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XAI-Enhanced Data Driven Player Churn Analysis for Actionable Decision Making

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#GDC22

FUXI-Lab

NetEase Games

Outline

- Team Introductions
- Why we need churn analysis
- What are challenges
- Our approaches
- Application cases

0 Who are we?

NetEase Games

#2 game company in China

Good games have no borders

伏羲实验室

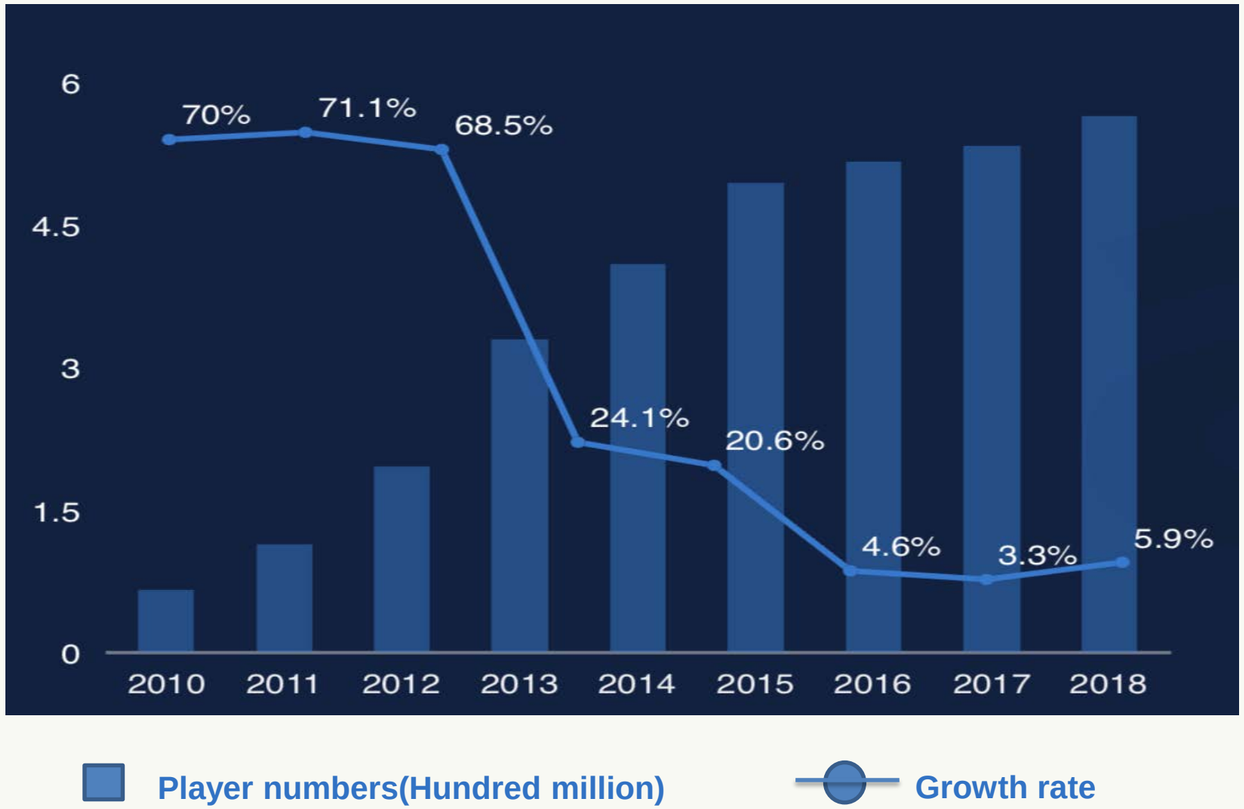
NetEase Games

+

- FUXI-Lab: Established in 2017
- First game AI lab in China
- Vision: Enlighten games with AI

