

# Validating User Survey Responses

Team Alpha - Capstone Fall 2019  
Final Presentation



# Executive Summary

## Problem Statement

30% of users falsely fill out psychometric surveys.  
How can we improve the survey validation process?

## Approach & Methodology

2 research questions on mouse activity patterns & survey questions.  
Devise 3 analytical approaches to identify suspicious behavior.

## Solutions & Findings

New validation framework consisting of Rule-based, LSTM & HMM analytical approaches.

## Recommendations & Business Implications

Enhanced & more robust validation methods  
Data Collection Methods  
Cost effective solution

# 30% of survey responses are not valid.



## Mouse Activity:

How do we use user mouse activity to validate survey answers to psychometric questions?

## Survey Questions:

Does the level of suspicious behavior vary across different types of survey questions?

# Current Validation Method Limitations

6 validation questions throughout the survey.

Inherently dependent on selection probability and fail to capture any nuances of user behavior throughout the survey completion time.

Do not capture the users' mouse movement patterns or the typology of survey responses based on questions.

## Validation Questions:

1. untidy
2. unworried
3. I'm travelling trans-Atlantic 5 or more times a month. Press 4 if you agree, 2 if you disagree.
4. I can avoid communication with other people for months. Press 4 if you agree, 2 if you disagree.
5. Press number six.
6. Press number 4.

# Analytical Approaches



**Rule  
Based**



**Long Short  
Term Memory  
(LSTM)**



**Hidden Markov  
Model (HMM)**

# Rule-based Approach

## TIME

Expected read time versus completion time analysis

**23%**

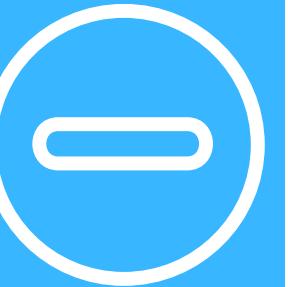
of users complete the survey before the expected read time of the questions they attempt.

## TOPIC

Deviation of user responses on similar questions



kind~sympathetic  
systematic~organized



rude~harsh  
uncreative~unimaginative

## SCORE

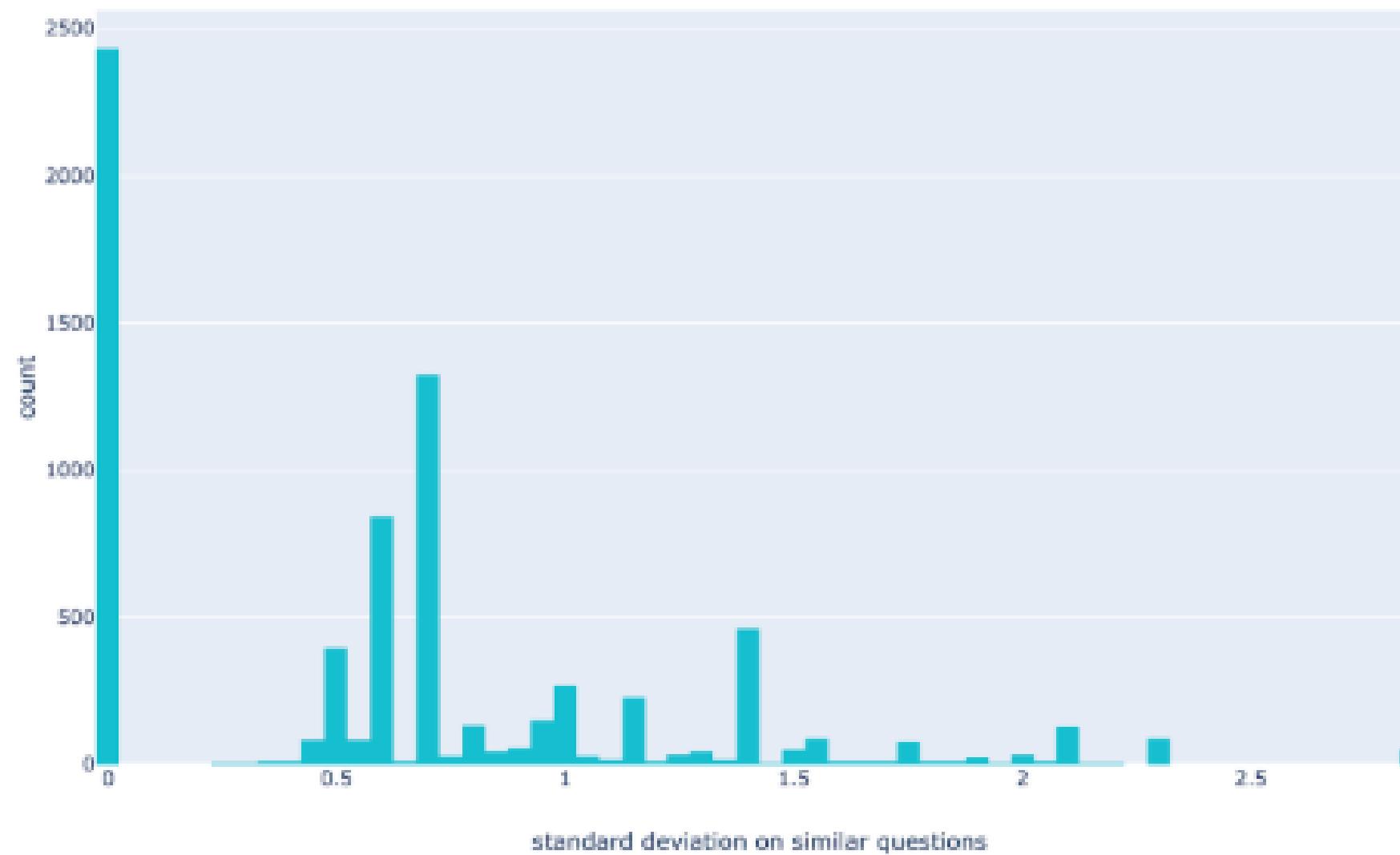
Same radio button clicks on a page and its frequency

