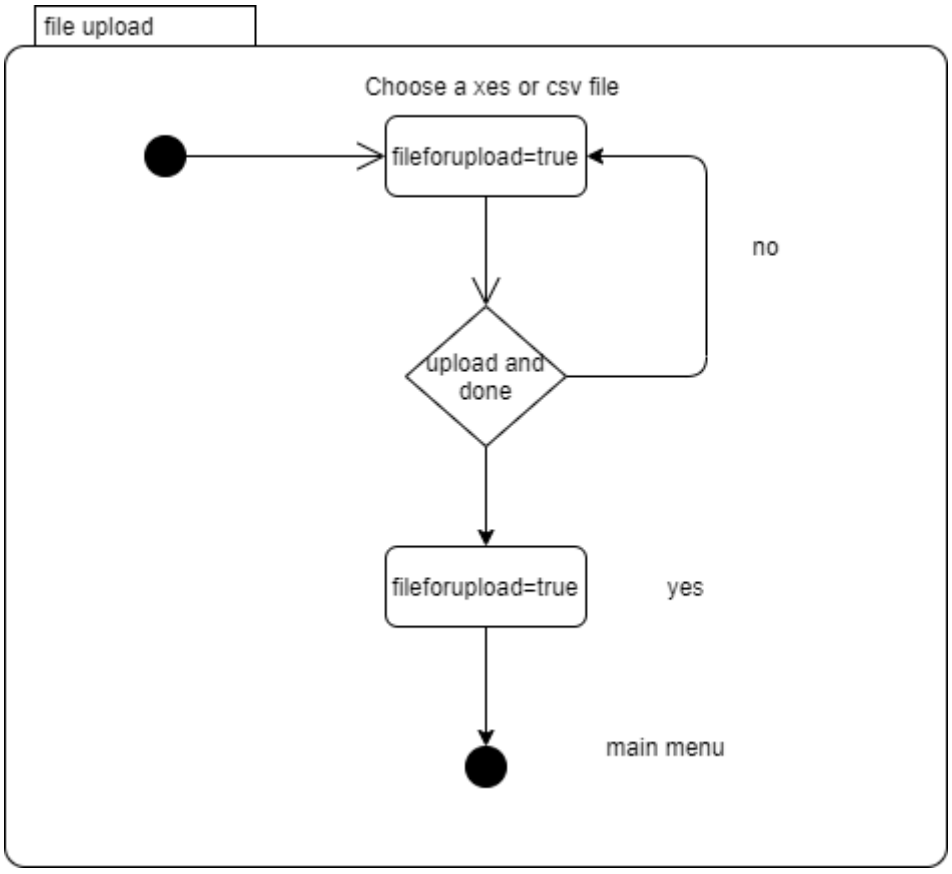


Image 3.4: File Upload State

3.3.2 File Menu

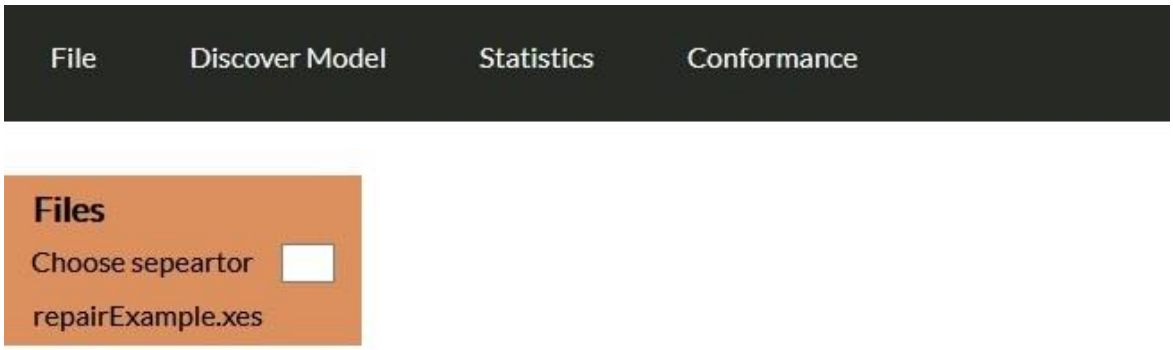


Image 3.5: File Menu

Under the file menu there is the option upload so the user can upload more than one file.

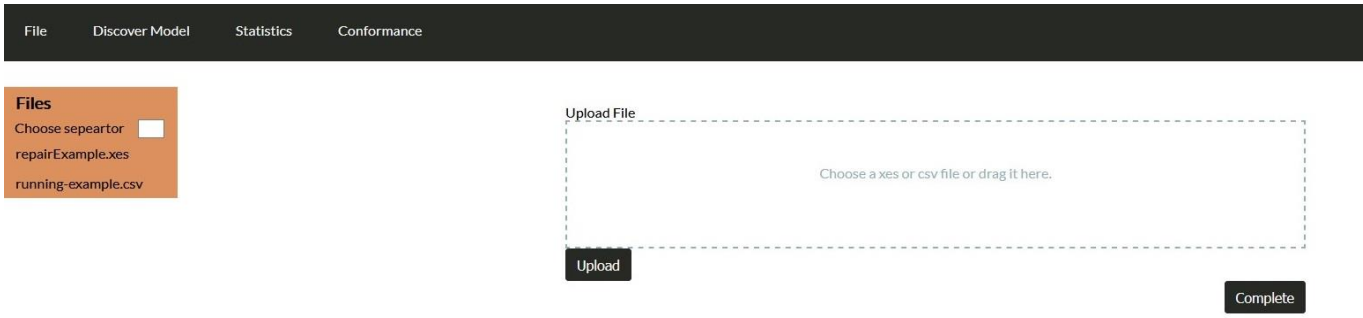


Image 3.6: File upload

Under file menu there are more option if the user has already uploaded at least one file. The user should select a file from the left menu and then select one of the options. If the user has not selected any file and presses an option then a blank screen will appear on the right until the user selects one file from the left menu. The first option is convert to xes.

Image 3.7: Convert to xes

In case user does not select a csv file:

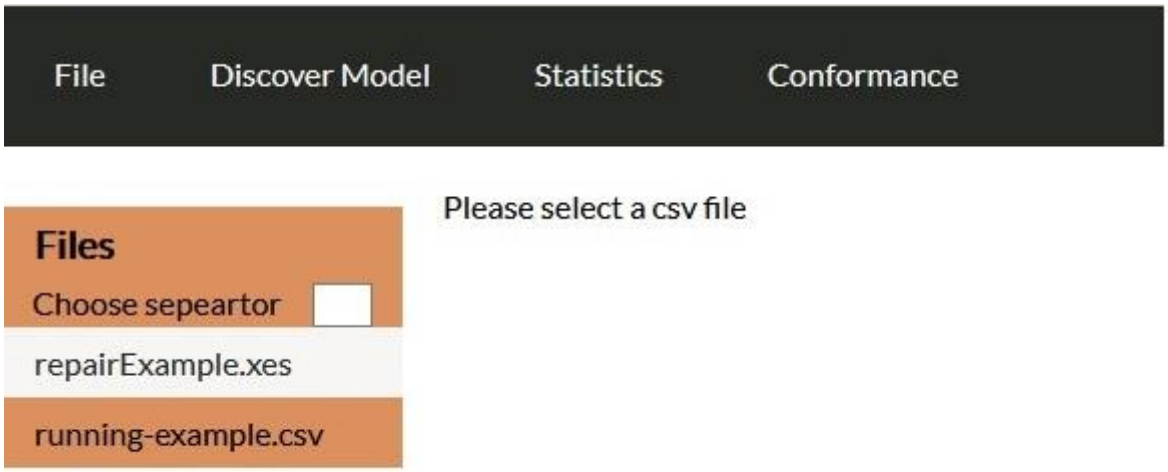


Image 3.8: Wrong csv input

In the opposite view a webpage with four dropdowns will appear so the user can declare which csv column will be: concept:name, concept:name, start_event and time:timestamp.

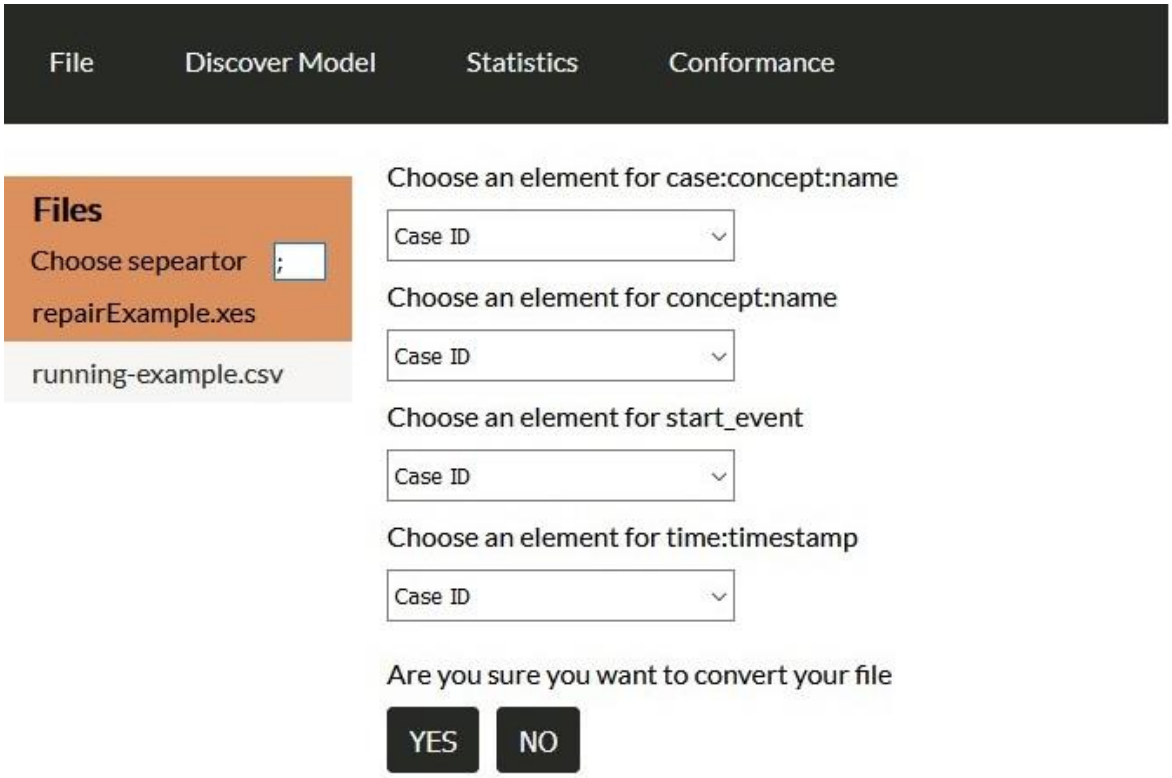


Image 3.9: Choose Headers

In this case the user has to provide a separator. If he leaves the input blank then the dropdowns will have null value:

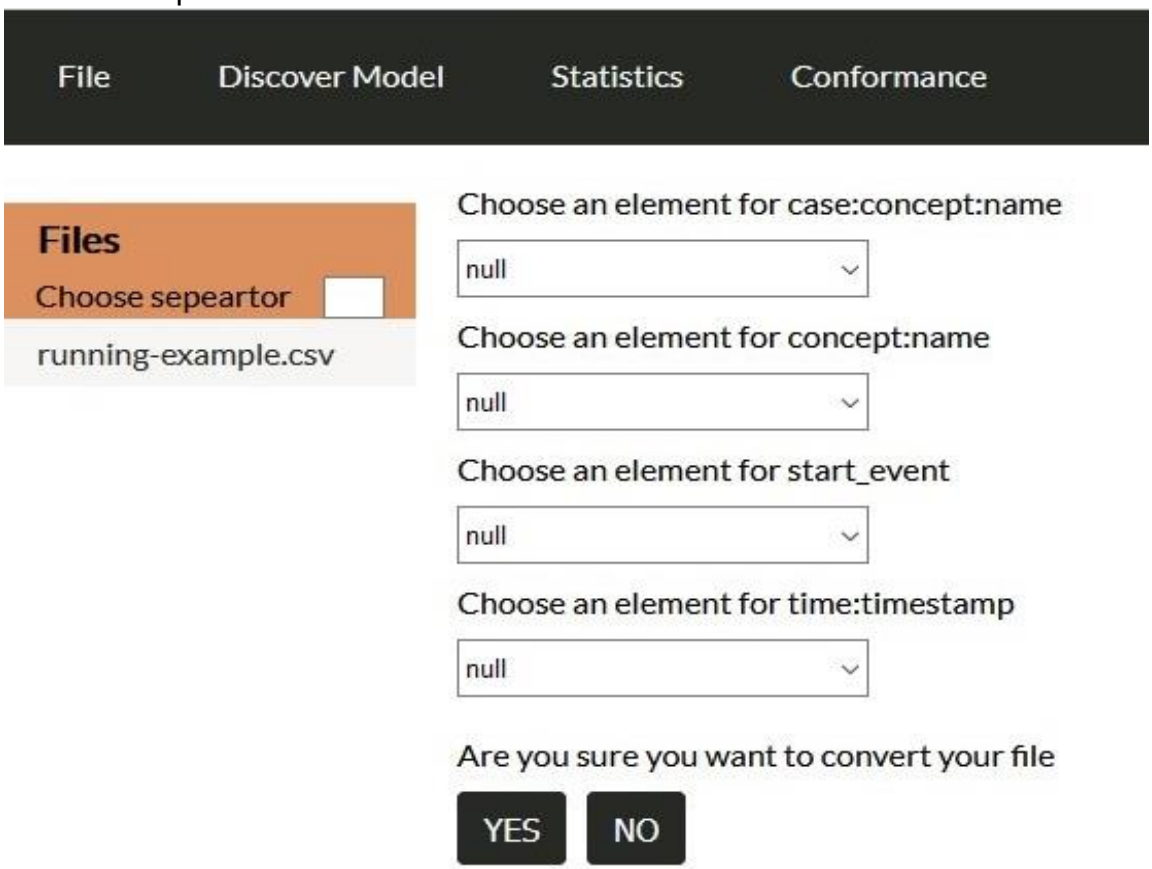


Image 3.10: No seperator

In case user gives wrong separator, the next screen will appear:

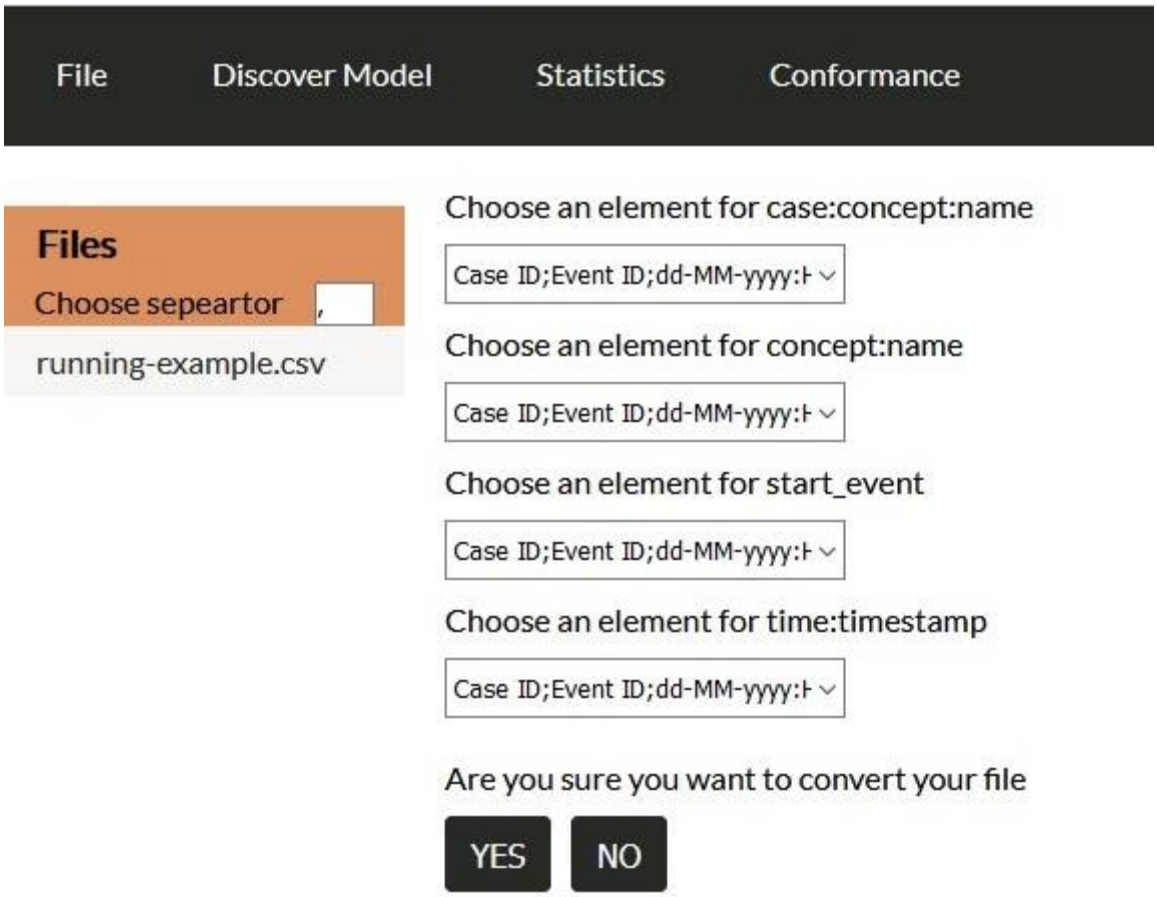


Image 3.11: Wrong separator

Otherwise, when the user presses Yes an extra file with the type .xes will appear on the left menu (Files).

