PREDICTING STUDENT PERFORMANCE FROM GAME PLAY

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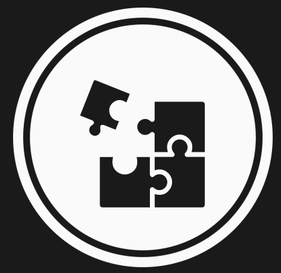
CONTEXT

The Field Day Lab is a publicly funded research lab at the Wisconsin Center for Education Research. It creates educational games across various subjects and age groups, using data-driven insights to optimize how people learn.

GOALS

Create a machine learning model that can predict students' academic performance based on their behavior in educational games.

Identify and define the functional and technical requirements based on student interaction data.



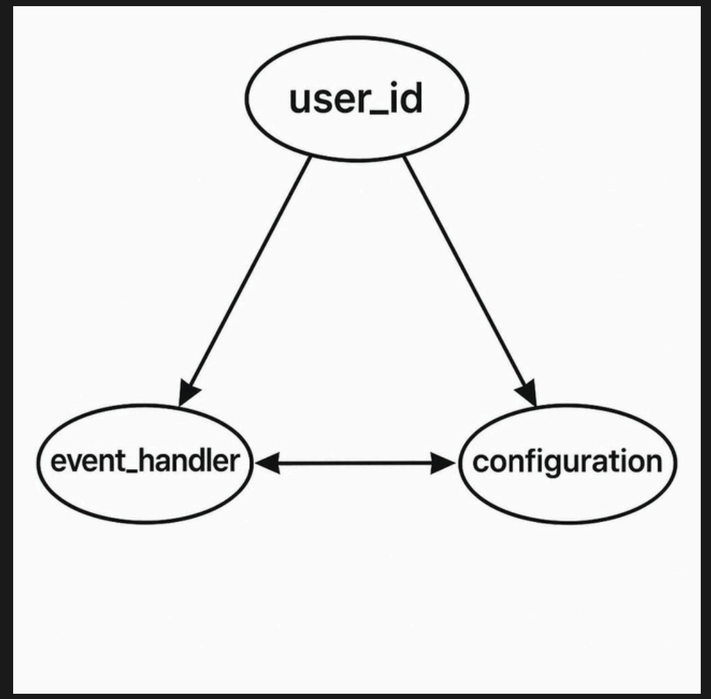
Develop a flexible and scalable architecture that supports real-time data processing.

MAIN COMPONENTS

- User interaction tracking: mouse clicks and movements.
- Session and level tracking.
- Game settings: options such as music and screen configurations.
- Analytics module: processes all data to predict the likelihood that a student will answer a question correctly.

RELATIONSHIP BETWEEN COMPONENTS

User actions generate events (clicks, hover) with coordinates, which are handled by modules responsible for recording these interactions. This data is centralized in an event manager that feeds the analytics module to assess performance.