**19%**

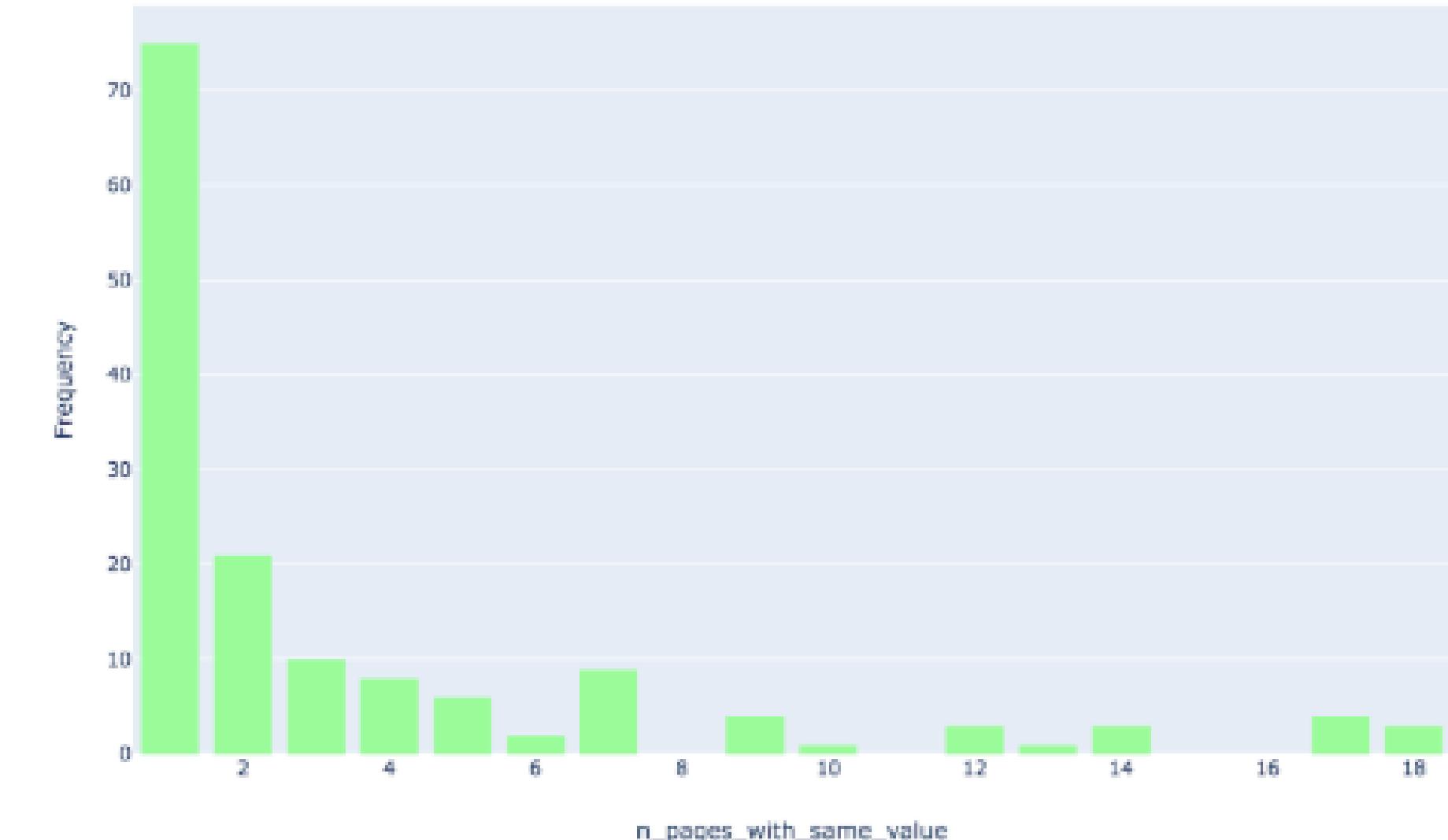
of users have at least once responded with the same answers across a particular page