Image 3.12: Convert Completed

Similar to the last option, convert to csv does not allow the user to convert a csv file and when the user selects a xes file the following web page appears

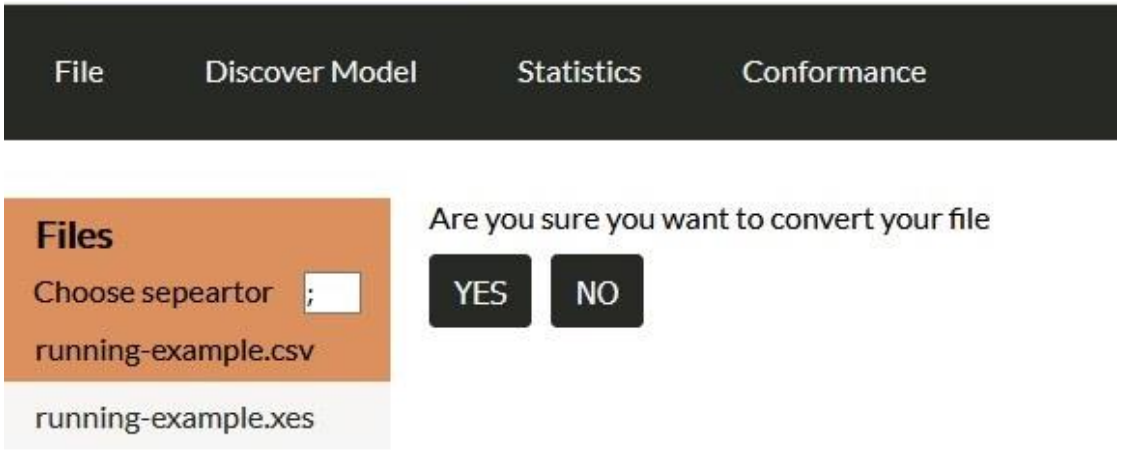
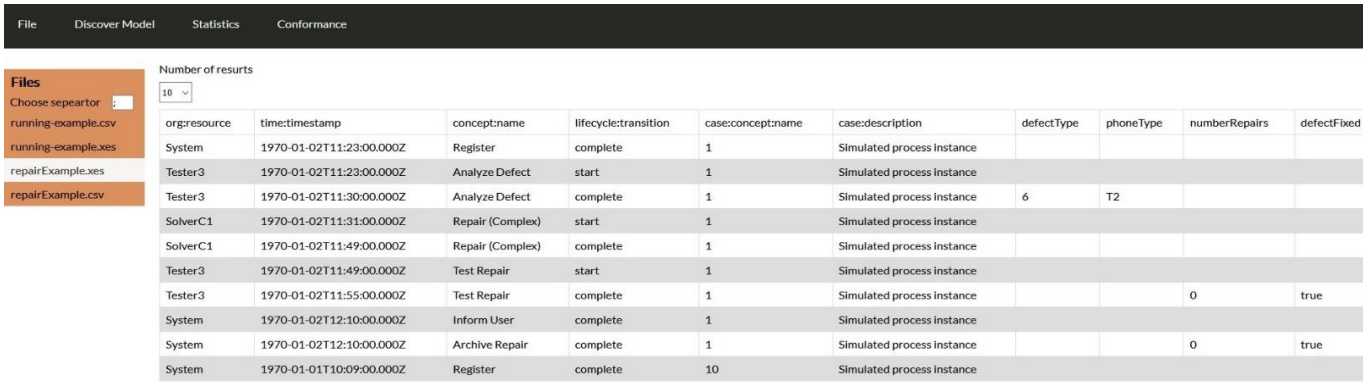


Image 3.13: Convert to csv

In case the user presses yes, on the left files list the converted file appears with the repairExample.csv.

Image 3.14: Convert to csv completed

When the user selects the view option, he can either choose a xes or csv file and an html table will appear with the content of file.



org:resource	time:timestamp	concept:name	lifecycle:transition	case:concept:name	case:description	defectType	phoneType	numberRepairs	defectFixed
System	1970-01-02T11:23:00.000Z	Register	complete	1	Simulated process instance				
Tester3	1970-01-02T11:23:00.000Z	Analyze Defect	start	1	Simulated process instance				
Tester3	1970-01-02T11:30:00.000Z	Analyze Defect	complete	1	Simulated process instance	6	T2		
SolverC1	1970-01-02T11:31:00.000Z	Repair (Complex)	start	1	Simulated process instance				
SolverC1	1970-01-02T11:49:00.000Z	Repair (Complex)	complete	1	Simulated process instance				
Tester3	1970-01-02T11:49:00.000Z	Test Repair	start	1	Simulated process instance				
Tester3	1970-01-02T11:55:00.000Z	Test Repair	complete	1	Simulated process instance			0	true
System	1970-01-02T12:10:00.000Z	Inform User	complete	1	Simulated process instance				
System	1970-01-02T12:10:00.000Z	Archive Repair	complete	1	Simulated process instance			0	true
System	1970-01-01T10:09:00.000Z	Register	complete	10	Simulated process instance				

Image 3.15: File Content

The web interface reads the whole table with post from python flask and when the user changes the number to results dropdown to 10, then the html table shows the first 10 rows, when the user changes the number to results dropdown

to 50, then the html table shows the first 10 rows and when the user changes to the dropdown to all then html table shows all the rows. Until the response is returned from the API react-loader-spinner is used (https://www.npmjs.com/package/react-loader-spinner).

About the Info option, the user can retrieve the next data: number of traces, number of events, file structure, an event array and how many times each event appears in the file, a table with start events and one with end events and how many traces start or end with those events.

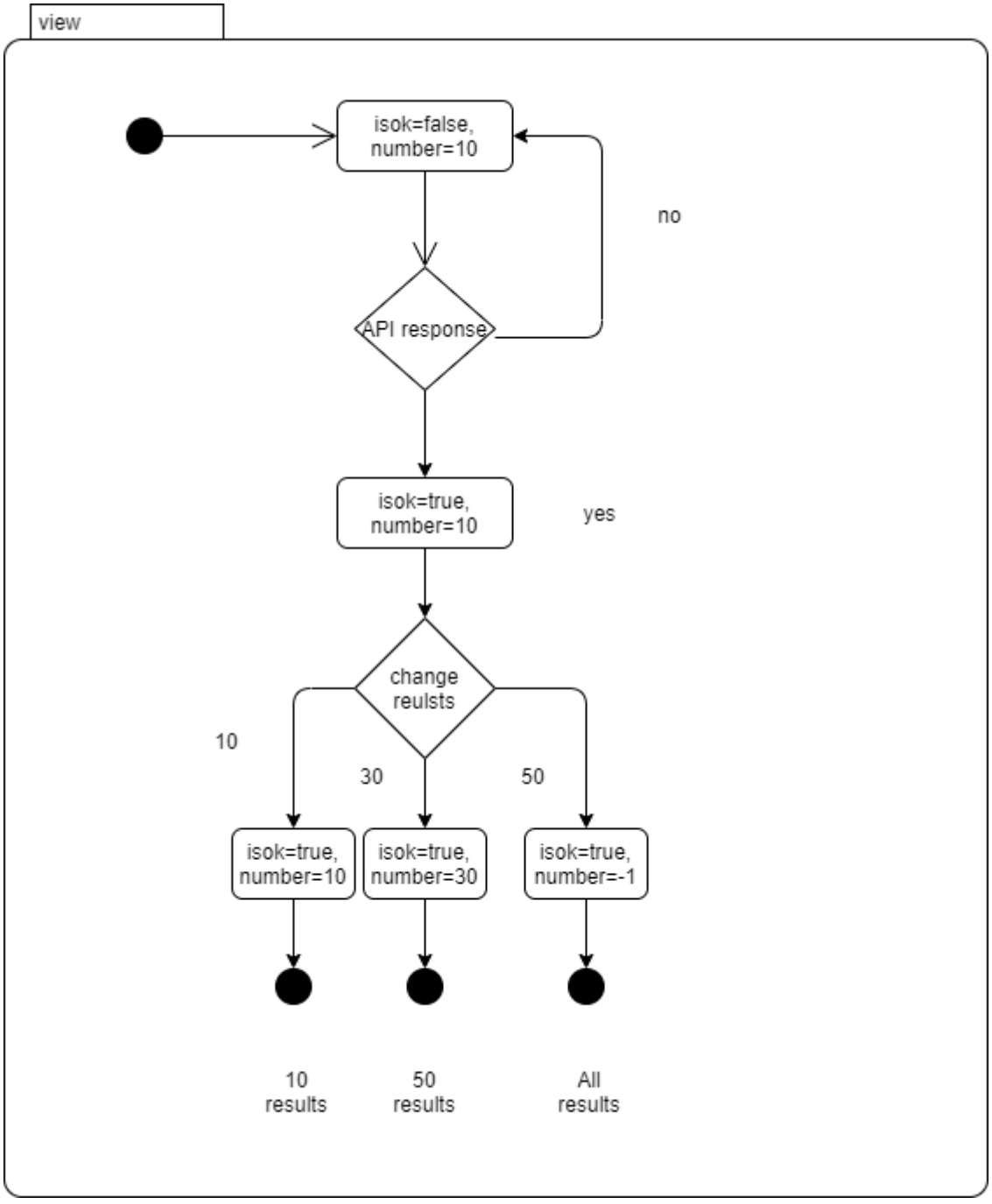


Image 3.16: View State

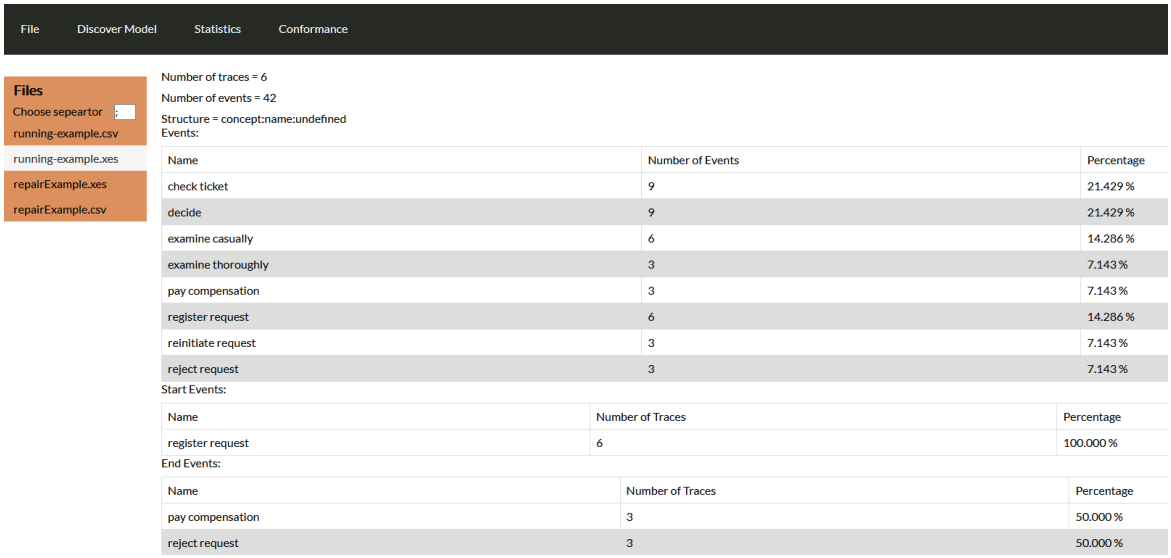


Image 3.17: File Info

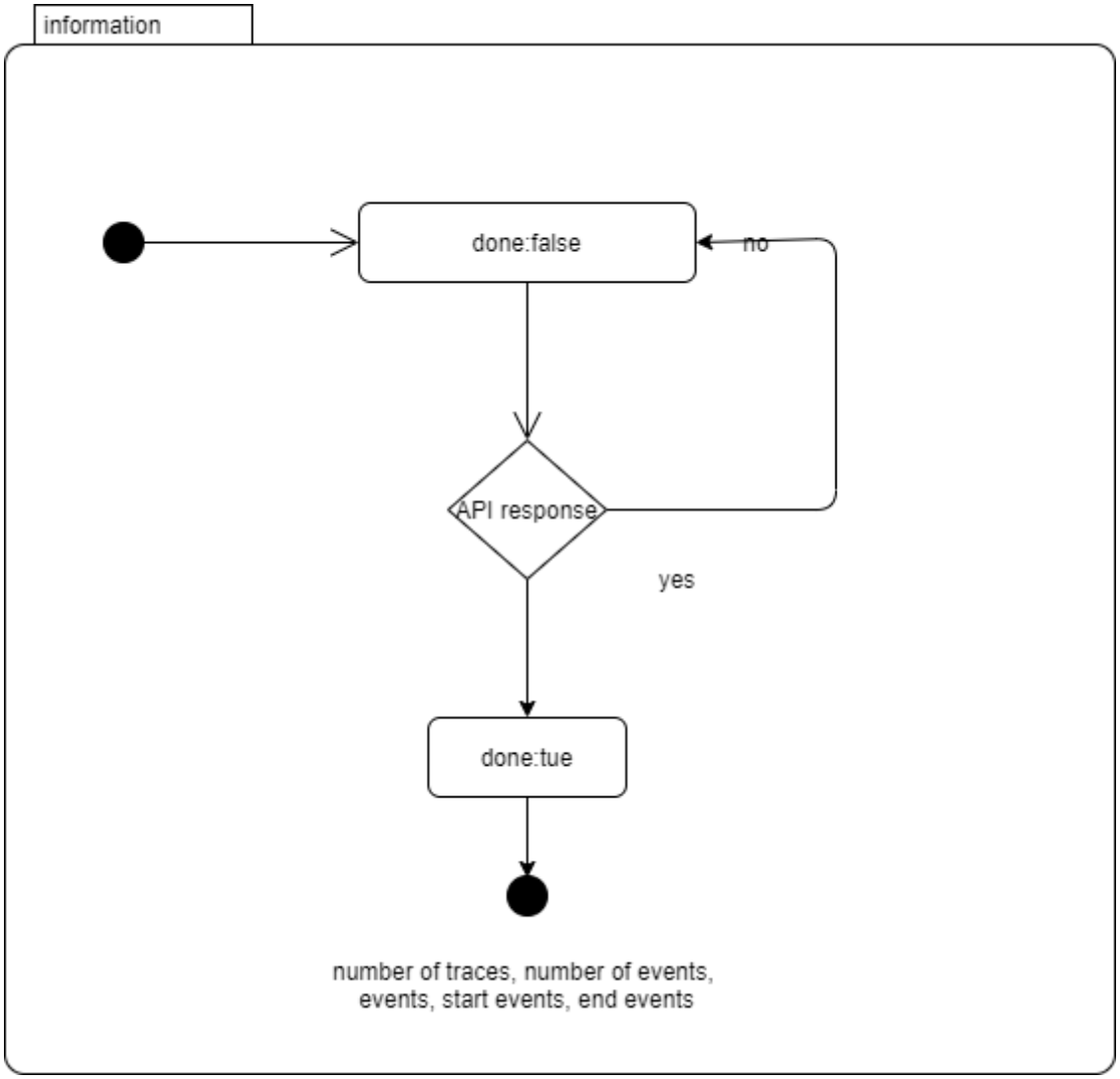


Image 3.18: File Info State

In case the user selects a csv file then the web interface will first appear a select header webpage.