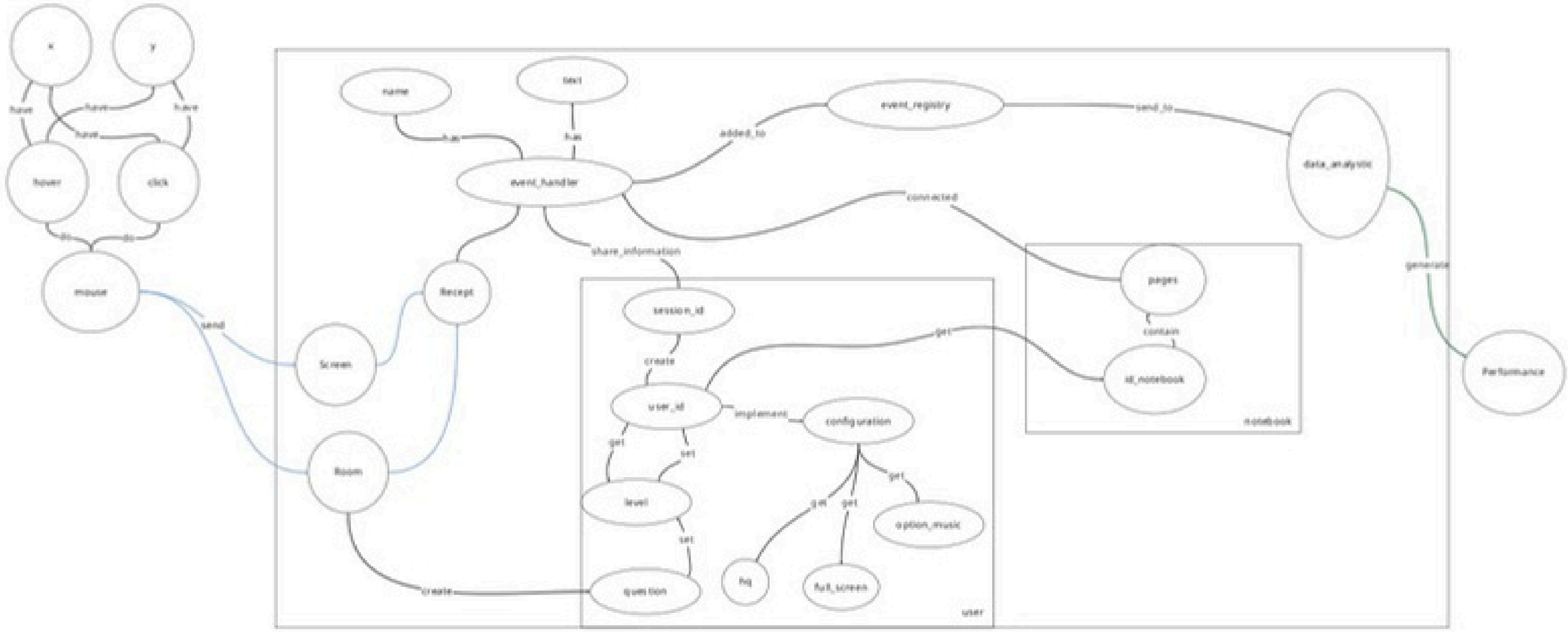


COMPLEXITY AND SENSITIVITY

The system is sensitive to small variations in input, such as minor changes in clicks or settings, which can significantly affect outcomes. This reflects the nonlinear and dynamic nature of game-based learning, where multiple factors interact in complex ways.

CHAOTIC DYNAMICS AND RANDOMNESS

Although the system follows deterministic rules, it exhibits characteristics of chaotic systems: high sensitivity to initial conditions, nonlinearity, emergence of patterns, and unpredictable trajectories in student behavior. Micro-decisions, response times, and settings generate variability that makes exact modeling difficult.


x
y
have
have
have
have
hover
click
do
do
mouse
send
Screen
Room
create
Receipt
name
text
has
has
event_handler
added_to
event_registry
send_to
data_analysis
connected
share_information
session_id
create
user_id
implement
configuration
get
set
level
set
question
get
get
get
fog
full_screen
option_music
user
pages
contain
id_notebook
notebook
generate
Performance

SYSTEM DESIGN

Requirements

High Arquitecture

Technical Stack

FUNCTIONAL REQUIREMENTS

DATA CAPTURE AND STORAGE

- Capture all user interactions including hovers, clicks, and drags with their respective x,y coordinates and timestamp
- Assign a unique session id per game session.
- Link all interactions to a specific user id.
- Store user configuration settings including full screen, hq, and music volume.
- Save the level group and question progress.

DATA PROCESSING AND NORMALIZATION

- Remove erroneous or duplicate clicks (condition: ¡90ms between clicks).
- Normalize x,y coordinates by standardizing to a key resolution.
- Extract temporal features: time between events, response speed.
- Extract spatial features: movement patterns like trajectories.
- Extract contextual features: difficulty level and number of retries.

PREDICTION MODEL

- The system must capture and record the mouse pointer position (x, y) at critical question points during the gameplay session.
- The system must detect and log the type of user interaction event, such as cutscene_click or map_click.
- The system must compute and store the cumulative time (elapsed_time) from the beginning of the session up to each recorded event.
- The system must measure and save the duration of time the cursor remains over interactive elements (hover_duration).

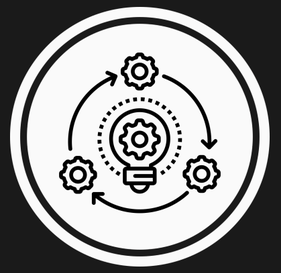
NON-FUNCTIONAL REQUIREMENTS

Performance

Reliability

Security

Ease of Use



Interoperability

HIGH ARQUITECTURE

1. DATA INGESTION
2. DATA PREPARATION
3. MODEL TRAINING
4. MODEL INFERENCE
5. SUBMISSION GENERATOR

TECHNICAL STACK

TensorFlow

FEATURE SETS

```
{
  1: {
     'categorical': ['event_name', 'name', 'fqid'],
     'numerical': ['elapsed_time', 'hover_duration', 'room_coor_x', 'room_coor_y'],
     'description': "Basic set with main user interactions"
  },
  2: {
     'categorical': ['fullscreen', 'hq', 'music', 'room_fqid'],
     'numerical': ['screen_coor_x', 'screen_coor_y', 'elapsed_time'],
     'description': "Set focused on user configuration settings"
  },
  3: {
     'categorical': ['event_name', 'fqid'],
     'numerical': ['elapsed_time'],
     'description': "Minimal set with only event-based features"
  },
  4: {
     'categorical': ['text', 'text_fqid'],
     'numerical': ['screen_coor_x', 'screen_coor_y', 'hover_duration'],
     'description': "Set focused on textual interaction features"
  }
}
```