# Rule-based Approach Results

Decoding User Responses on Similar Questions

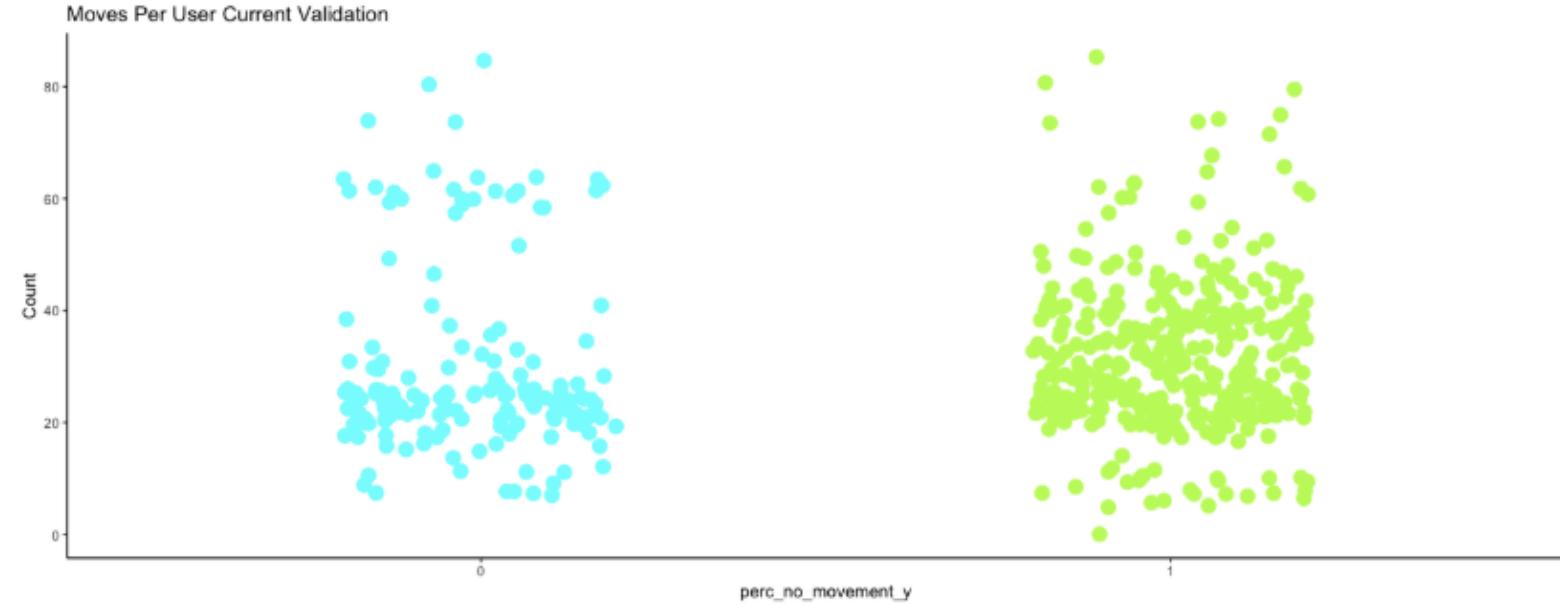
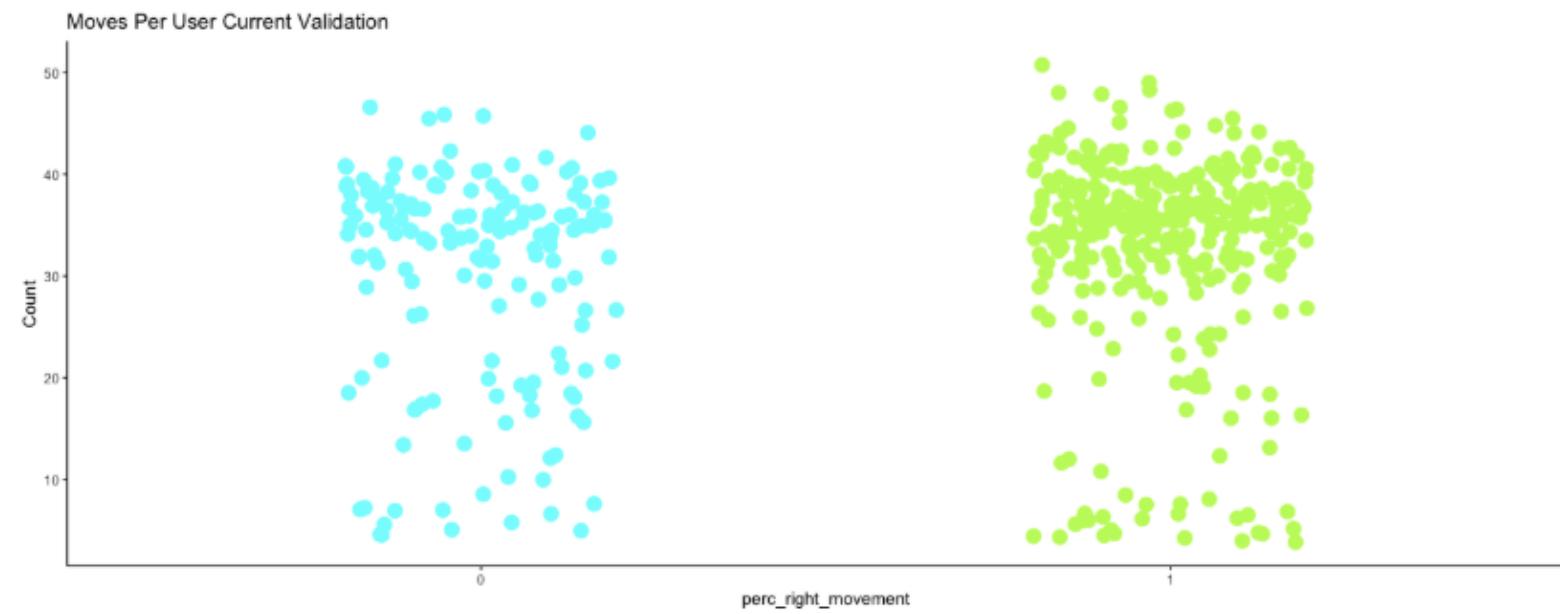