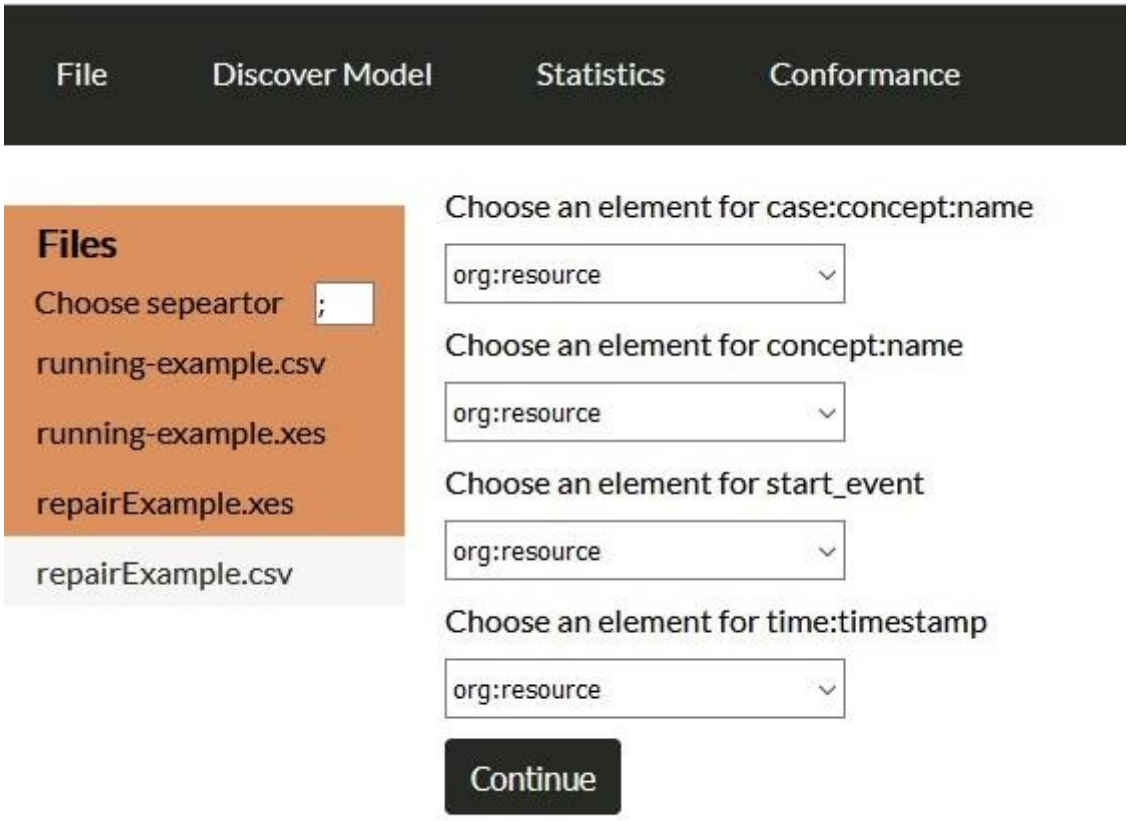


Image 3.19: Choose header for file info

3.3.3 Discover Menu

When the user hovers on Discover Model, then he can choose one of the discover algorithms as an option: alpha miner, inductive miner, heuristics miner.

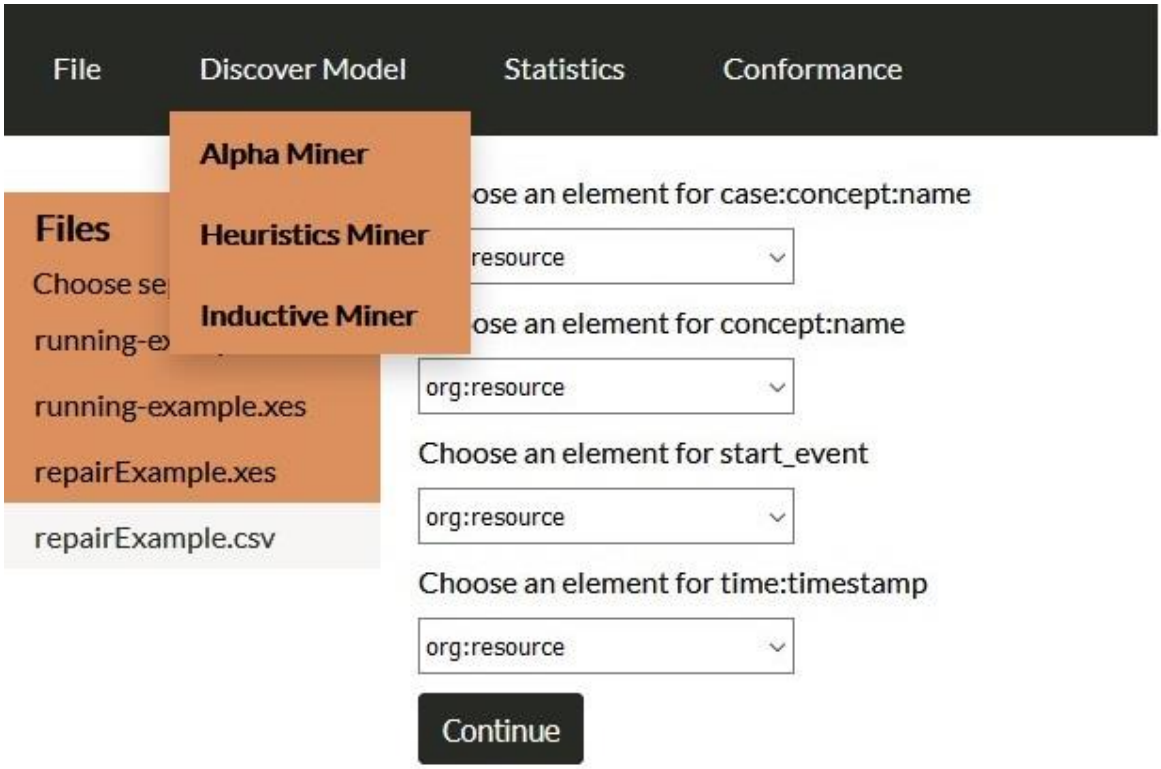


Image 3.20: Discover Menu

In case the user chooses alpha miner then a webpage with a table will appear which show the Log Fitness, Precision, Generalization and Simplicity evaluation for the specific file. Also, petri net of the algorithm will appear under the table. The petri net is developed with react flow, an open-source library which allow the web user to drag and drop any transition and place of the graph.

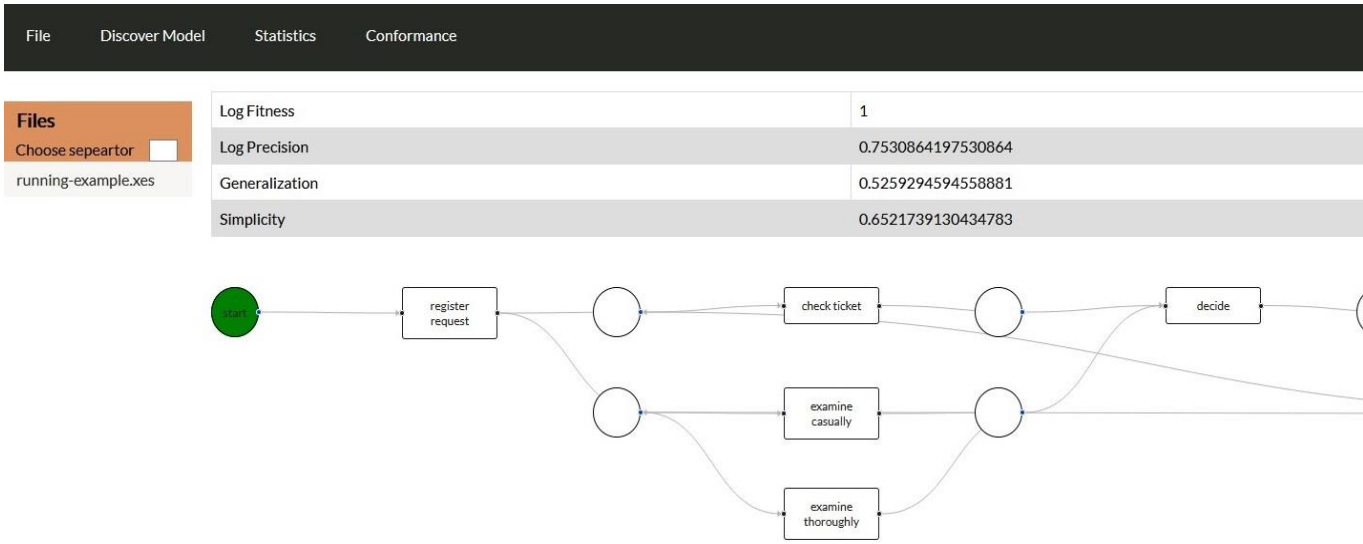


Image 3.21: Alpha miner site

For Heuristic Miner:

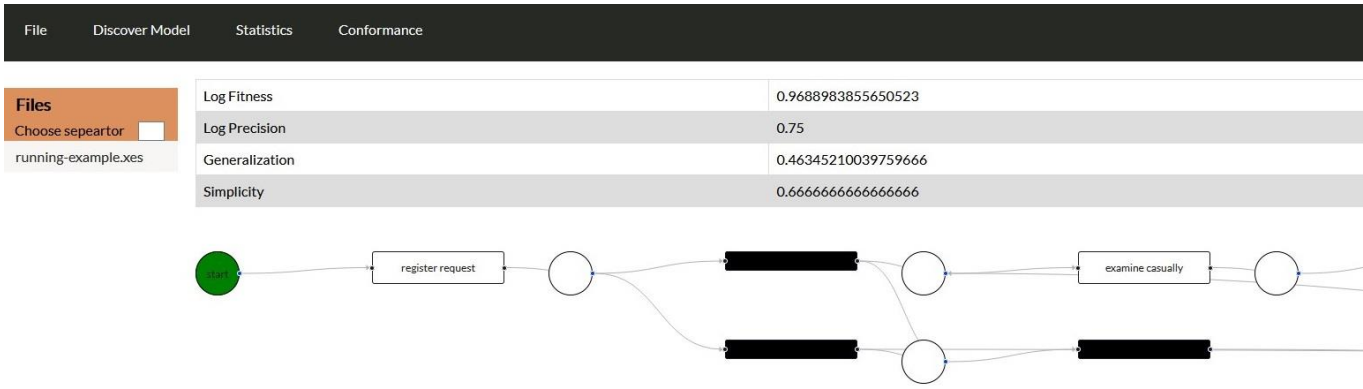


Image 3.22: Heuristics miner site

And Inductive Miner:

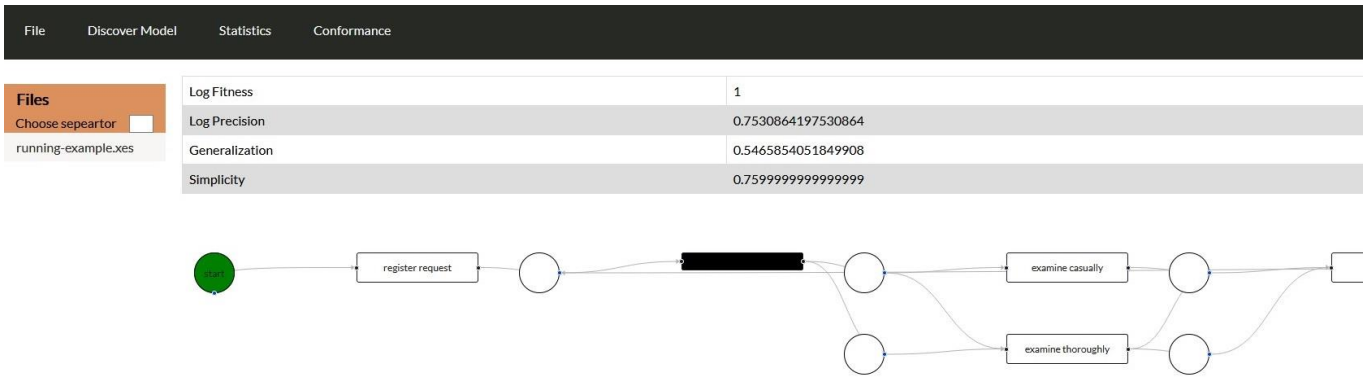


Image 3.23: Inductive miner site

In case the user chooses a csv file and then selects one of the above three options, then the choose heeder screen will appear and then the web interface will display the webpage with the table and the petri net.