1 Why we need churn analysis?

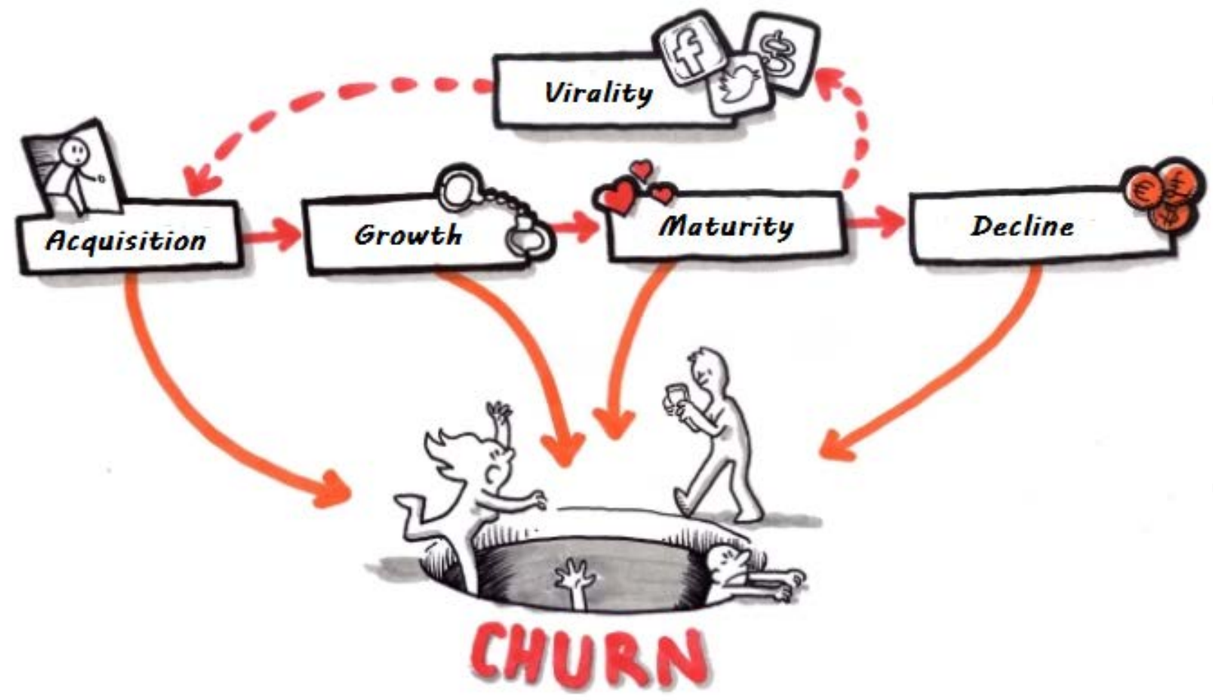
Player Churn Analysis



Problem

- Saturated market and fierce competition
- Maintain sufficient players is the core demand for game publishers
- Attract new players or addressing the leaving players?