Analyzing consistency of user responses across different pages

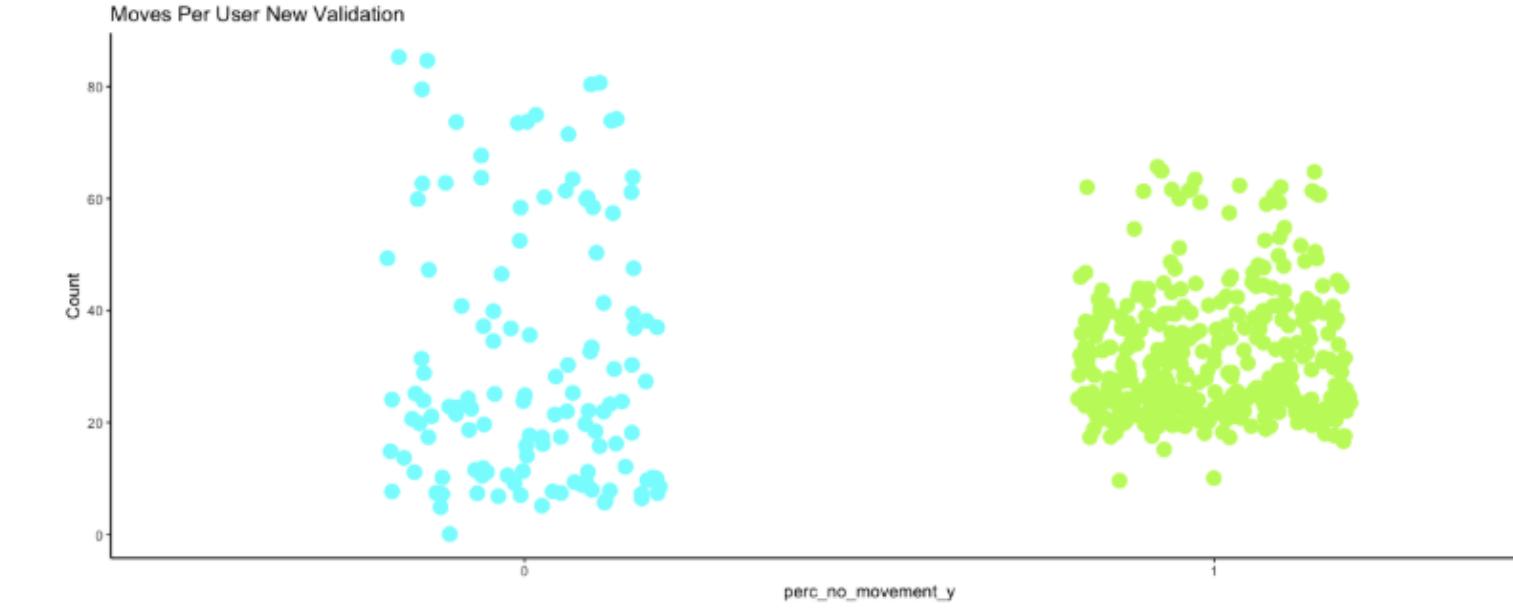
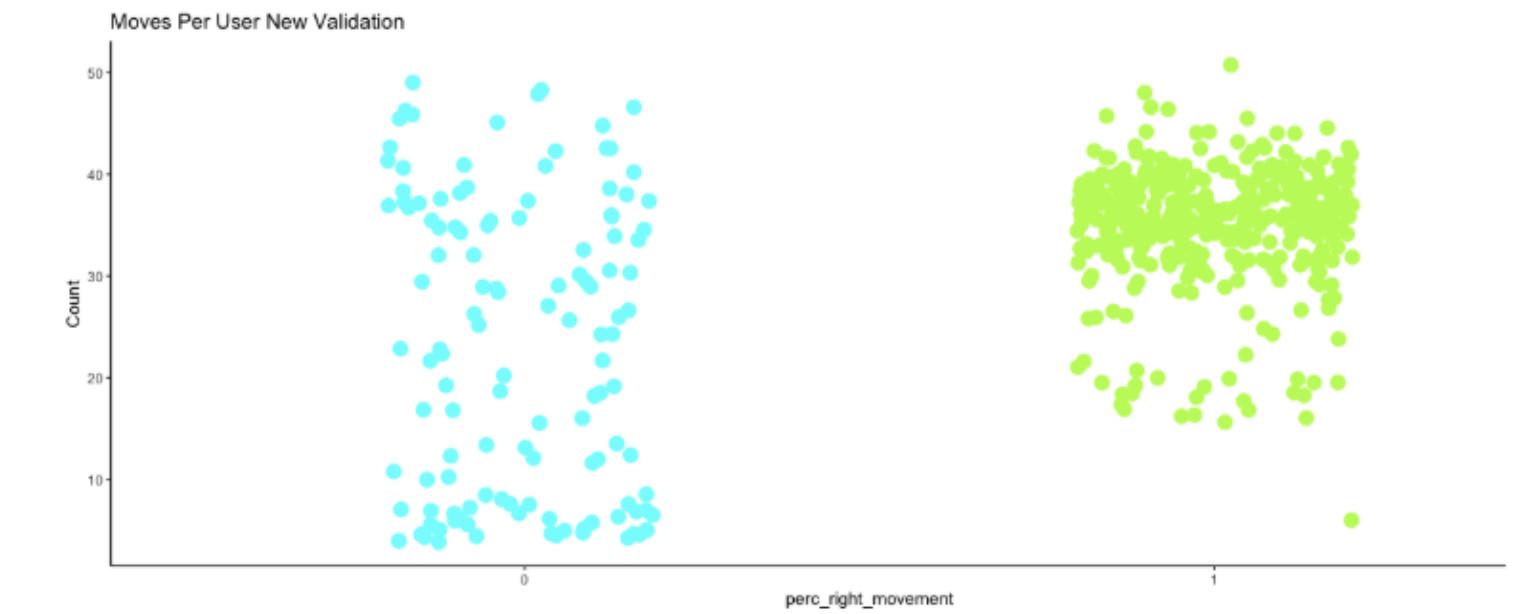