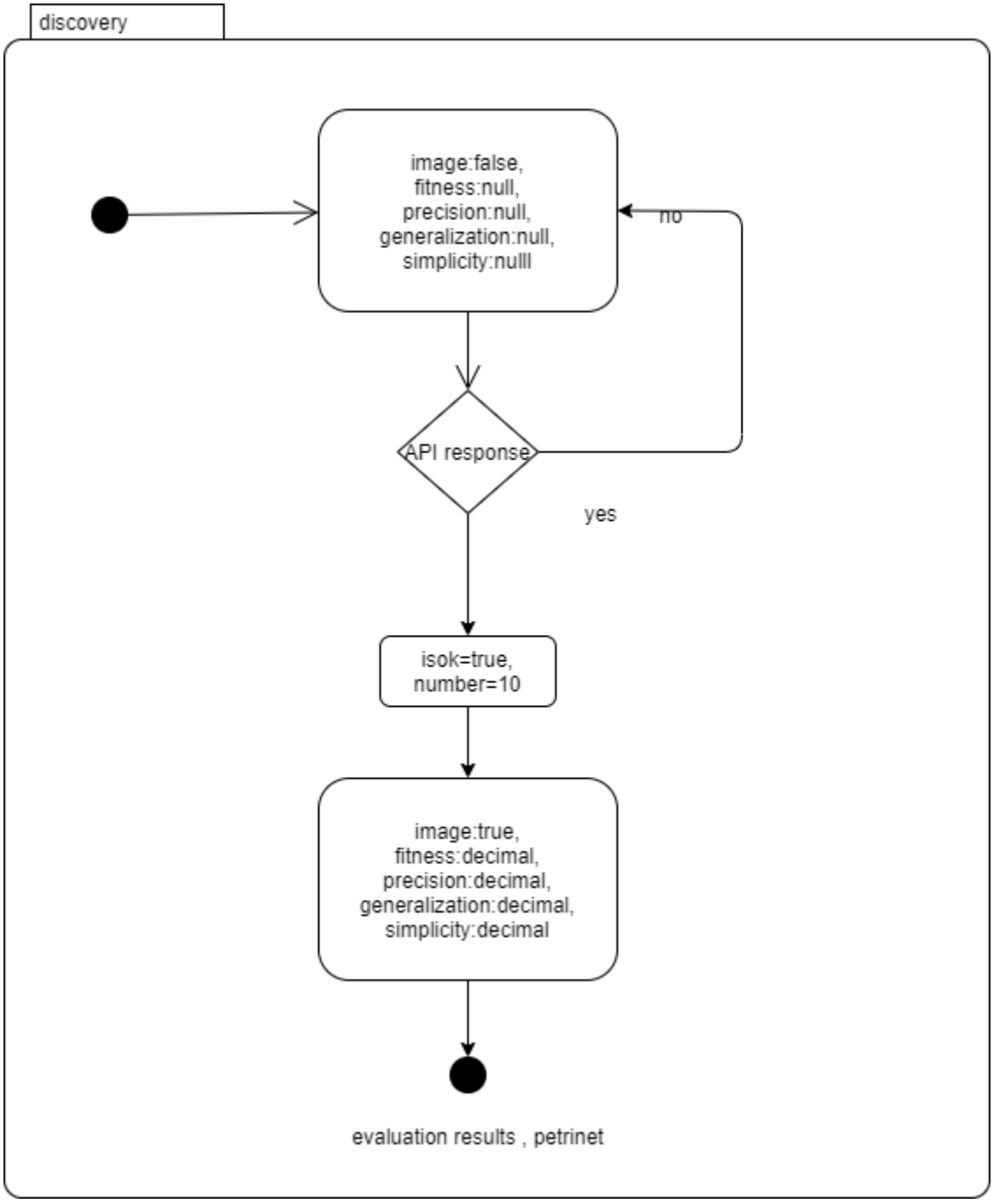


Image 3.24: Discovery State

3.3.4 Conformance Menu

When the user hovers the menu Conformance then he can select the option replay results or alignments

In case the user selects replay results, then a dropdown appears with the three discovery models (alpha miner, Inductive Miner, Heuristics Miner) as option. If the file is csv, then the other four dropdowns from header select will appear in this screen as well.

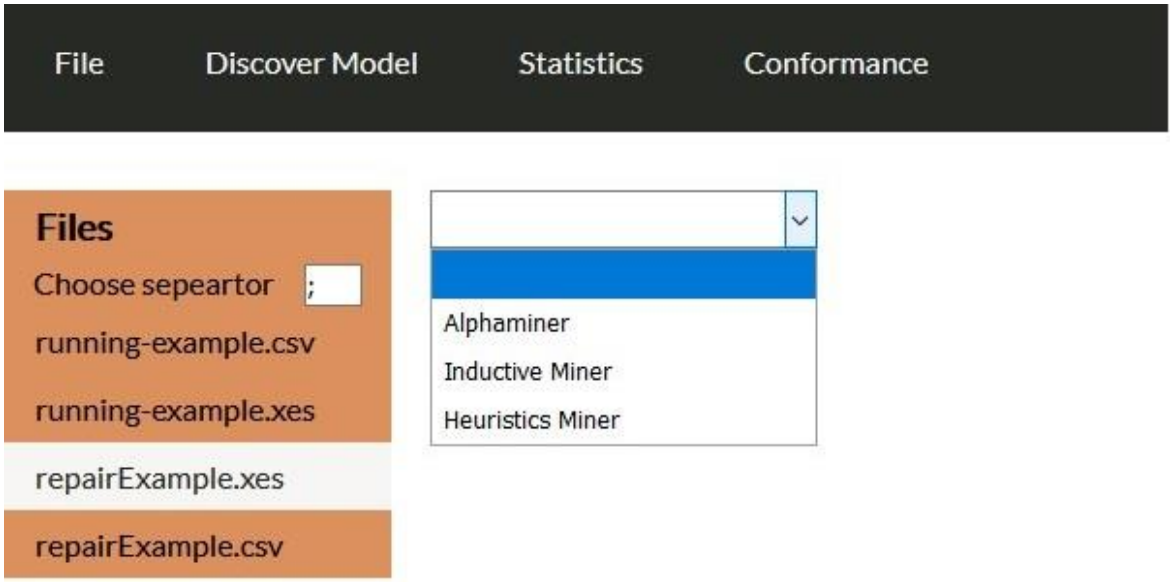
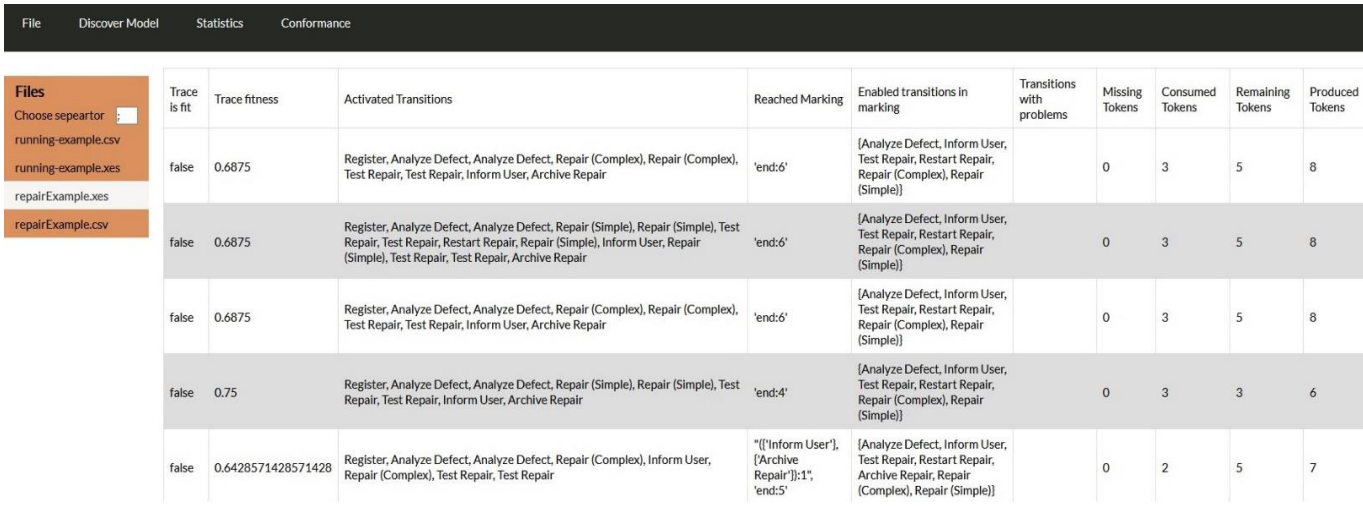


Image 3.25: Conformance menu

When the user selects one of the three algorithms then a table appears with the following data

- Trace is fit
- Trace fitness
- Activated Transitions
- Reached Marking
- Enabled transitions in marking
- Transitions with problems
- Missing Tokens
- Consumed Tokens
- Remaining Tokens
- Produced Tokens



Trace is fit	Trace fitness	Activated Transitions	Reached Marking	Enabled transitions in marking	Transitions with problems	Missing Tokens	Consumed Tokens	Remaining Tokens	Produced Tokens
false	0.6875	Register, Analyze Defect, Analyze Defect, Repair (Complex), Repair (Complex), Test Repair, Test Repair, Inform User, Archive Repair	'end:6'	{Analyze Defect, Inform User, Test Repair, Restart Repair, Repair (Complex), Repair (Simple)}		0	3	5	8
false	0.6875	Register, Analyze Defect, Analyze Defect, Repair (Simple), Repair (Simple), Test Repair, Test Repair, Restart Repair, Repair (Simple), Inform User, Repair (Simple), Test Repair, Test Repair, Archive Repair	'end:6'	{Analyze Defect, Inform User, Test Repair, Restart Repair, Repair (Complex), Repair (Simple)}		0	3	5	8
false	0.6875	Register, Analyze Defect, Analyze Defect, Repair (Complex), Repair (Complex), Test Repair, Test Repair, Inform User, Archive Repair	'end:6'	{Analyze Defect, Inform User, Test Repair, Restart Repair, Repair (Complex), Repair (Simple)}		0	3	5	8
false	0.75	Register, Analyze Defect, Analyze Defect, Repair (Simple), Repair (Simple), Test Repair, Test Repair, Inform User, Archive Repair	'end:4'	{Analyze Defect, Inform User, Test Repair, Restart Repair, Repair (Complex), Repair (Simple)}		0	3	3	6
false	0.6428571428571428	Register, Analyze Defect, Analyze Defect, Repair (Complex), Inform User, Repair (Complex), Test Repair, Test Repair	"({'Inform User'}, {'Archive Repair'}):1", 'end:5'	{Analyze Defect, Inform User, Test Repair, Restart Repair, Archive Repair, Repair (Complex), Repair (Simple)}		0	2	5	7

Image 3.26: Replay results site

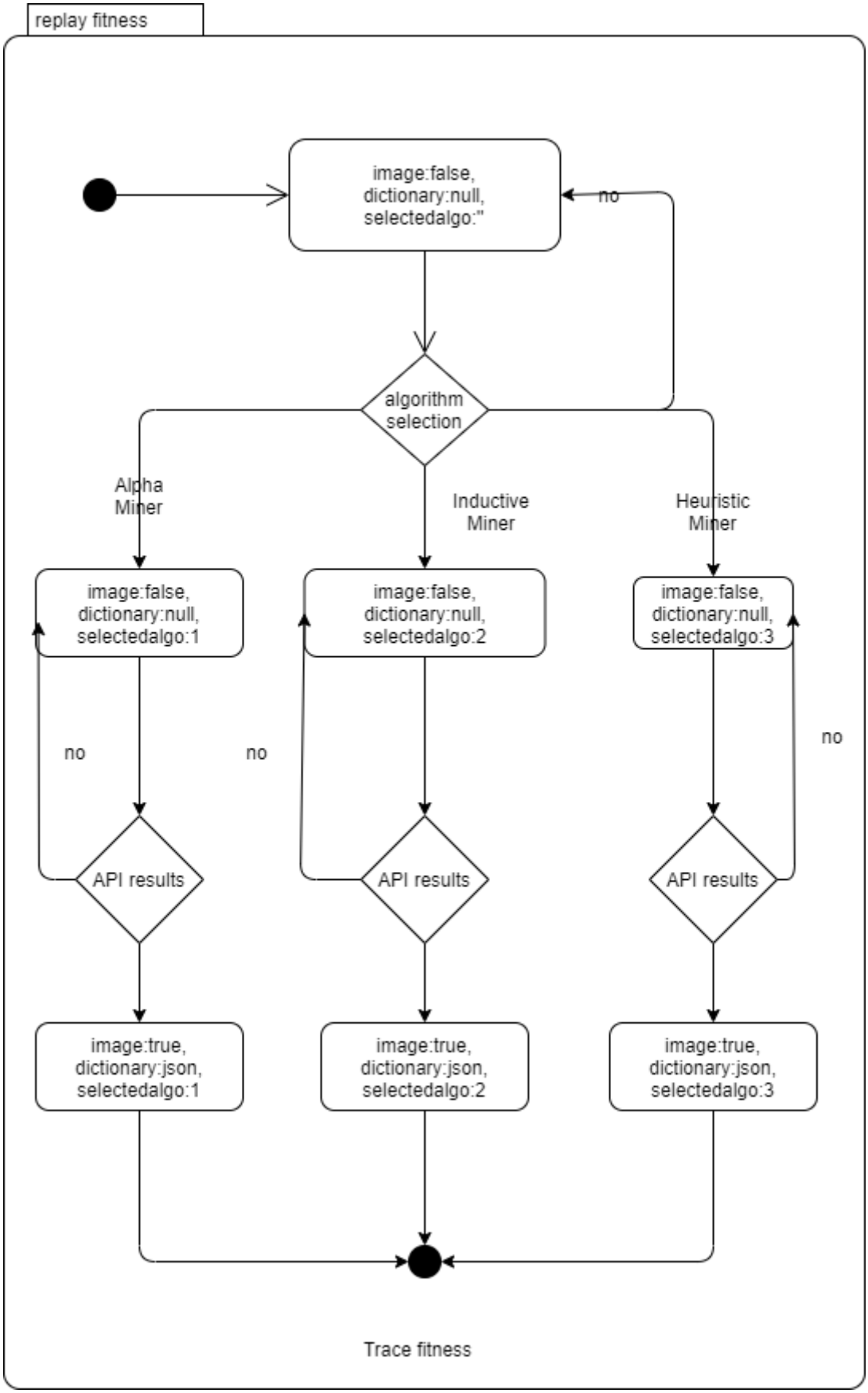


Image 3.27: Replay Fitness State

In case the user selects the other option (alignments) then the same dropdown appears with the discovery models as option. When the user selects one algorithm then a lot of tables appear, each one with two rows so the user can tell if the trace is fit on the process model.