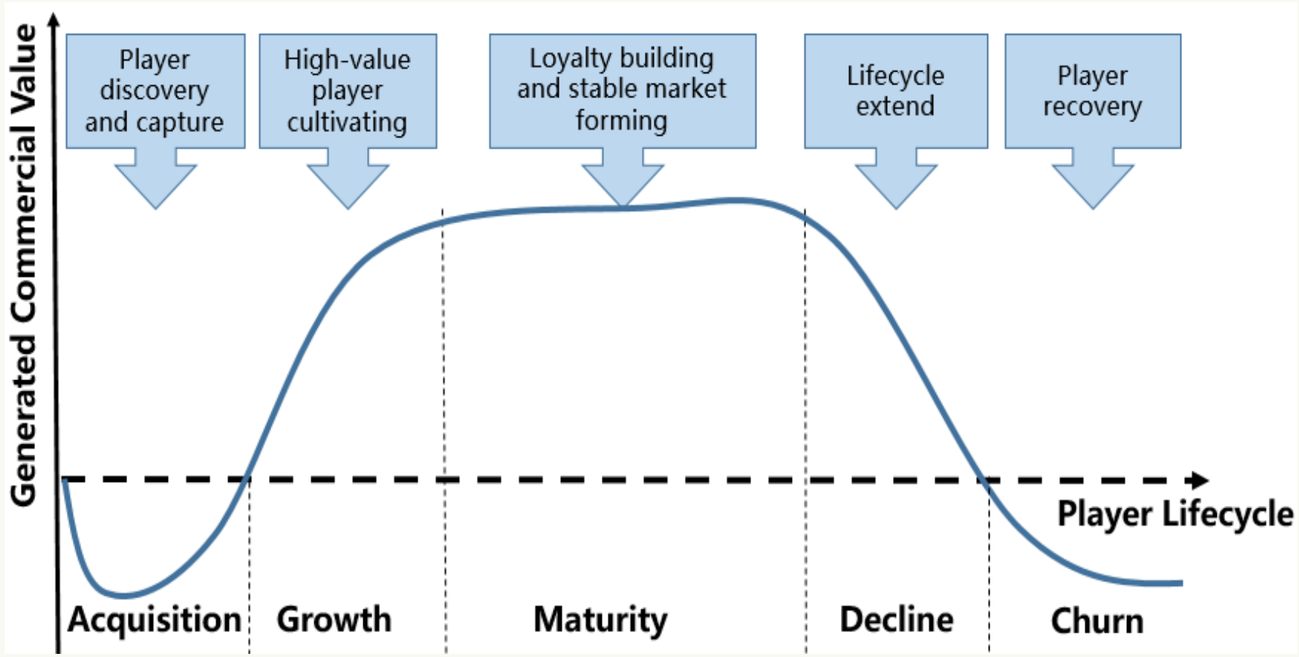
Player Lifecycle



- **Growth:** Lots players churn in this early stage. Change product positioning, cater to market and maintain value increment

- **Decline:** The accumulation of churn causes during this stage leads to thorough player churn

Player Lifecycle

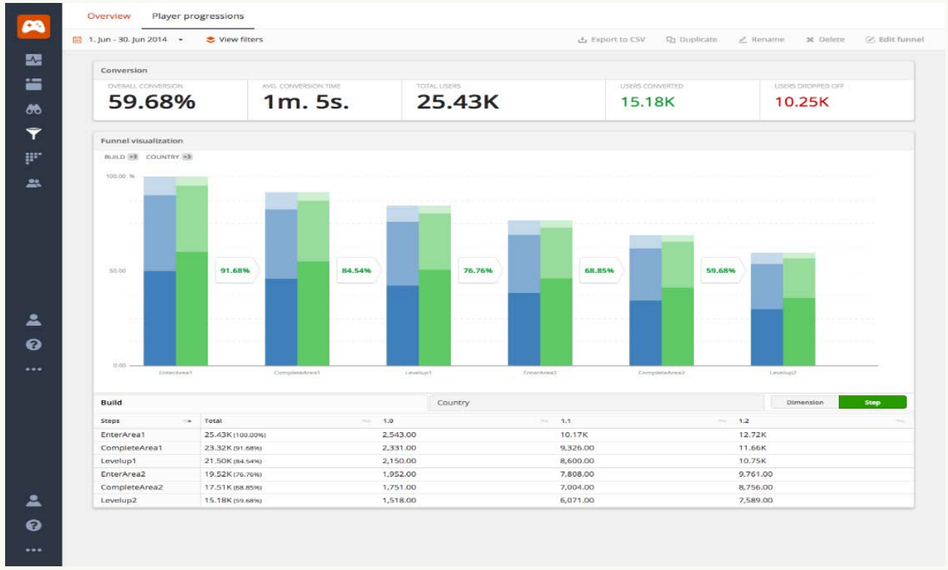


The curve of commercial value in different stage

The churn analysis in the growth and decline stages is **the key** **to maintain the number of players, ensure game revenue and even survival**

2 What are challenges?

Potential Analysis Methods



Statistical Data Analysis

- Analyze the distribution of levels, tasks, dungeons and maps before players churn
- Cohort and funnel analysis
- Require lots of human costs and expert knowledge, Hard to expansion