# Developing New Validation Labels

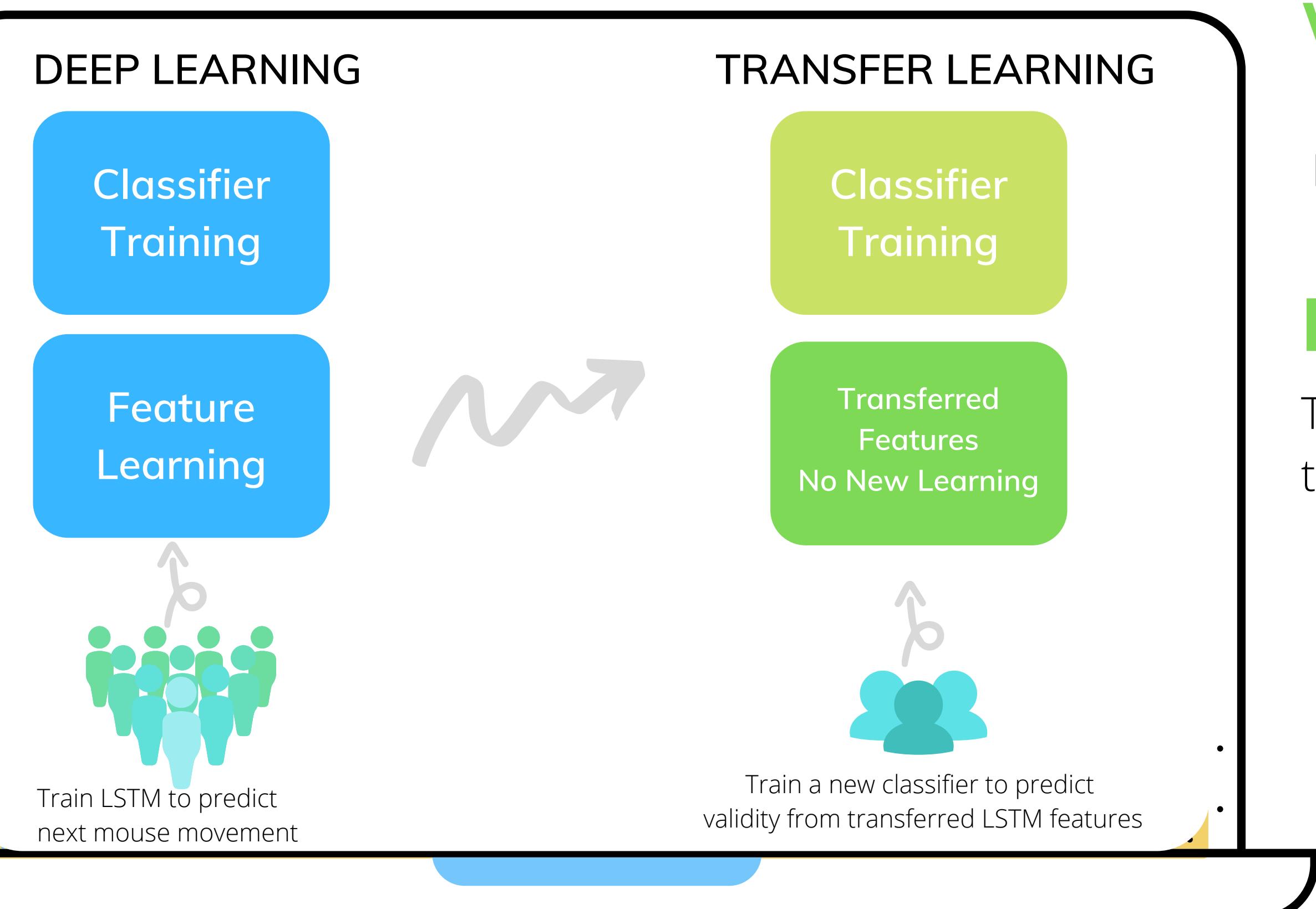
CURRENT VALIDATION



NEW VALIDATION



# LSTM Approach



## Why LSTM?

Ideal for sequential tasks

Robust against vanishing gradient

## Key Idea:

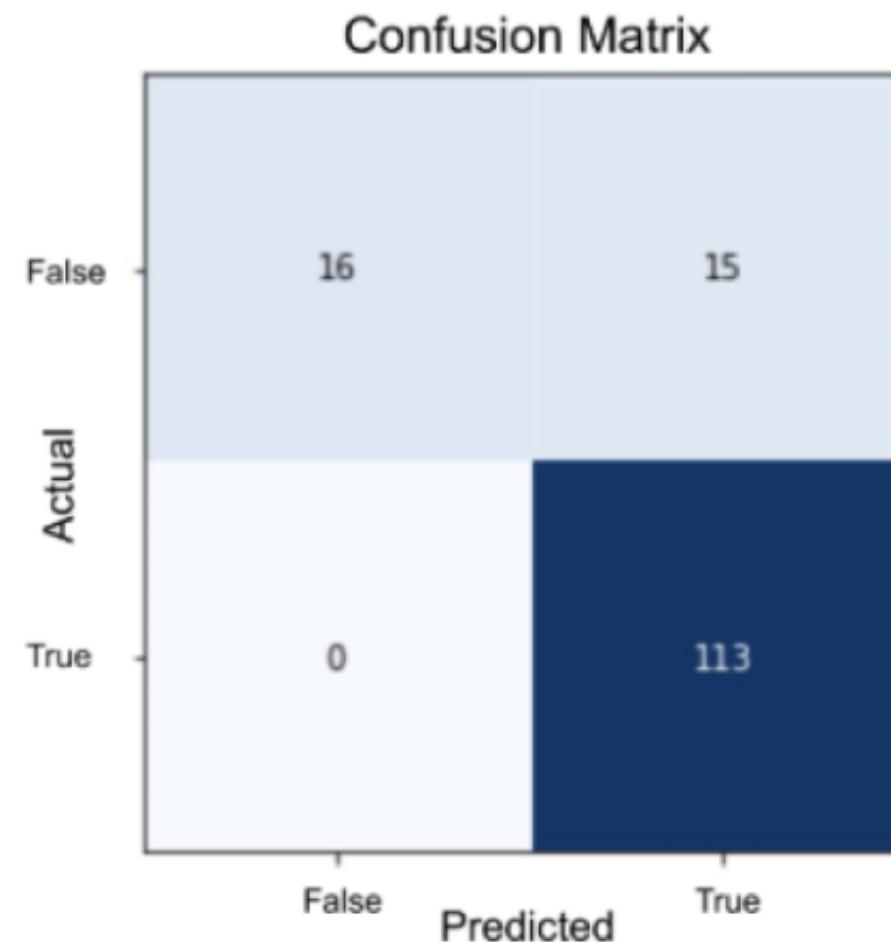
Two pronged approach with transfer learning.