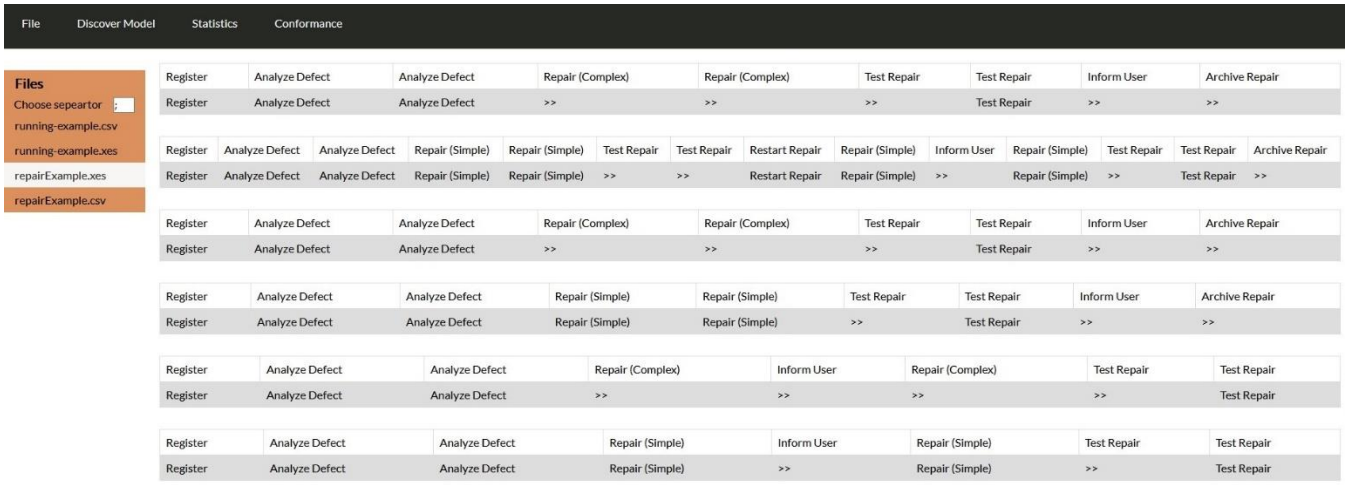


Image 3.28: Alignments site

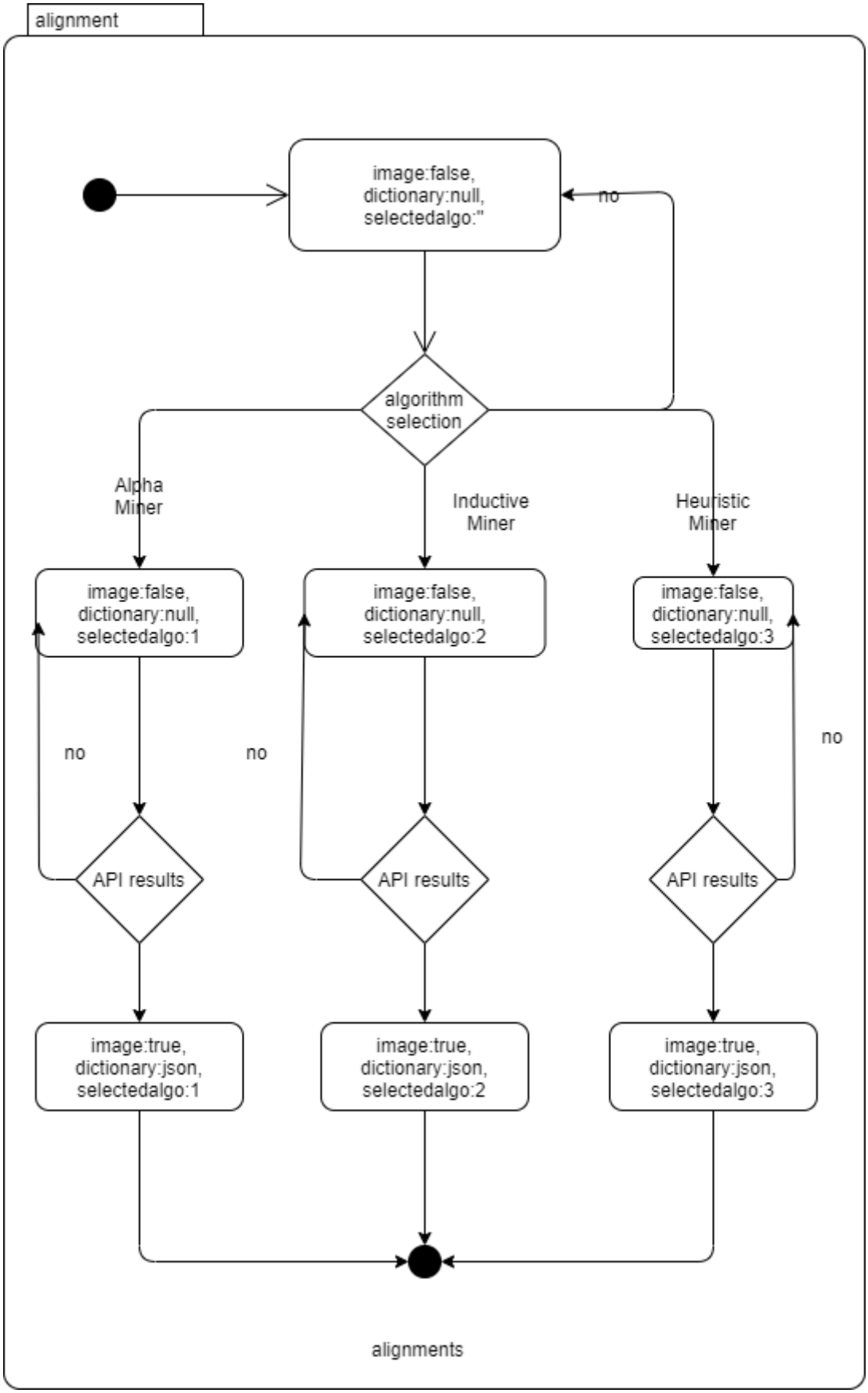


Image 3.29: Alignment state

3.4 System Walkthrough

For this Walkthrough I used the file running-example.xes which can be found in the following link https://github.com/pm4py/pm4py-ws/blob/master/files/event_logs/running-example.xes

- File upload

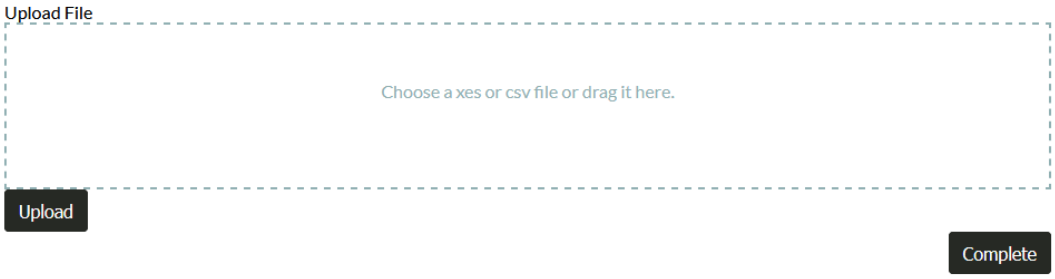


Image 3.30: Running example file upload

Image 3.31: Running example file upload selected

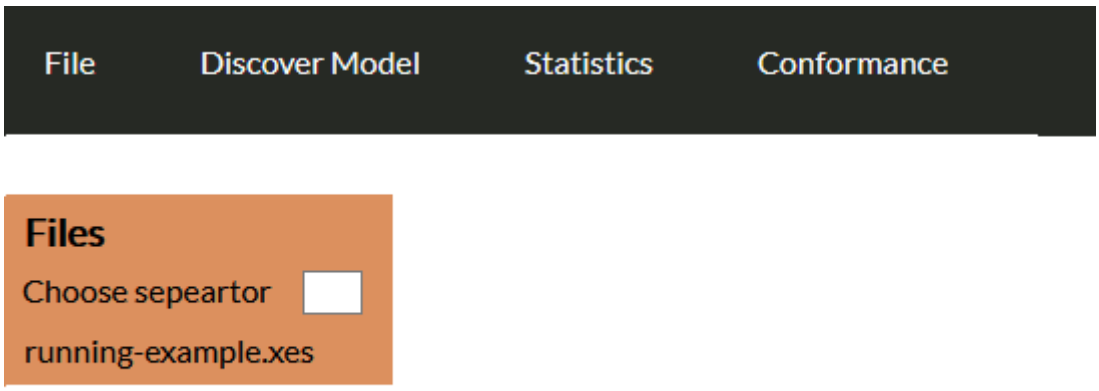


Image 3.32: Running example file uploaded

- Convert to csv

Image 3.33: Running example convert to csv

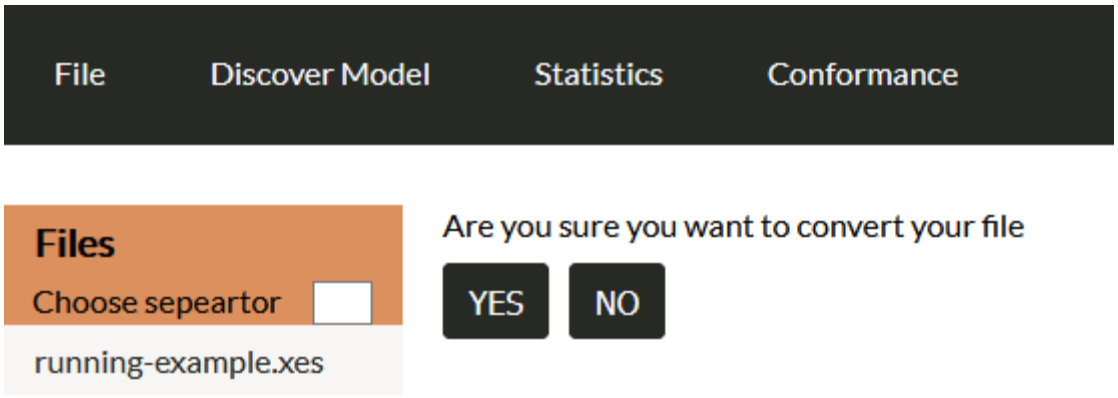


Image 3.34: Running example convert to csv question

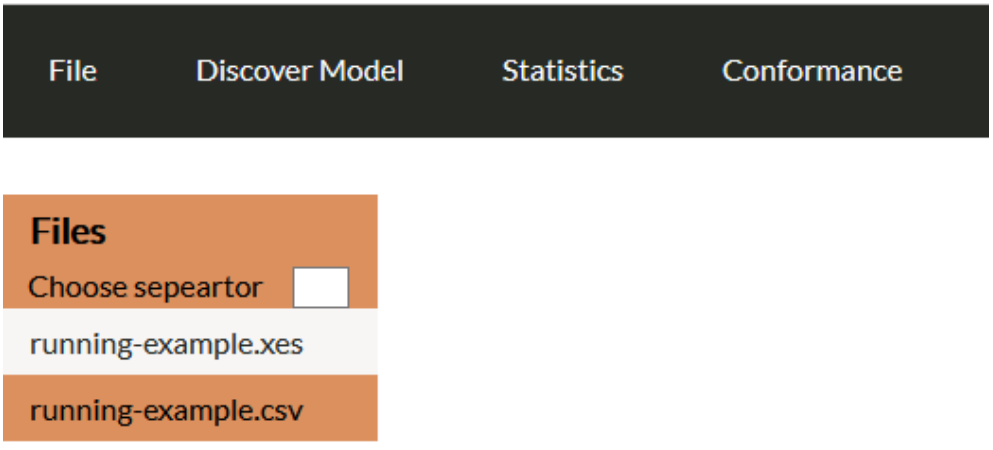


Image 3.35: Running example csv converted

- View

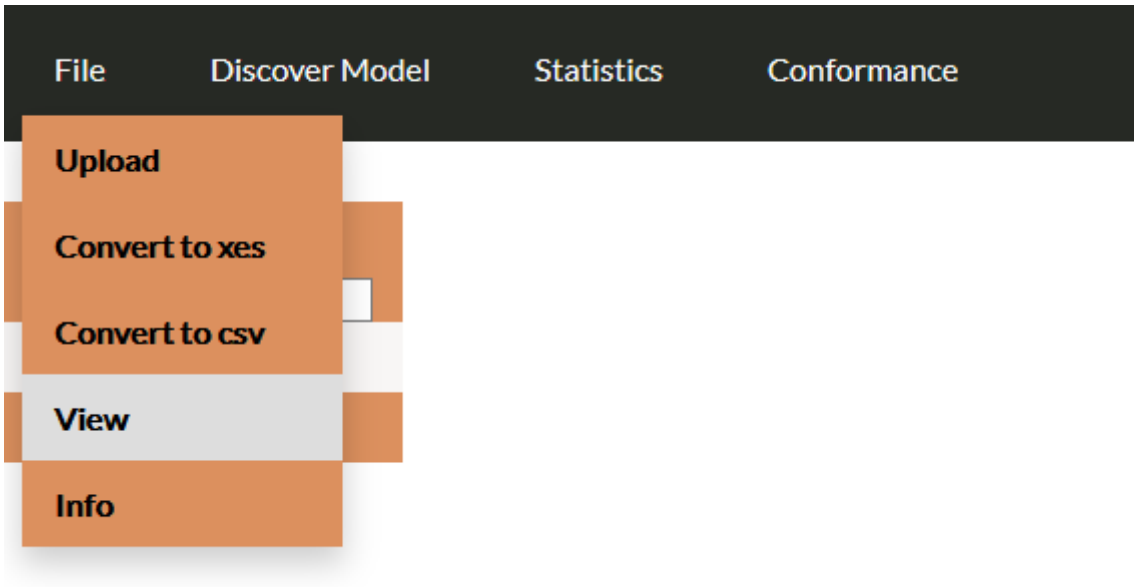


Image 3.36: Running example view

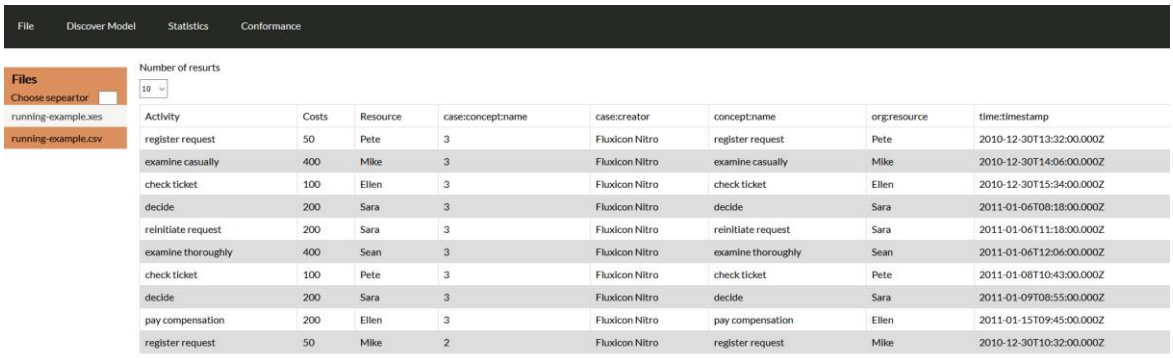


Image 3.37: Running example rows

- Info

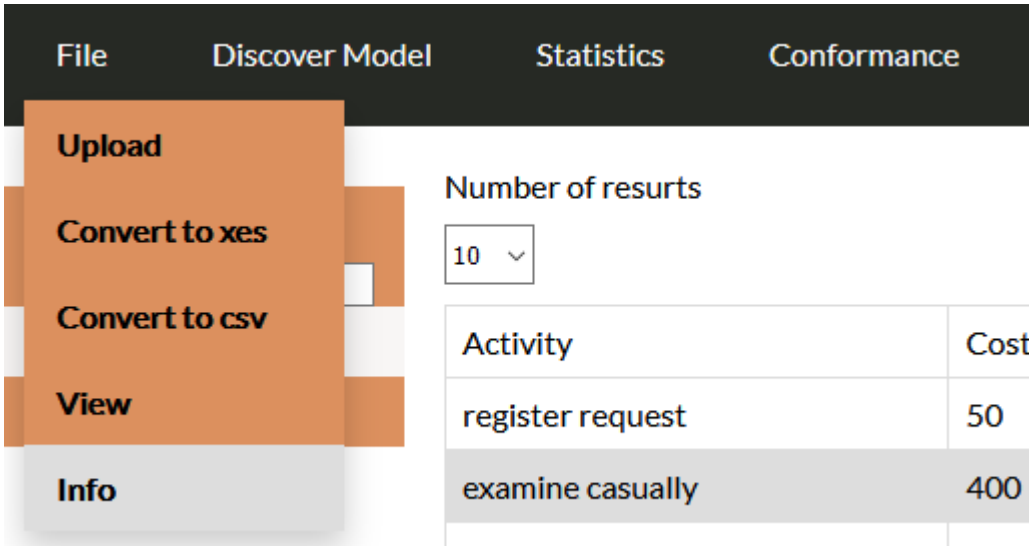


Image 3.38: Running example information menu

Number of traces = 6

Number of events = 42

Structure = concept:name: creator

Events:

Name	Number of Events	Percentage
check ticket	9	21.429 %
decide	9	21.429 %
examine casually	6	14.286 %
examine thoroughly	3	7.143 %
pay compensation	3	7.143 %
register request	6	14.286 %
reinitiate request	3	7.143 %
reject request	3	7.143 %

Start Events:

Name	Number of Events	Percentage
register request	6	14.286 %

End Events:

Name	Number of Events	Percentage
pay compensation	3	7.143 %
reject request	3	7.143 %

Image 3.39: Running example information

- Alpha Miner

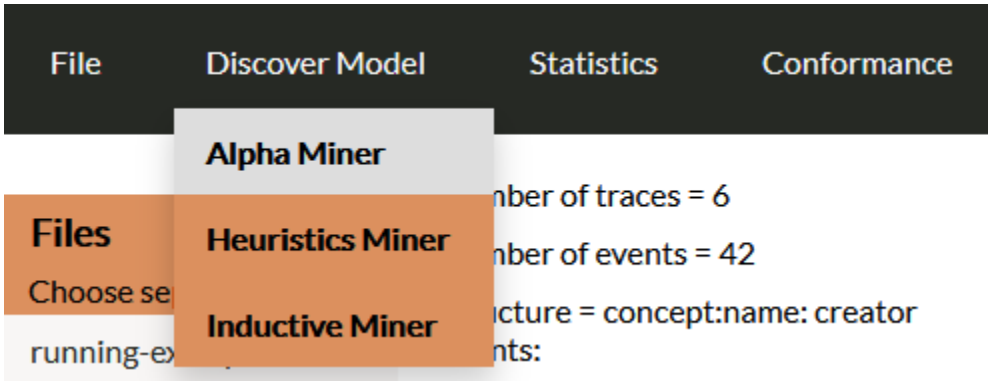


Image 3.40: Running example discovery menu

Log Fitness	1
Log Precision	0.7530864197530864
Generalization	0.5259294594558881
Simplicity	0.6521739130434783