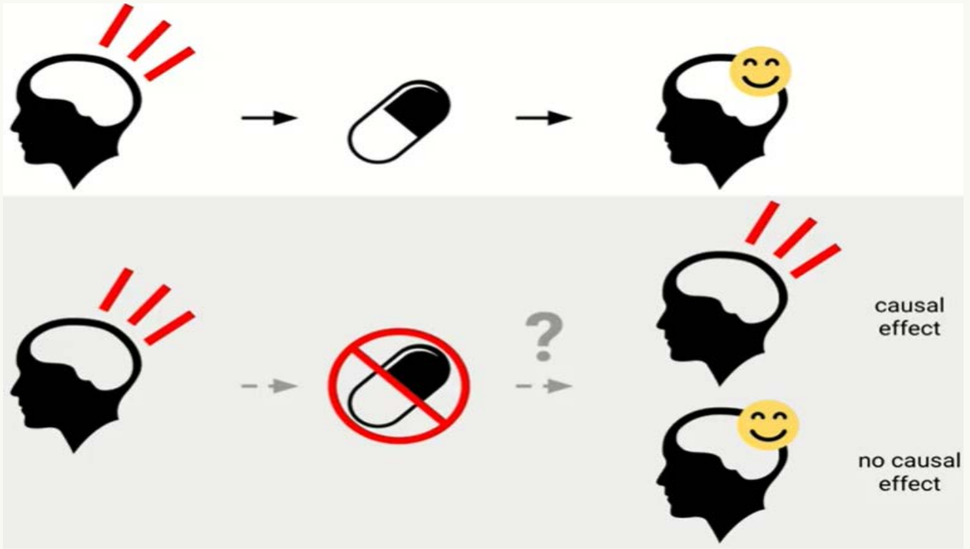
Clustering Analysis

- Clustering algorithm such as K-means, DBSCAN
- Lack appropriate feature weights, susceptible to outliers, poor performance in high-dimensional data

Potential Analysis Methods

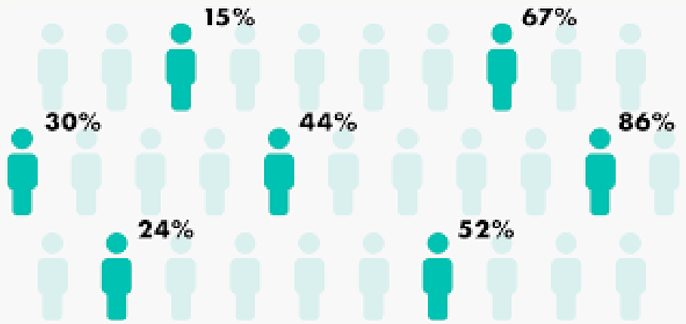
Causal Analysis

- Eliminate the spurious effect caused by confounders, analyze the causal churn effect of variables
- This field still in infancy, several strong assumptions need to be met, lacks reliability measures



Churn Prediction

- High-value players, new players churn prediction are the focus
- Lack of explanations, difficult to use, poor performance of specific interventions