1. Train model which predicts next movement
2. Use weights from first model to classify survey validity

# LSTM Approach Results

Language Model  
64%

Classification Model  
90%



	precision	recall	f1-score	support
0	0.58	0.90	0.71	20
	0.98	0.90	0.94	124
accuracy			0.90	144
macro avg	0.78	0.90	0.82	144
weighted avg	0.93	0.90	0.90	144

# HMM Approach - Feature Engineering

Convert directions into  
**cardinal directions:**  
North, South, East..

Rule based approach of  
tracking when user  
**changes survey page**

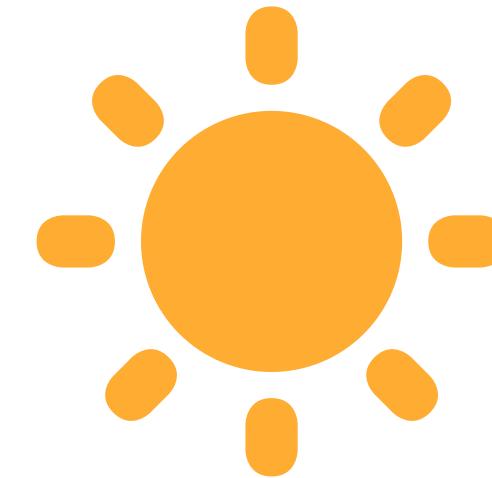
Filter for users who  
completed all pages and  
limit to **first 200  
observations**

**66 users** included  
in the model

User	Page	Directions
155	Page 1	North, North, East, South, South West, No movement...
155	Page 3	South, East, North, North....
201	Page 1	West, No Movement, No Movement, No Movement, East

# HMM Approach - What is an HMM?

OBSERVED SEQUENCE



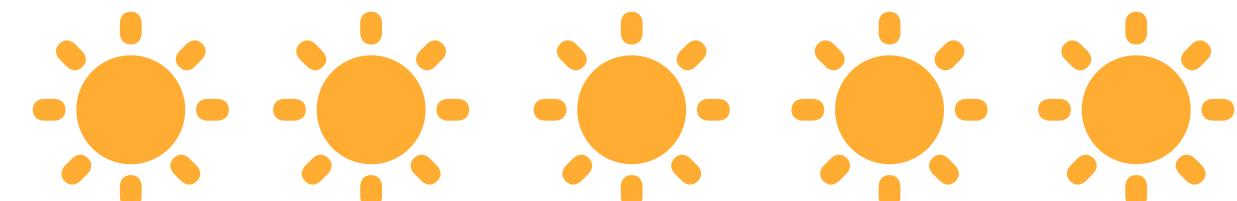
STATES: RAINY, SUNNY



TRANSITION MATRIX:

	RAIN	SUNNY
SUNNY	Probability	Probability
RAIN	Probability	Probability

PATH 1



PATH 2



# HMM Approach - User Journey Matrix

	Page 1	Page 2	Page 3	Page 4	Page 5	Page 6	Page 7	Page 8	Page 9	Page 10	Page 11	Page 12	Page 13	Page 14	Page 15	Classified
User ID																
384	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
422	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Flag
448	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
507	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
549	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
570	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
571	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
592	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
686	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
691	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
727	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Flag
740	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
752	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
776	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
786	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
849	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
862	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
866	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Flag
885	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
934	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
974	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
1008	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal
1108	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Normal

15 Pages

66 Users

7 Flags

# Validation Approaches Recap

## RULE-BASED APPROACH

Users can receive a maximum of 3 rule-based flags



Aggregated score  
for all flags

**0-1** Flag score range  
arbitrarily assigned

**100%** Users met criteria  
for analysis

**45%**  
users with  
suspicious behavior

## LSTM APPROACH

Generated labels using an Autoencoder and trained an LSTM to classify

**90%** Accuracy in predicting  
future suspicious behavior

**19%** Users met criteria  
for analysis

**11%**  
users with  
suspicious behavior

## HMM APPROACH

Probabilistic approach based on cardinal movements



Users receive a score  
for each page and  
an overall score



Isolation forest to  
identify suspicious  
users

**9%** Users met criteria  
for analysis

**11%**  
users with  
suspicious behavior

# Limitations

## RULE BASED APPROACH

Limited to business rules defined for the user.

Business rules will vary with different survey designs.

## LSTM APPROACH

Since we are predicting the autoencoder-based results, we are limited to the efficacy of the autoencoder validation labels.