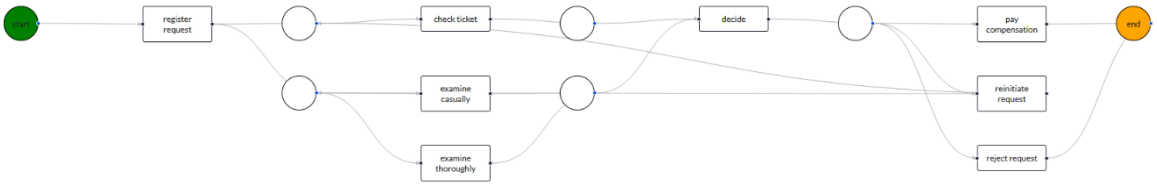


Image 3.41: Running example Alpha Miner

- Heuristics Miner

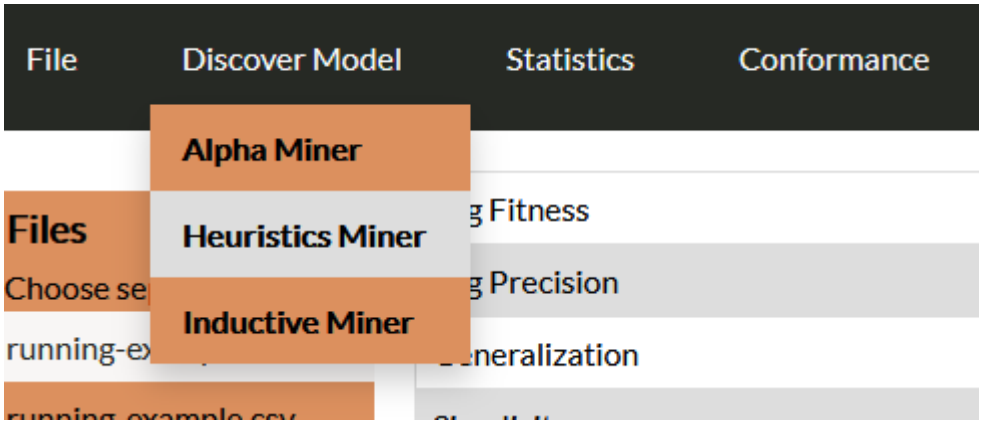


Image 3.42: Running example Heuristics Miner Menu

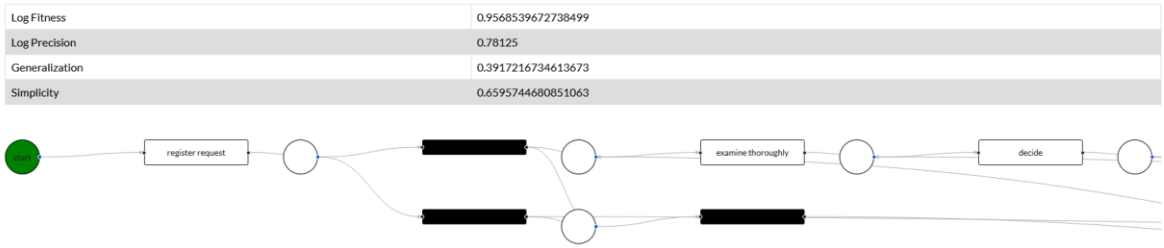


Image 3.43: Running example Heuristics Miner

- Inductive Miner

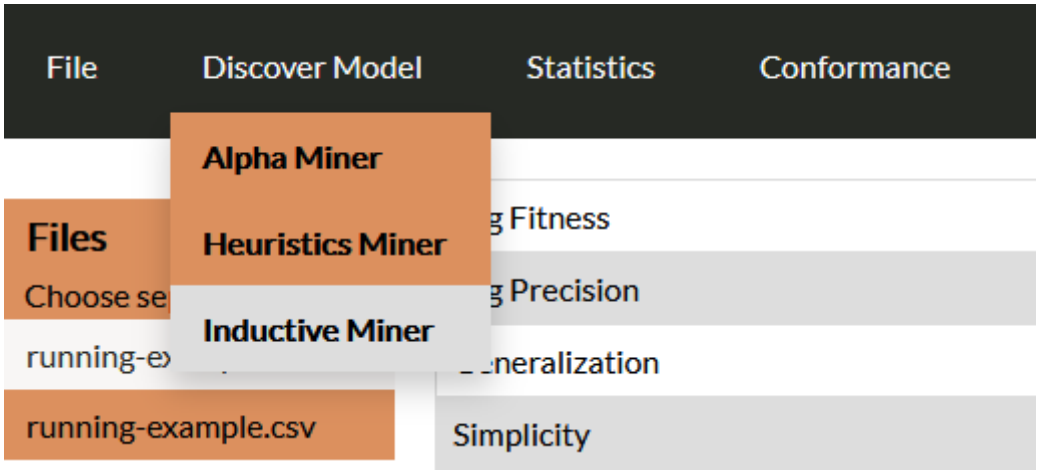


Image 3.44: Running example Inductive Miner Menu

Log Fitness	1
Log Precision	0.7530864197530864
Generalization	0.5465854051849908
Simplicity	0.7599999999999999

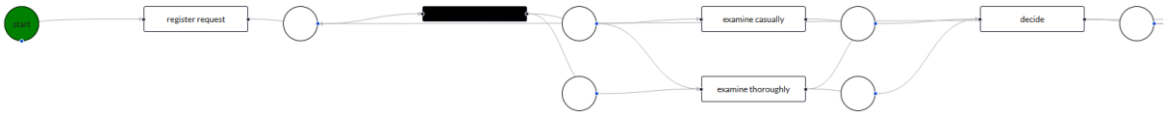


Image 3.45: Running example Inductive Miner

- Replay Results

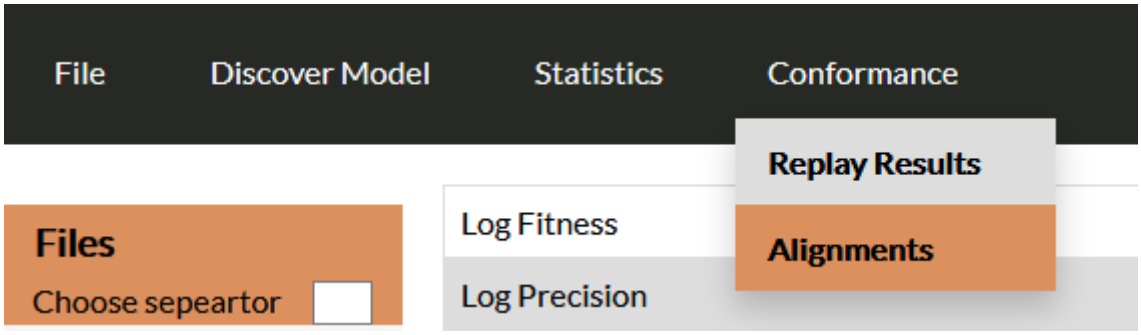


Image 3.46: Replay Results Menu

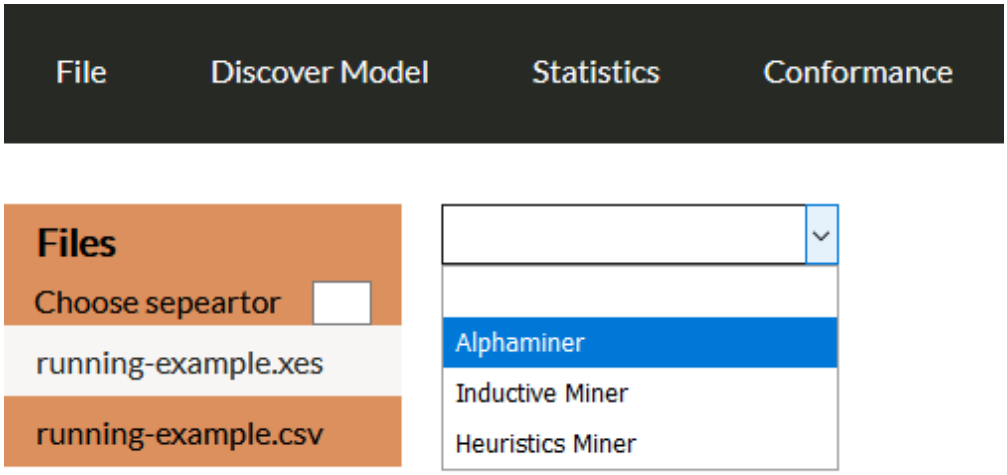


Image 3.47: Running example algorithm selection for replay

Trace is fit	Trace fitness	Activated Transitions	Reached Marking	Enabled transitions in marking	Transitions with problems	Missing Tokens	Consumed Tokens	Remaining Tokens	Produced Tokens
true	1	register request, examine casually, check ticket, decide, reinitiate request, examine thoroughly, check ticket, decide, pay compensation	'end:1'	set()		0	12	0	12
true	1	register request, check ticket, examine casually, decide, pay compensation	'end:1'	set()		0	7	0	7
true	1	register request, examine thoroughly, check ticket, decide, reject request	'end:1'	set()		0	7	0	7
true	1	register request, examine casually, check ticket, decide, pay compensation	'end:1'	set()		0	7	0	7
true	1	register request, examine casually, check ticket, decide, reinitiate request, check ticket, examine casually, decide, reinitiate request, examine casually, check ticket, decide, reject request	'end:1'	set()		0	17	0	17
true	1	register request, check ticket, examine thoroughly, decide, reject request	'end:1'	set()		0	7	0	7

Image 3.48: Running example Replay Results

- Alignments

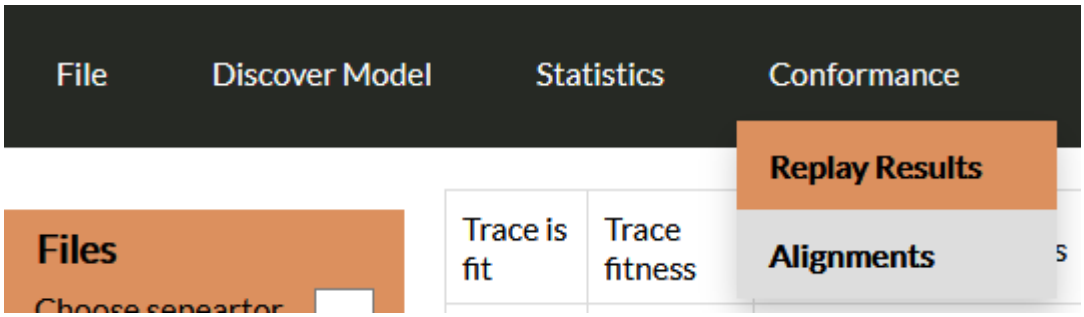


Image 3.49: Running example Alignments menu

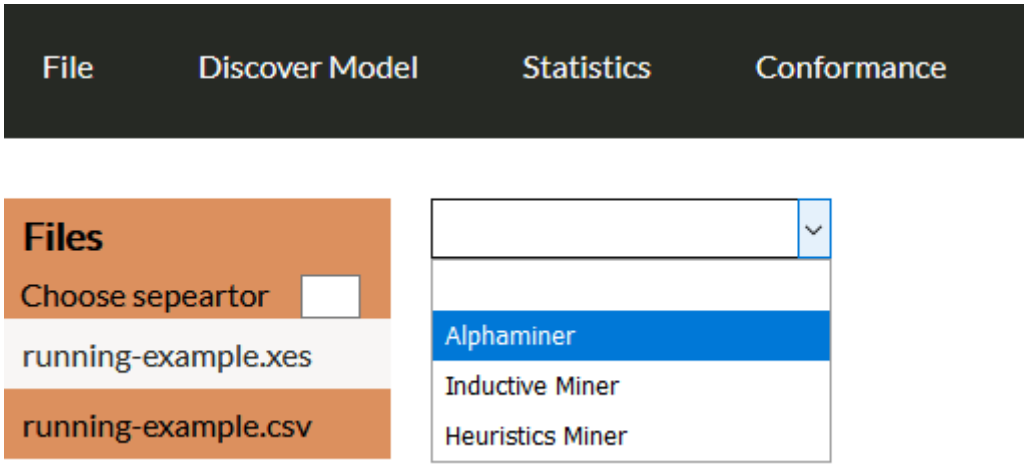


Image 3.50: Running example algorithm select for alignments

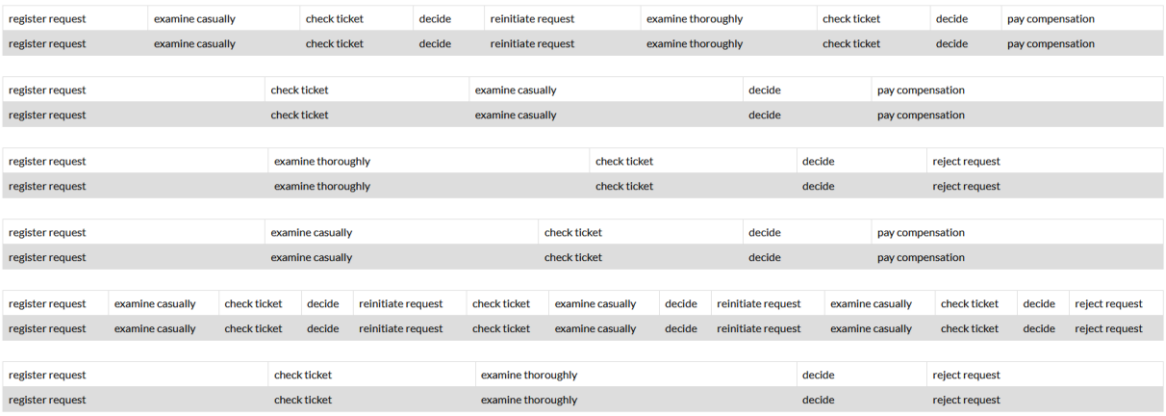


Image 3.51: Running example Alignments

CHAPTER 4

CONCLUSION

This master thesis deals with the development of a web service application (web API) for process mining. As I mentioned in chapter two the API is developed with python and pm4py library. The user can easily call the end point and get response for many functions. He can get json information of the file with one endpoint (number of traces, number of events, events of file, start and end events) instead of calling each pm4py function and he can also get percentage of each event of file. He can also get xes files content in a json objects. Instead of getting the petri net's image

from p4mpy he can get as json objects all the information needed to draw his own petri net and instead of using different functions to get each algorithms evaluation he now gets four json objects.

This master thesis also deals with the development of a web interface to represent the json data from API's response. The interface is created for the user that don't want to hit an endpoint to get Json results but want visualized responses of their actions. The interface is user-friendly, easily accessible and easy to navigate. The only thing the user has to do is to upload a file for process mining and then he views the contents of his file as table rows, event information as table rows, evaluation for a specific algorithm as table rows, a petri net that is not static but he can even drag places and transitions on screen and conformance results in table rows.

In addition, because the project is agile, future recommendations can easily be implemented either on API or interface. If in the future it is decided to create a new web interface, the API can be reused. One suggestion is to do conformance checking using a standard petri net and choosing a log file to run on top of it. A way to do this, is to make every edge between the nodes animated for (example change the color of the edge) when a token passed by, so the user can understand the path of each token. Another future recommendation is to create a login form for the web interface and an authenticate function in the API. Finally, colleagues can easily implement their own process mining functions to the API and create a web page to show their results.