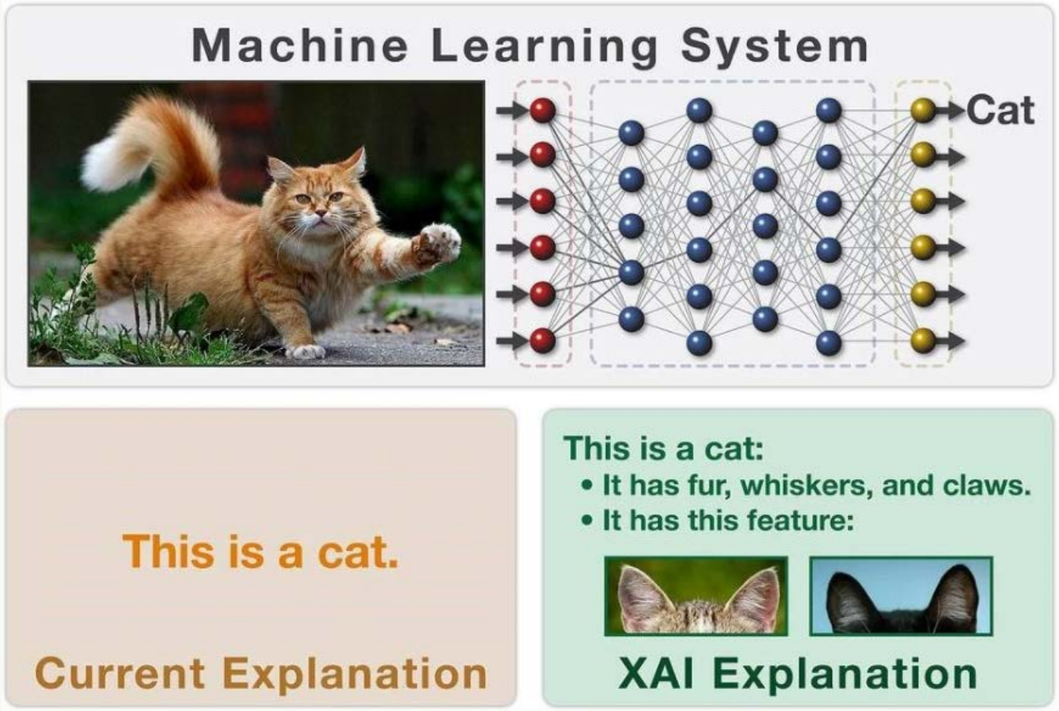


Potential Analysis Methods

It is important and necessary to find an automatic, scalable, personalized, accurate and efficient churn analysis scheme

Explainable AI (XAI) Analysis

- Employ XAI technology to explain the churn model, generate important churn information for operators to perform targeted interventions
- Improve the intervention performance in a targeted manner
- Satisfy almost all ideal properties



Ideal properties

An ideal churn analysis method should be:

- **Scalable(S):** Easy to adjust for new setting
- **Reliability-Modelable(RM):** Have objective indicators to support the analysis result
- **Individual-Analyzable(IA):** Analyzable for the churn of individual player
- **Continuous variable-Analyzable(CA):** Analyzable for the effect of continuous variable
- **Predictable(P):** Able to predict and analyze the churn of players who will be lost
- **Debiased(D):** Able to alleviate the spurious effect caused by selection bias in data

Method	Properties					
	S	RM	IA	CA	P	D
Statistical data analysis		√		□		
Clustering analysis	√	√		□		
Churn prediction	√	√			√	
Causal analysis	√		□	□		√
XAI analysis	√	√	√	√	√	□