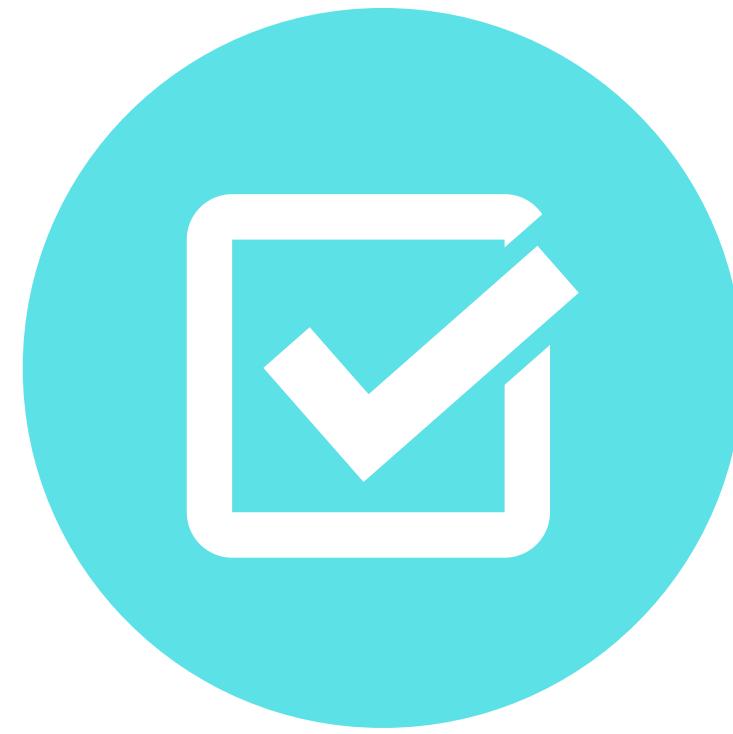
## HMM APPROACH

Data quality plays a critical role in model performance.

# Recommendations

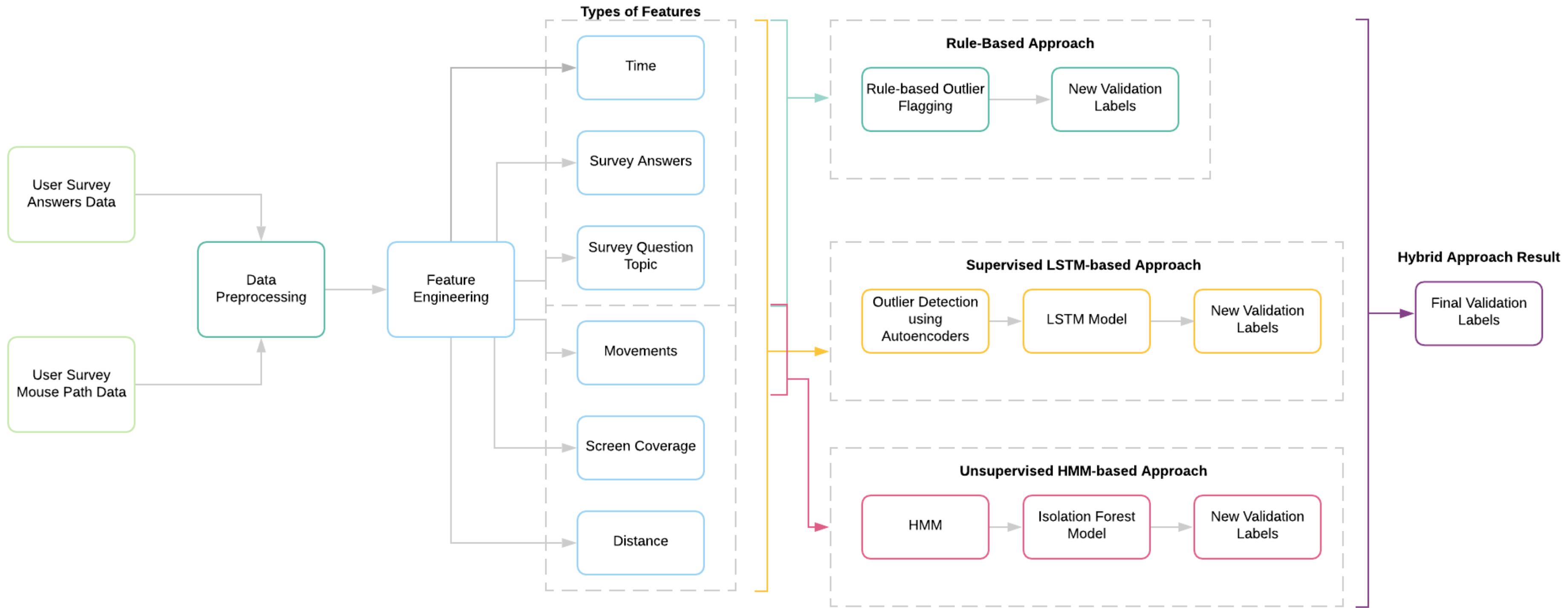


**New Validation  
Framework**



**Data Quality**

# New Validation Framework



# User Validity Assessment Journey

The screenshot shows a user completing a survey on a Mac OS X desktop. The browser window is titled "A study on favorite photos and" and displays the URL "psy.dotin.us/psy\_test/view". The page is labeled "Part 4: Test" and contains a warning: "Please pass the following test". A red warning message states: "WARNING: We ask you to fill this survey carefully. The donation will be paid only after checking your answers and only in the case you filled it carefully and correctly." Below this, demographic information is shown: Age 26, Sex Female, and United States. The user is asked to type their occupation for the last five years, with options for "DATA SCIENTIST, BUSIN" or "NO OCCUPATION". A yellow box highlights the name "EMILY" entered in the identification field. The survey includes a list of activities with Likert-scale rating scales from 1 to 7. The activities are:

- Draw cartoons
- Supervise children in a nursery
- Defend people in court
- Smooth wood-furniture with sandpaper

The rating scales for each activity are as follows:

Activity	Rating Scale
Draw cartoons	1 2 3 4 5 6 7
Supervise children in a nursery	1 2 3 4 5 6 7
Defend people in court	1 2 3 4 5 6 7
Smooth wood-furniture with sandpaper	1 2 3 4 5 6 7

At the bottom left is a "Prev" button, and at the bottom right is a "Submit responses" button, which is being clicked by a cursor.