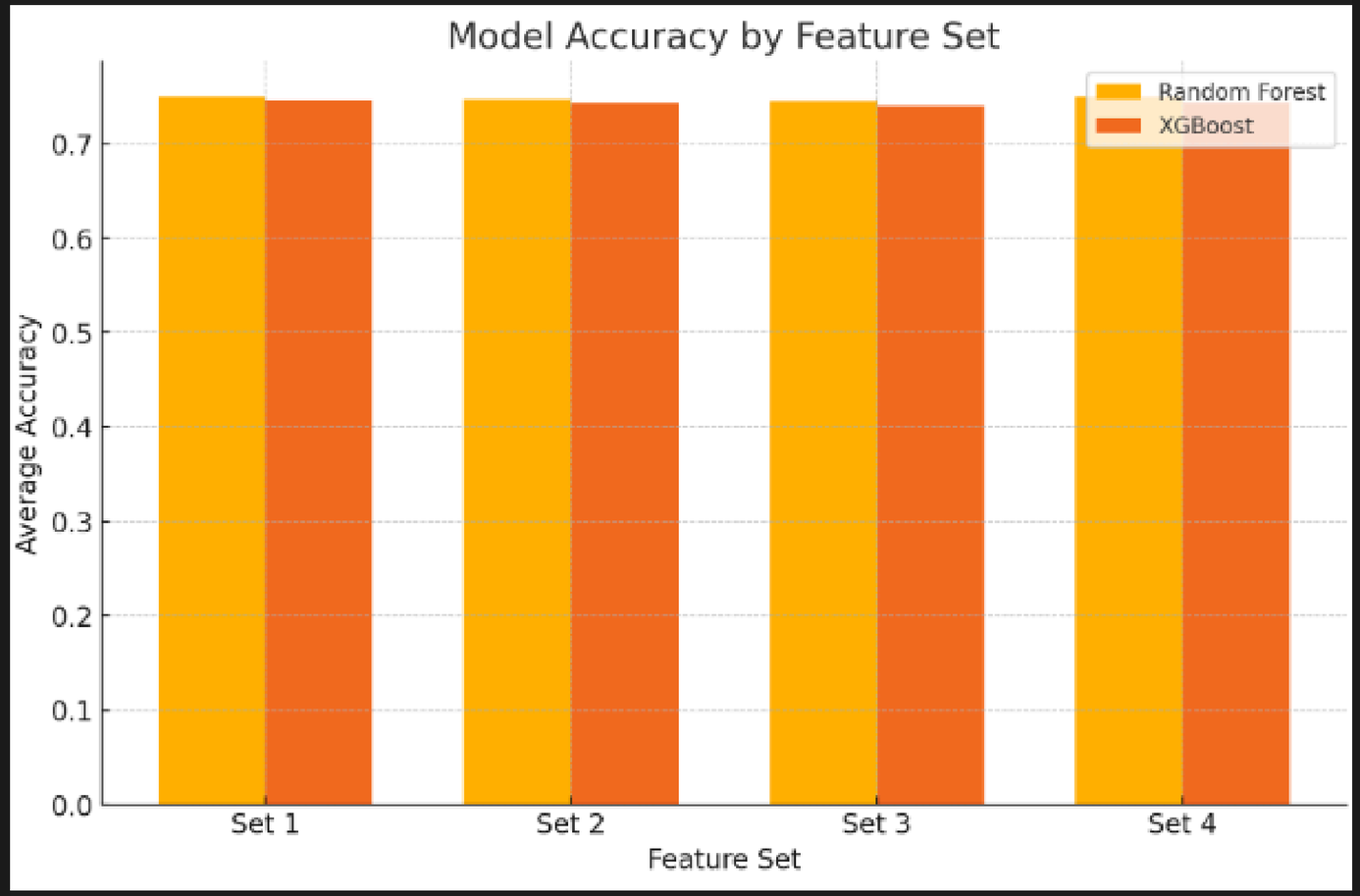
TABLES

Question	Accuracy
1	0.736
2	0.983
3	0.933
4	0.831
5	0.559
6	0.718
7	0.684
8	0.644
9	0.712
10	0.525
11	0.616
12	0.887
13	0.701
14	0.718
15	0.627
16	0.768
17	0.644
18	0.955

Question	Accuracy
1	0.736
2	0.983
3	0.933
4	0.791
5	0.582
6	0.729
7	0.650
8	0.559
9	0.712
10	0.582
11	0.605
12	0.870
13	0.672
14	0.689
15	0.610
16	0.802
17	0.661
18	0.955

Question	Accuracy
1	0.725
2	0.983
3	0.933
4	0.808
5	0.548
6	0.723
7	0.655
8	0.599
9	0.695
10	0.548
11	0.621
12	0.881
13	0.678
14	0.706
15	0.537
16	0.768
17	0.633
18	0.955

GRAPHS


Model Accuracy by Feature Set
Random Forest
XGBoost
Average Accuracy
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Set 1
Set 2
Set 3
Set 4
Feature Set

CONCLUSION

Adopting a systems perspective shifts focus beyond isolated data points to model the entire learning environment as interconnected components. This holistic approach accelerates problem decomposition, enabling scalable and precise predictive solutions.

THANKS!