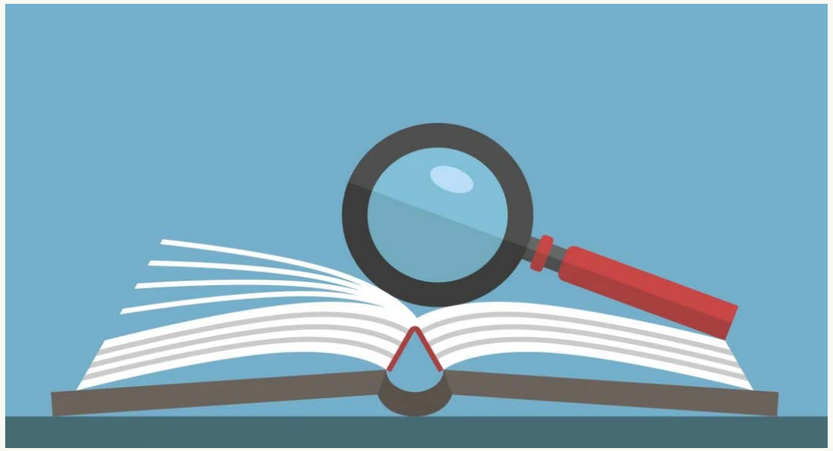
'√' indicates presence of property,

'□' indicates limited presence of property

Definition of Churn Analysis

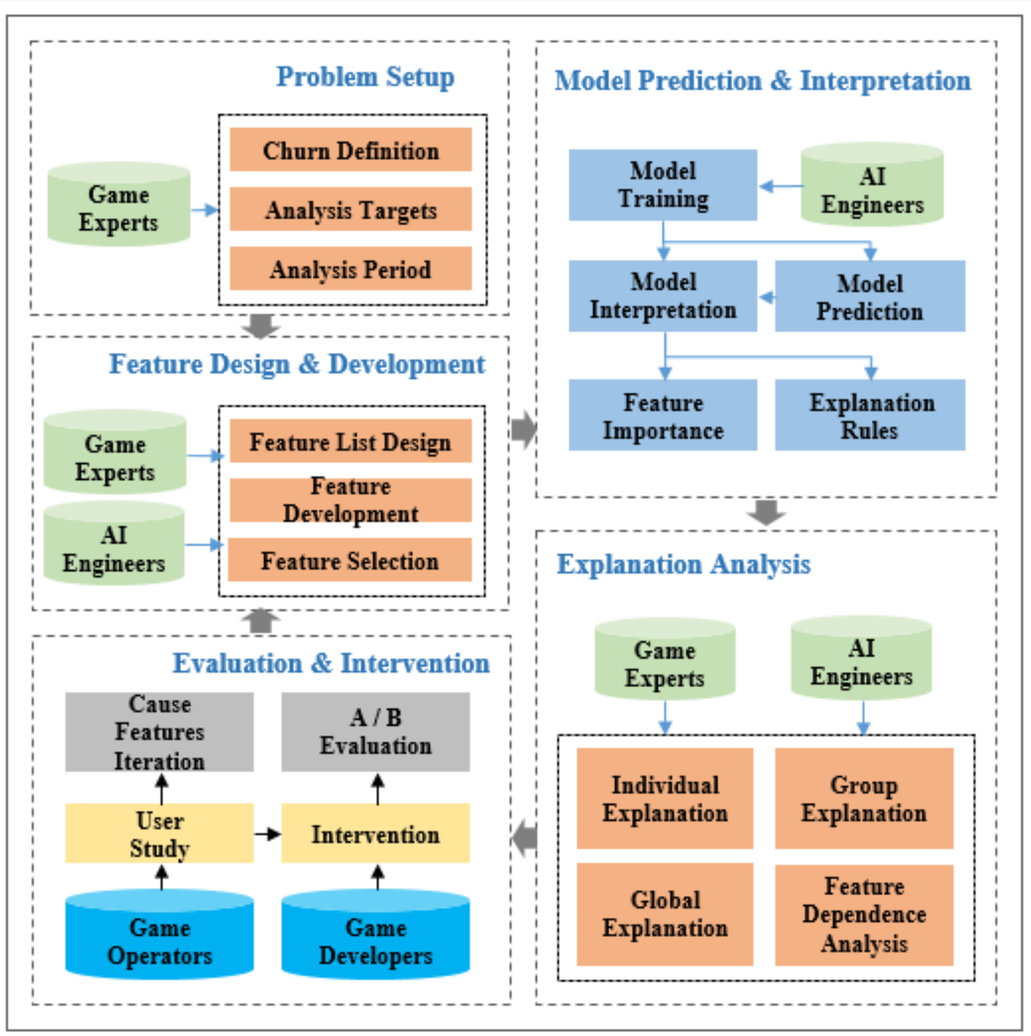
Define the churn analysis in online game from a more practical perspective

- Mining the **important objective facts** and **deep rules** of players churn from the game data and combining with expert knowledge to form a reliable churn causes, then performing **targeted player intervention** and game improvements based on the causes to alleviate churn



3 Our approaches and application cases

XAI-Enhanced Churn Analysis Framework



The Automatic XAI-Enhanced Decision Support Churn Analysis Framework

- **Problem Setup**
  - **Churn definition, Analysis targets, Analysis period**
- **Feature Design and Development**
- **Model Prediction and Interpretation**
- **Explanation Analysis**
- **Evaluation and Intervention**