# User Validity Assessment Journey

dotin

Overview User Details Model Details

### Psychometric Survey Validation

User Details

USER ID	NAME	TOTAL COMPLETION TIME	OCCUPATION	COUNTRY	AGE	SEX	OVERALL RESULT
381	Emily	4:30 min	Data Scientist, Business Analyst	United States	26	Female	Suspected

### Validation Results

USER ID	RULE-BASED APPROACH	HIDDEN MARKOV MODEL (HMM)	LONG SHORT-TERM MEMORY (LSTM)
381	Suspected	Passed	Suspected

Time Spent per Page

Mouse Movements per Page

Above average 70%  
Below average 30%

Overall User Mouse Activity

LEGEND  
Red Clicks  
Green Scrolls  
Grey Movement

Page 1 ... 2

Page 1 ... 15

Window y  
Window x

Page 1 ... 2

# User Validity Assessment Journey

dotin

Overview User Details Model Details

Psychometric Survey Validation

Validation Results

USER ID	RULE-BASED APPROACH	HIDDEN MARKOV MODEL (HMM)	LONG SHORT-TERM MEMORY (LSTM)
652	Suspected	Suspected	Suspected
325	Suspected	Suspected	Suspected
381	Suspected	Passed	Suspected
537	Suspected	Suspected	Passed
733	Suspected	Suspected	Passed
435	Suspected	Suspected	Passed
289	Suspected	Suspected	Passed
701	Passed	Suspected	Passed
441	Passed	Passed	Suspected
216	Passed	Passed	Suspected

Validation Results Breakdown

Number of Mouse Movements by User

see more

Page 1 ... 2

dotin

# Data Quality

## Findings

Only 54 users fulfilled the basic requirement of clicking 196 radio buttons.

The entire survey can be filled out by using "Tab", "Space" and "Arrow keys" commands on the keyboard.

## Recommendations

Disable keyboard capability for survey responses.

Explore additional mouse-tracking collection methods.

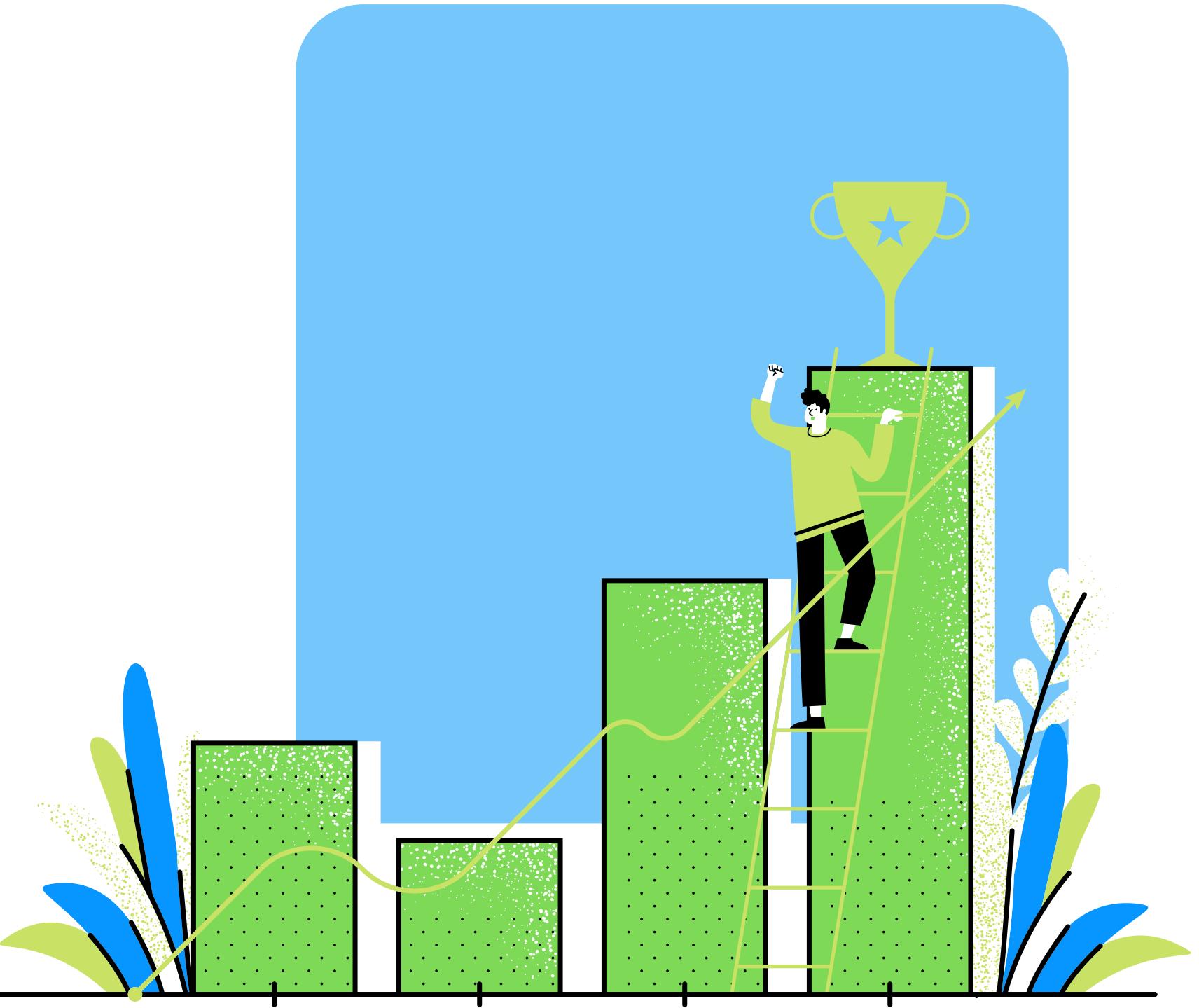


# Business Implications

Innovative Survey Validation Framework

Cost-effective Data Collection

Improved Data Quality



# Thank You!



# References

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