Appendix

Appendix A) Upload / Save file

Server Side:

```
file = request.files['file']    #the file react sends
filename = file.filename #name of react sends
splitedfile = filename.split('.')
if(splitedfile[len(splitedfile)-1]) =='xes' or
(splitedfile[len(splitedfile)-1]) =='csv':
#we only save on server side xes csv files
        if not os.path.exists('filesfolder/'):
        #create folder if doesn't exist
                 os.makedirs('filesfolder/')
                        if path.exists('filesfolder/'+filename):
                #overwrite file if exists
                 os.remove('filesfolder/'+filename)
        file.save('filesfolder/'+filename)  #save file
APIresults = [{'filename':str(filename)}]
response = jsonify(APIresults)
response.headers.set('Access-Control-Allow-Origin', '*')
return response;
```

Client Side:

```
StatechangeFileDone = event => {
        if(this.file.filename!==null){
                this.sendData();
                if (this.file.filename.includes('xes')){
//value of xes files in dictionary is true else false
                this.userfiles.allfiles[this.file.filename]=true
                }else{
                this.userfiles.allfiles[this.file.filename]=false
                }

                this.setState({ fileforupload: false});
//change state when file is uploaded
                const data = new FormData();
                data.append('file', this.file.selectedfile);
                data.append('filename',this.file.filename);
                fetch('http://127.0.0.1:5000/savefile', {
                method: 'POST',
                body: data,
                })
                this.file.filename=null;
                this.file.selectedfile=null;
              }
     }
```

Appendix B) Convert Csv File

Server Side:

```
if request.method == 'POST':
            csvinput = request.form.get('filename')
            case_concept_name = str(request.form.get('caseconcept'))
            time_timestamp = str(request.form.get('timestamp'))
            concept_name = str(request.form.get('conceptname'))
            start_event = str(request.form.get('startevent'))
            seperator = str(request.form.get('seperator'))
        if request.method == 'GET':
            if (request.args.get('filename') is None) or
            (request.args.get('seperator') is None) or
            (request.args.get('caseconcept') is None) or
            (request.args.get('timestamp') is None) or
            (request.args.get('conceptname') is None) or
            (request.args.get('startevent') is None):
                 return badrequest();
            csvinput = str(request.args.get('filename'))
            case_concept_name = str(request.args.get('caseconcept'))
            time_timestamp = str(request.args.get('timestamp'))
            concept_name = str(request.args.get('conceptname'))
            start_event = str(request.args.get('startevent'))
            seperator = str(request.args.get('seperator'))

        if ".csv" not in csvinput:
                  return badrequest();
        log = ""
        dataframe = None
        start = csvinput.replace('.csv', '')
        if path.exists('filesfolder/'+csvinput):
            log_file_path = 'filesfolder/'+csvinput
            log = pd.read_csv(log_file_path, sep=seperator)
            dataframe=pm4py.convert_to_dataframe(log)
            dataframe.rename(columns={case_concept_name:
            'case:concept:name'}, inplace=True)
            dataframe.rename(columns={time_timestamp: 'time:timestamp'},
            inplace=True)
            dataframe.rename(columns={concept_name: 'concept:name'},
            inplace=True)
            dataframe.rename(columns={start_event: 'start_event'},
            inplace=True)
            log=pm4py.convert_to_event_log(dataframe)

            if path.exists('filesfolder/'+start + '.xes'):
                os.remove('filesfolder/'+start + '.xes')
            pm4py.write_xes(log,'filesfolder/'+ start+".xes")

            APIresults = [{'xesname':str(start + '.xes')}]
            response = jsonify(APIresults)
            response.headers.set('Access-Control-Allow-Origin', '*')
            return response;
        else:
             return filenotfound();
```

Client Side:

```
converttostate = () => {
      const data = new FormData();
```

```
      data.append('filename',this.props.data);   //send filename to API
      var caseconcept = document.getElementById('caseconcept').value;
//get values of dropdown
      var start_event = document.getElementById('start_event').value;
      var timestamp = document.getElementById('timestamp').value;
      var conceptname = document.getElementById('conceptname').value;
      data.append('caseconcept',caseconcept);
      data.append('startevent',start_event);
      data.append('timestamp',timestamp);
      data.append('conceptname',conceptname);
      data.append('seperator',this.props.value.seperator);
      fetch('http://127.0.0.1:5000/convertoxes', {
                                        method: 'POST',
                                        body: data,
      }).then(response => (response.json()))
        .then(data => {
            if (data[0].error===undefined){
            this.props.parentCallback(data[0].xesname);
            var url =  window.location.href;
            url = url.replace("toxes", "mainmenu");
            window.location.href = url;}
//redirect to main menu after convertion
      });
    }
```

Appendix C) Convert Xes File

Server Side:

```
if request.method == 'POST':
            xes = request.form.get('filename')
if request.method == 'GET':
            if request.args.get('filename') is None:
                 return badrequest();
            xes = request.args.get('filename')
        if ".xes" not in xes:   #file is not xes
            return badrequest();
        if xes is not None:
            start = xes.replace('.xes', '')
            if path.exists('filesfolder/'+xes): #if it exists on server
                    log = pm4py.read_xes('filesfolder/'+xes)    #get log
                    dataframe = pm4py.convert_to_dataframe(log)
#convert it to dataframe
                    if path.exists('filesfolder/'+start + '.csv'):
#overwrite if exists
                        os.remove('filesfolder/'+start + '.csv')
                    dataframe.to_csv('filesfolder/'+start +
'.csv',index=False,na_rep='false')  #convert to csv
                    APIresults = [{'csvname':str(start + '.csv')}]
                    response = jsonify(APIresults)
                    response.headers.set('Access-Control-Allow-Origin',
'*')
                    return response
            else:
                 return filenotfound();
```

Client Side:

```
converttostate = () => {
      const data = new FormData();
      data.append('filename',this.props.data);
```

```
//send filename to API to convert it
      fetch('http://127.0.0.1:5000/convertocsv', {
                                          method: 'POST',
                                          body: data,
      }).then(response => (response.json()))
        .then(data => {
            if (data[0].error===undefined){
            this.props.parentCallback(data[0].csvname);
            var url =  window.location.href;
            url = url.replace("tocsv", "mainmenu");
            window.location.href = url;//redirect to mainmenu after the
file convertion
        }
      });
    }
```

Appendix D) View File

Server Side:

```
if request.method == 'POST':
             xes = request.form.get('filename')
         if request.method == 'GET':
             xes = request.args.get('filename')
             if (request.args.get('filename')  is None) :
                    return badrequest();
         if ".xes" not in xes: #if file is not xes
             return badrequest();
         if not path.exists('filesfolder/'+xes):
#if file does not exist on server
            return filenotfound();
         splited = xes.split(".")
         log = pm4py.read_xes('filesfolder/'+xes)  #get log from file
         dataframe = pm4py.convert_to_dataframe(log)
  #convert to dataframe
         dataframedict =
dataframe.to_json(orient="index",date_format='iso')
         parsed = json.loads(dataframedict)
         if splited[len(splited)-1] == 'xes':
                apiresults = [
                    {
                     'view':parsed
                    }
                    ]

                response = jsonify(apiresults)
                response.headers.set('Access-Control-Allow-Origin', '*')
                response.headers.set('cache-control', 'public,max-
age=0')
                return response;
```

Client Side:

```
StateImage = () => {
        const data = new FormData();
        data.append('filename',this.props.data);
        fetch('http://127.0.0.1:5000/view', {
                                                    method: 'POST',
                                                    body: data,
```

```
                  }).then(response => (response.json()))
                  .then(data => {
                    if (data[0].error===undefined){
                              this.view.dict= data[0].view;
                              this.setState({isok:true}); //when the
API returns data with the content of file
                    }
                  });

       }

function builddf(dictionary,resultsno){
    var header=[];
    var body=[];
    var tempinside=[];
    const  htmlhead=[];
    const  dataframe=[];
    const  thead = 'stat_';
    var key='';
    var headersaresok=false;
    var counter=0;

    for (var i in dictionary){
        if (resultsno!==-1){
            if(counter===resultsno){
 //shows results until number of dropdown
                break;
            }
        }
        if(headersaresok===false){  //headers of file
            for (const [key] of Object.entries(dictionary[i])) {
                header.push(<td key={i}>{key}</td>);
             }
             headersaresok=true;
        }

        for (var j in dictionary[i]){   //content of file
            key='td'+i+'_'+j;
            if (dictionary[i][j]!==null){
      tempinside.push(<td key={key}>{dictionary[i][j].toString()}</td>);
            }
            else{
                tempinside.push(<td key={key}></td>);
            }

        }
         counter++;
        key='tr'+i;
        body.push(<tr key={key}>{tempinside}</tr>)
        tempinside=[];
    }
htmlhead.push(<thead key={thead}><tr key='0'>{header}</tr></thead>)
const tablekey='table_';
dataframe.push(<table key={tablekey}
className='resultstable'>{htmlhead}<tbody>{body}</tbody></table>)
return dataframe;
}
```

Appendix E) File Statistics

Server Side:

```
def firstassignment(log):
    dataframe = None
    stream = converter.apply(log,
variant=converter.Variants.TO_EVENT_STREAM)
    dataframe = pm4py.convert_to_dataframe(log)

    lenlog = len(log)   #length of log
    lenevent = len(stream)  #number of events
    trace_list = []


    for trace in log:
        trace_list.append(str(list(trace.attributes.keys())))
    unique_trace_list=set(trace_list)  #trace list

    dictionary = dict()
    array=1

    dataframe=dataframe.sort_values('concept:name')

    last_value= None
    for event in dataframe['concept:name']:
        if last_value is None:
            last_value=event
        else:
            if not last_value == event:
                 dictionary[last_value] = array;
                 array = 1
                 last_value=event
            else:
                array=array+1
    dictionary[last_value] = array;  #all file events

    end_activities=pm4py.get_end_activities(log)    #end events
    start_activities=pm4py.get_start_activities(log) #start events
    return lenlog, lenevent,unique_trace_list,
start_activities,end_activities,dictionary;
```

Client Side:

```
Infobuild(){

      const data = new FormData();
      data.append('filename',this.props.data);
      fetch('http://127.0.0.1:5000/statistics', {
                                            method: 'POST',
                                            body: data,
      }).then(response => (response.json()))
      .then(data => {

        if (data[0].error===undefined){
      this.statistics.notraces=data[0].notraces;
      this.statistics.noevents=data[0].noevents;
      this.statistics.tracelist=data[0].tracelist;
      this.statistics.events=data[0].dictionary;
```

```
      this.statistics.startactivities=data[0].startactivities;
      this.statistics.endactivities=data[0].endactivities;
      this.setState({done:true}); //when API returns results
        }
    });
    }

function buildevent(dictionary,noevents,number){

    const  eventhtml=[];
    const  htmlhead=[];
    const  htmlbody=[];
    const  thead = 'stat_'+number;
    htmlhead.push(<thead key={thead}><tr
key={`${number}?${0}`}><td>Name</td><td>  Number of Events </td><td>
Percentage </td></tr></thead>)
    for (var i in dictionary) {
                  const trkey='tr_'+number+'_'+i;
                  const trkey2 = trkey+'_2';
                  const trkey3 = trkey+'_3';
                  htmlbody.push(<tr key={`${number}?${i}`}><td
key={trkey}>{i}</td><td key={trkey2}>   {dictionary[i].toString()}
</td><td key={trkey3} >
{(100*parseInt(dictionary[i])/parseInt(noevents)).toFixed(3).toString()}
%</td></tr>)

          }
const tablekey='table_'+number;
eventhtml.push(<table key={tablekey}
className='resultstable'>{htmlhead}<tbody>{htmlbody}</tbody></table>)
    return eventhtml;
  }

function buildactivities(dictionary,notraces,number){
    const  eventhtml=[];
    const  htmlhead=[];
    const  htmlbody=[];
    const  thead = 'stat_'+number;
    htmlhead.push(<thead key={thead}><tr
key={`${number}?${0}`}><td>Name</td><td>  Number of Traces </td><td>
Percentage </td></tr></thead>)
    for (var i in dictionary) {
                  const trkey='tr_'+number+'_'+i;
                  const trkey2 = trkey+'_2';
                  const trkey3 = trkey+'_3';
                  htmlbody.push(<tr key={`${number}?${i}`}><td
key={trkey}>{i}</td><td key={trkey2}>   {dictionary[i].toString()}
</td><td key={trkey3} >
{(100*parseInt(dictionary[i])/parseInt(notraces)).toFixed(3).toString()}
%</td></tr>)

          }
    const tablekey='table_'+number;
        eventhtml.push(<table key={tablekey}
className='resultstable'>{htmlhead}<tbody>{htmlbody}</tbody></table>)
    return eventhtml;
  }
```

Appendix F) Discovery Algorithms

Server Side:

```
if request.method == 'POST':
             xes = request.form.get('filename')
             sitealgo = request.form.get('sitealgo')
         if request.method == 'GET':
             xes = request.args.get('filename')
             sitealgo = request.args.get('algorithm')
             if (request.args.get('filename')  is None) or
            (request.args.get('algorithm') is None):
                    return badrequest();
             if not path.exists('filesfolder/'+xes):
                return filenotfound();
         splited = xes.split(".")
         log = pm4py.read_xes('filesfolder/'+xes)  #get log of xes file
         if splited[len(splited)-1] == 'xes':
                if int(sitealgo) == 1:
#pm4py discover_algo functions for the three algorithms
                    net,initial_marking,final_marking =
discover_algo.discover_petri_net_alpha(log)
                elif int(sitealgo) == 2:
                    net,initial_marking,final_marking =
discover_algo.discover_petri_net_inductive(log)
                elif int(sitealgo) == 3:
                    net,initial_marking,final_marking  =
discover_algo.discover_petri_net_heuristics(log)
                fitnesses= pm4py.evaluate_fitness_tbr(log, net,
initial_marking, final_marking)
                evaluationresult = pm4py.evaluate_precision_tbr(log,
net, initial_marking, final_marking)
                evaluation=evaluation_factory.apply(log, net,
initial_marking, final_marking)  #evalution object
                netplaces=list(net.places)  #petrinet places
                nettransitions=list(net.transitions) #petrinet
transitions
                netarcs=list(net.arcs)  #petrinet arcs
                placeslist = []
                transitionlist =[]
                arcslist = []
                for eachplaces in netplaces:
                     placeslist.append(str(eachplaces))

                for eachtransition in nettransitions:
                     transitionlist.append(str(eachtransition))

                for eacharc in netarcs:
                    arcslist.append(str(eacharc))
                file_path="static/temp.svg"
                savesvgfromalgo.save_vis_petri_net(net, initial_marking,
final_marking,file_path)

                apiresults = [{
'image':'http://127.0.0.1:5000/static/temp.svg',

'log_fitness':evaluation['fitness']['log_fitness'],

'evaluation_result':evaluation['precision'],
```

```
'generalization':evaluation['generalization'],
                                'simplicity':evaluation['simplicity'],
                                'netplaces':placeslist,
                                'nettransitions':transitionlist,
                                'netarcs':arcslist
                                }]                response =
jsonify(APIresults)
                response.headers.set('Access-Control-Allow-Origin', '*')
                response.headers.set('cache-control', 'public,max-
age=0')
                return response;
```