Feature Design Principle

- **Well-express:** The feature set includes features that best express the potential churn causes and indicators that the game developer focus on
- **Comprehensive:** The more comprehensive the churn causes covered by the feature set, the better to reduce the interaction between the uncovered churn information and the designed feature (endogenous problem)
- **Actionable:** Features are as actionable as possible
- **Categorical:** Use categorical features whenever possible because they have better domain information. Domain knowledge can be use to categorize continuous features

Feature Examples

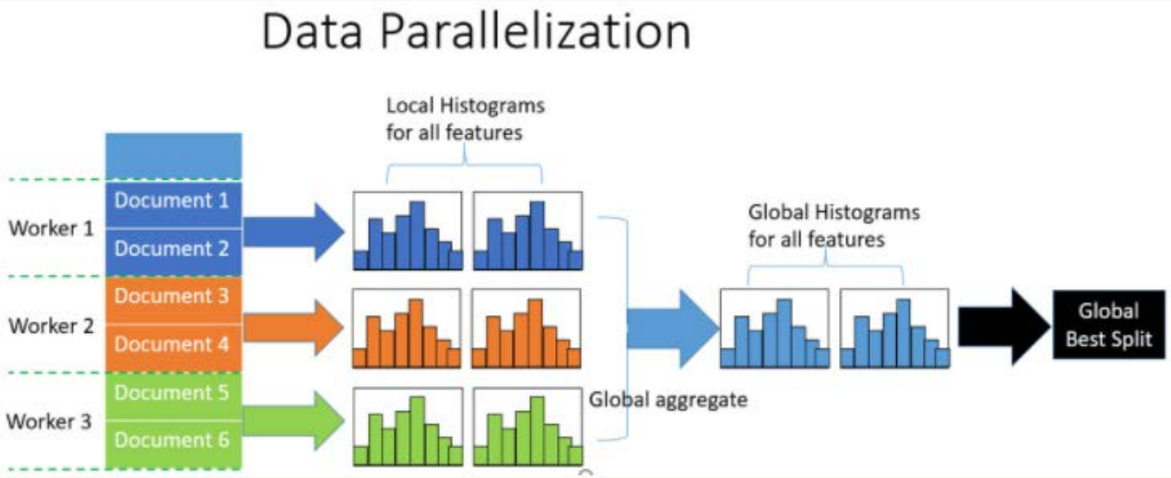
- Limited Hardware
- Basic Information
- Art Style
- Novice Guide
- Social Influence
- Gameplay Influence
- Role Growth
- Economic System

Limited Hardware	
Limited Device	Device model
Limited Operating System	Operating system version
Limited Channel	App Channel
Server Instability	Server
Basic Information	
Class Unfriendliness	Class
Art Style	
Unappreciated Character	Time spent on customizing
Unappreciated Animation	Animation watching percentage
Novice Guide	
Complicated Guide	Guide stop step
Long Time Guide	Time spent on guide
Social Influence	
Few Friends	Unchurn friends number
Few Teams	Team times, Kicked times
Spouse Leaves	Spouse logout days
Master Leaves	Master logout days
Guild Decline	Unchurn members proportion
Gameplay Influence	
Difficult Key Level/Task	Stop level/task/map
Gameplay A Influence	Gameplay A participation times
Role Growth	
New Player Unfriendliness	Player level & stop days
Old Player Bored	Player level & stop days
PVP Growth Blocked	Ladder level & stop days
Equipment Growth Blocked	Equipment Score & stop days
Economic System	
Difficult Coin Obtain	Coin balance

Model Prediction

Churn Prediction

- LightGBM model, a distributed gradient boosting framework designed to be highly efficient with fast training speed, lower memory usage and better accuracy
- The accuracy is the basic of good explanation