Client Side:

```
StateImage = () => {
        const data = new FormData();
        data.append('filename',this.props.data);
        data.append('sitealgo', '1'); //the same endpoint different
algorithm
        fetch('http://127.0.0.1:5000/getimage', {
                                                        method: 'POST',
                                                        body: data,
                  }).then(response => (response.json()))
                  .then(data => {
                                if (data[0].error===undefined){

                  this.image.nettransitions=data[0].nettransitions;
                                 this.image.netplaces=data[0].netplaces;
                                 this.image.netarcs=data[0].netarcs;
                                 this.image.image=data[0].image;
                                 this.image.imageHash= Date.now();
                                 this.setState({ image:
true,fitness:data[0].log_fitness,precision:data[0].evaluation_result,gen
eralization:data[0].generalization,simplicity:data[0].simplicity});
                                }
                  });

       }

function removestrings(str){
    var newstr=str.replace('(p)','');
    newstr=newstr.replace('(t)','');
    newstr=newstr.trim();
    return newstr;
}


function buildminer(trans,places,arcs){
    var idstring=1;
    var ycount=100;
    var xcount=0;
    var  elements=[];
    var trans_sort_list = trans.sort();
    var transdictionary = {};
    var moved = {};
    transdictionary['start'] = 0;
    transdictionary['end'] = -1;
    for (var x in trans_sort_list)  //Drawing the transitions into graph
    {
```

```
            transdictionary[trans_sort_list[x]] = idstring;
            moved[trans_sort_list[x]]=false;

            elements.push({ id: idstring.toString(),data: { label:
trans_sort_list[x] },style:{width: '100px'},position: { x:xcount,
y:ycount }});

            ycount+=100;
            idstring++;
    }

    xcount+=200;
    ycount=0;
    var places_sort_list = places.sort();
    for ( x in places_sort_list)  //Drawing the places into graph
    {

        if(places_sort_list[x].includes('start')){
            elements.push({id:
transdictionary['start'].toString(),type: 'input',data: { label: 'start'
},position: { x: 0, y: 0 },draggable: false,style:{width: '50px',height:
'50px','border-radius': '50%', 'padding-top': '17px','border-
color':'black','background-color': 'green'} });

        }
        else if(places_sort_list[x].includes('end')){

        }
        else{
            transdictionary[places_sort_list[x]] = idstring;
            elements.push({id: idstring.toString(),type: 'input',data: {
label: ' ' },position: { x: xcount, y: ycount },draggable:
true,style:{width: '50px',height: '50px','border-radius': '50%',
'padding-top': '17px','border-color':'black','background-color':
'white'} });

            idstring++;
        }
        moved[places_sort_list[x]]=false;
        ycount+=100;
    }
    xcount+=200;
    elements.push({id: transdictionary['end'].toString(),type:
'input',data: { label: 'end' },position: { x: 950, y: 0 },draggable:
false,style:{width: '50px',height: '50px','border-radius': '50%',
'padding-top': '17px','border-color':'black','background-color':
'orange'} });

   var  arcs_sort_list = arcs.sort();

    for ( x in arcs_sort_list){
        var left=arcs_sort_list[x].split('->')[0];
        var right=arcs_sort_list[x].split('->')[1];

        elements.push({ id: left.split(',')[0]+'~'+right,  source:
transdictionary[removestrings(left)], target:
transdictionary[removestrings(right)],arrowHeadType:'arrowclosed' });

    }

    var rightelemt=[];
```

```
    for ( x in arcs_sort_list){ //Drawing the arcs into graph
        left=arcs_sort_list[x].split('->')[0];
        right=arcs_sort_list[x].split('->')[1];
        if(removestrings(left).includes('start')){
            rightelemt.push(removestrings(right));
        }
    }
    xcount=200;
    ycount=0;
    for ( x in rightelemt){
        for (var ele in  elements)
        {
            if
(parseInt(elements[ele].id)===parseInt(transdictionary[rightelemt[x]])){
                elements[ele].position={ x: xcount, y: ycount};
                ycount+=100;
            }
        }
    }
    ycount=0;
    xcount+=200;
    if((rightelemt.length>0)){
        for (var y in rightelemt){
            if (!rightelemt[y].includes('end')){

elements=recursive(arcs_sort_list,elements,rightelemt[y],ycount,xcount,t
ransdictionary,moved);  //recursive function to change elements position
from start to end
            }
        }
    }
    return elements;
  }

  function
recursive(arcs_sort_list,elements,rightelemt,ycount,xcount,transdictiona
ry,moved){
    var newrightelemt=[];
    for (var x in arcs_sort_list){
        var left=removestrings(arcs_sort_list[x].split('->')[0]);
        var right=removestrings(arcs_sort_list[x].split('->')[1]);
            if( (left)=== (rightelemt)){

                if (moved[right]===false){
                    newrightelemt.push((right));
                }

            }
    }

    for ( x in newrightelemt){

        for (var ele in  elements)
        {
            if
(parseInt(elements[ele].id)===parseInt(transdictionary[newrightelemt[x]]
)){
                elements[ele].position={ x: xcount, y: ycount};
                moved[newrightelemt[x]]=true;
                ycount+=100;
            }
```

```
        }
    }
    ycount=0;
    xcount+=200;
    var tempyposition=0;
    if (newrightelemt.length>0){
        for (var y in newrightelemt){
            if (!newrightelemt[y].includes('end')){
                for ( ele in  elements)
                {
                    if
(parseInt(elements[ele].id)===parseInt(transdictionary[newrightelemt[y]]
)){

tempyposition=parseInt(elements[ele].position.y);
                    }
                }

elements=recursive(arcs_sort_list,elements,newrightelemt[y],tempypositio
n,xcount,transdictionary,moved);
            }
        }
    }
    return elements;
  }


<div>
      <table>
           <tr>
                <td>
                      Log Fitness
                </td>
                <td>
                      {this.state.fitness}
                </td>
           </tr>
           <tr>
                <td>
                       Log Precision
                </td>
                <td>
                      {this.state.precision}
                 </td>
          </tr>
          <tr>
               <td>
                       Generalization
                </td>
                <td>
                       {this.state.generalization}
                </td>
          </tr>
          <tr>
                <td>
                       Simplicity
                </td>
                <td>
                       {this.state.simplicity}
                </td>
          </tr>
```

```
    </table>
   <div   className="move50"style={{ height: 1001 }}>
                                <ReactFlow  elements={minerhtml}  />
                                </div>

    </div>
```

Appendix G) Get Replay Results

Server Side:

```
try:
         if request.method == 'POST':
             xes = request.form.get('filename')
             sitealgo = request.form.get('sitealgo')
         if request.method == 'GET':
             xes = request.args.get('filename')
             sitealgo = request.args.get('algorithm')
             if (request.args.get('filename')  is None) or
(request.args.get('algorithm') is None):
                    return badrequest();
             if not path.exists('filesfolder/'+xes):
                return filenotfound();
         splited = xes.split(".")
         log = pm4py.read_xes('filesfolder/'+xes)
#get log from xes file
         if splited[len(splited)-1] == 'xes':
 #get net from specific algorithm
                if int(sitealgo) == 1:
                    net,initial_marking,final_marking =
discover_algo.discover_petri_net_alpha(log)
                elif int(sitealgo) == 2:
                    net,initial_marking,final_marking =
discover_algo.discover_petri_net_inductive(log)
                elif int(sitealgo) == 3:
                    net,initial_marking,final_marking  =
discover_algo.discover_petri_net_heuristics(log)
                conftbr =
pm4py.conformance_tbr(log,net,initial_marking,final_marking)
 #Pm4py conformance
                returndict=[]
                for each in conftbr:

tempactivate=str(each['activated_transitions']).replace('[', '')
                    tempactivate=tempactivate.replace(']', '')

tempreached_marking=str(each['reached_marking']).replace('[', '')
                    tempreached_marking=tempreached_marking.replace(']',
'')

temptransitions_with_problems=str(each['transitions_with_problems']).rep
lace('[', '')

temptransitions_with_problems=temptransitions_with_problems.replace(']',
'')
                                        #Jsons we need to show on site
                    tempdict= {
                                    'trace_is_fit': each['trace_is_fit'],
```

```
                                    'trace_fitness':
each['trace_fitness'],
                                    'activated_transitions':
tempactivate,
                                    'reached_marking':
tempreached_marking,
                                    'enabled_transitions_in_marking':
str(each['enabled_transitions_in_marking']),

'transitions_with_problems':temptransitions_with_problems,
                                    'missing_tokens':
each['missing_tokens'],
                                    'consumed_tokens':
each['consumed_tokens'],
                                    'remaining_tokens':
each['remaining_tokens'],

'produced_tokens':each['produced_tokens']
                                }
                    returndict.append(tempdict)
                apiresults = [{ 'dictionary': returndict }]
                response = jsonify(apiresults)
                response.headers.set('Access-Control-Allow-Origin', '*')
                response.headers.set('cache-control', 'public,max-
age=0')
                return response;
```

Client Side:

```
StateImage = () => {
        const data = new FormData();
        data.append('filename',this.props.data);
        data.append('sitealgo', this.state.selectedalgo);
        fetch('http://127.0.0.1:5000/getreplayresults', {
                                                        method: 'POST',
                                                        body: data,
                  }).then(response => (response.json()))
                  .then(data => {
                                if (data[0].error===undefined){

this.setState({ image: true,dictionary:data[0].dictionary});
                                }
                  });

       }


function buildevent(dictionary){  ///converts API response into table

      var obj = dictionary;
      const  eventhtml=[];
      const  htmlhead=[];
      const  htmlbody=[];
      const  thead = 'stat';
      htmlhead.push(<thead key={thead}><tr key={0}><td>Trace is
fit</td><td>  Trace fitness </td><td> Activated Transitions </td><td>
Reached Marking </td>
      <td>Enabled transitions in marking</td><td>Transitions with
problems</td><td>Missing Tokens</td><td>Consumed
Tokens</td><td>Remaining Tokens</td><td>Produced
Tokens</td></tr></thead>)
```

```
     for ( var i=0;i<obj.length;i++) {
                  const trkey='tr_'+i;
                  const trkey2 = trkey+'_2';
                  const trkey3 = trkey+'_3';
                  const trkey4 = trkey+'_4';
                  const trkey5 = trkey+'_5';
                  const trkey7 = trkey+'_7';
                  const trkey8 = trkey+'_8';
                  const trkey9 = trkey+'_9';
                  const trkey10 = trkey+'_10';
                  const trkey11 = trkey+'_11';
                  htmlbody.push(<tr key={i}><td
key={trkey}>{obj[i].trace_is_fit.toString()}</td><td key={trkey2}>
{obj[i].trace_fitness} </td><td key={trkey3} >
{obj[i].activated_transitions}  </td>
                  <td key={trkey4}>{obj[i].reached_marking}</td><td
key={trkey5}>{obj[i].enabled_transitions_in_marking}</td><td
key={trkey7}>{obj[i].transitions_with_problems}</td>
                  <td key={trkey8}>{obj[i].missing_tokens}</td><td
key={trkey9}>{obj[i].consumed_tokens}</td><td
key={trkey10}>{obj[i].remaining_tokens}</td><td
key={trkey11}>{obj[i].produced_tokens}</td></tr>)
               }
     const tablekey='table';
     eventhtml.push(<table key={tablekey}
className='resultstable'>{htmlhead}<tbody>{htmlbody}</tbody></table>)
    return eventhtml;

  }
```

Appendix H) Get Alignments

Server Side:

```
if request.method == 'POST':
             xes = request.form.get('filename')
             sitealgo = request.form.get('sitealgo')
         if request.method == 'GET':
             xes = request.args.get('filename')
             sitealgo = request.args.get('algorithm')
             if    (request.args.get('filename')        is    None)    or
(request.args.get('algorithm') is None):
                    return badrequest();
             if not path.exists('filesfolder/'+xes):
                return filenotfound();
         splited = xes.split(".")
         log = pm4py.read_xes('filesfolder/'+xes)  #get log from xes
         if splited[len(splited)-1] == 'xes':
                if int(sitealgo) == 1:  #get net from specific algorithm
                    net,initial_marking,final_marking                    =
discover_algo.discover_petri_net_alpha(log)
                elif int(sitealgo) == 2:
                    net,initial_marking,final_marking                    =
discover_algo.discover_petri_net_inductive(log)
                elif int(sitealgo) == 3:
                    net,initial_marking,final_marking                    =
discover_algo.discover_petri_net_heuristics(log)
```

```
                alignments                                                  =
pm4py.conformance_alignments(log,net,initial_marking,final_marking)
#get conformance aligments
                # pretty_print_alignments(alignments)
                returndict=[]
                for each in alignments:
                    tempdict= {
                                'alignment': each['alignment']
                    }
                    returndict.append(tempdict)
                apiresults = [{ 'dictionary': returndict }]
                response = jsonify(apiresults)
                response.headers.set('Access-Control-Allow-Origin', '*')
                response.headers.set('cache-control', 'public,max-age=0')
                return response;
```

Client Side:

```
StateImage = () => {
        const data = new FormData();
        data.append('filename',this.props.data);
        data.append('sitealgo', this.state.selectedalgo);
        fetch('http://127.0.0.1:5000/getalignments', {
                                                        method: 'POST',
                                                        body: data,
                  }).then(response => (response.json()))
                  .then(data => {
                                if (data[0].error===undefined){

this.setState({ image: true,dictionary:data[0].dictionary});
                                }
                  });

       }


function buildevent(dictionary){

      var obj = dictionary; //gets reponse from API
      var returnhtml = [];
      for ( var i=0;i<obj.length;i++) {
        returnhtml.push(<div
className="pdropwdown">{buildsinglealignemnt(obj[i].alignment,i)}</div>)
; //creates a single table for every object of dictionary
      }


    return returnhtml;

  }

var key=0;
function buildsinglealignemnt(step_list,number){
  var trace_steps=[];
  var model_steps=[];
  var max_label_length = 0;
  var rethtml=[];
  var rethtml2=[];
  var dividerhtml=[];
  var step=[];
  var splitstep = step_list.toString().split(',');
```

```
  var i,j;
  for (i=0;i<splitstep.length;i+=2){
    step.push(splitstep[i]+','+splitstep[i+1]);
  }
  for (i=0;i<step.length;i++)
  {
    var insidesplitstep=step[i].toString().split(',');
    trace_steps.push(" " + insidesplitstep[0].toString() + " ")
    model_steps.push(" " +  insidesplitstep[1].toString()  + " ")
    if ((insidesplitstep[0].length) > max_label_length){
         max_label_length = insidesplitstep[0].toString().length;
    }
    if ( insidesplitstep[1].toString().length > max_label_length){
         max_label_length =  insidesplitstep[1].toString().length;
    }

  }
  for (i=0;i<trace_steps.length;i++){
    if  (trace_steps[i].toString().length - 2 < max_label_length){
            var step_length =  trace_steps[i].toString().length - 2;
            var spaces_to_add = max_label_length - step_length;
            for (j=0;j<spaces_to_add;j++){
                if (j % 2 === 0){
                    trace_steps[i] = trace_steps[i] + " ";
                  }
                else{
                    trace_steps[i] = " " + trace_steps[i];
                  }
            }
      }

      key++;
      rethtml.push(<td key={key}>{trace_steps[i]}</td>);
  }
  dividerhtml.push(<tr>{rethtml}</tr>);
  for (i=0;i<model_steps.length;i++)
  {
    if ((model_steps[i].length - 2) < max_label_length){
            var step_lengthmodel = model_steps[i].length - 2;
            var spaces_to_addmodel = max_label_length -
step_lengthmodel;
            for (j=0;j<spaces_to_addmodel;j++){
                if (j % 2 === 0){
                    model_steps[i] = model_steps[i] + " ";
                  }
                else{
                    model_steps[i] = " " + model_steps[i];
                  }
            }

    }
    key++;
    rethtml2.push(<td  key={key} >{model_steps[i]}</td>);
  }
  dividerhtml.push(<tr>{rethtml2}</tr>)
  var finalhtml=[];
  finalhtml.push(<table>{dividerhtml}</table>);
  return finalhtml;
}
```

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