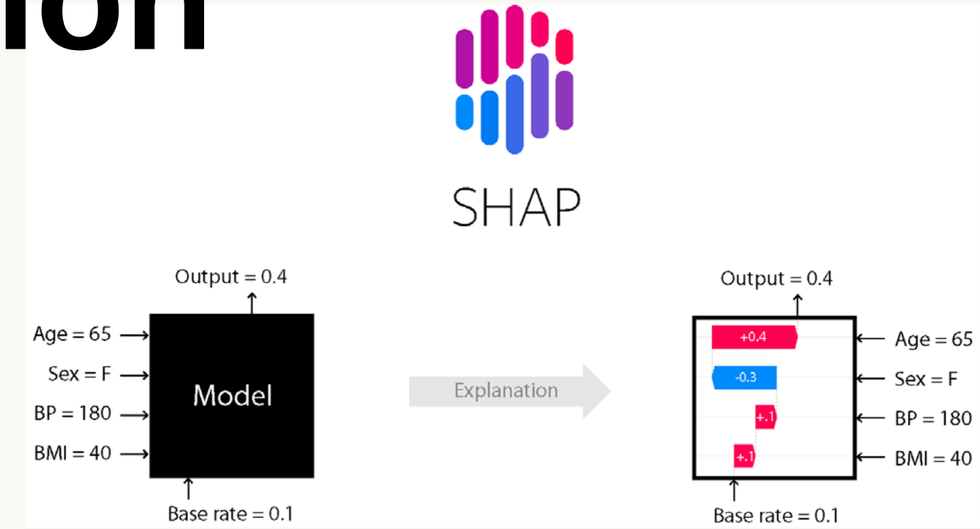


Method	Accuracy	Precision	Recall	AUC
Logistic Regression [15]	85.50	80.37	76.01	92.02
Decision Tree [10]	83.46	75.80	76.15	81.82
Survival Forest [25]	89.26	87.21	78.79	96.18
MLP	88.48	84.05	81.30	95.64
Random Forest	85.54	83.93	70.89	92.83
CatBoost	90.91	87.43	84.94	97.32
XGBoost	90.90	87.49	84.83	97.53
LightGBM	91.10	87.99	84.83	97.57
LightGBM(mdlp)	**92.21**	**88.83**	**85.10**	**97.76**

Model Interpretation

XAI Techniques

- **SHAP Values**
  - A promising feature contribution XAI technique with solid theoretical support

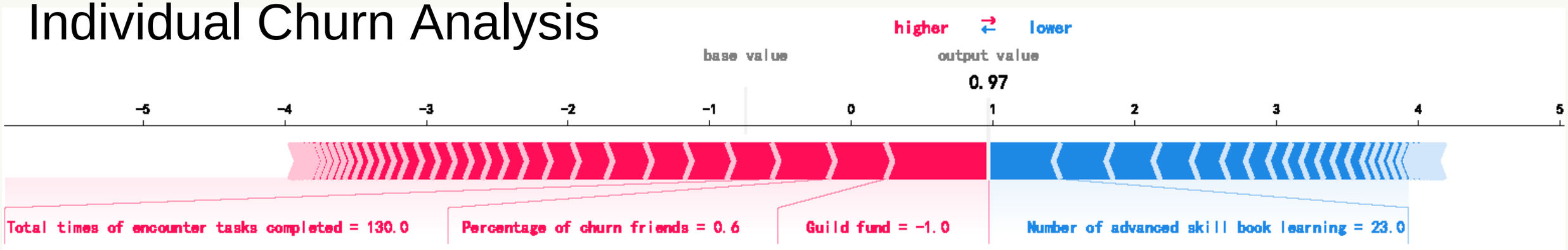


- **Anchor**
  - Generate churn rules which are intuitive, easy to understand, and the coverage is very clear

	If	Predict
adult	No capital gain or loss, never married	$\leq$ 50K
	Country is US, married, work hours $>$ 45	$>$ 50K
recdv	No priors, no prison violations and crime not against property	Not rearrested
	Male, black, 1 to 5 priors, not married, and crime not against property	Re-arrested
lending	FICO score $\leq$ 649	Bad Loan
	649 $\leq$ FICO score $\leq$ 699 and \$5,400 $\leq$ loan amount $\leq$ \$10,000	Good Loan

Explanation Analysis

Individual Churn Analysis



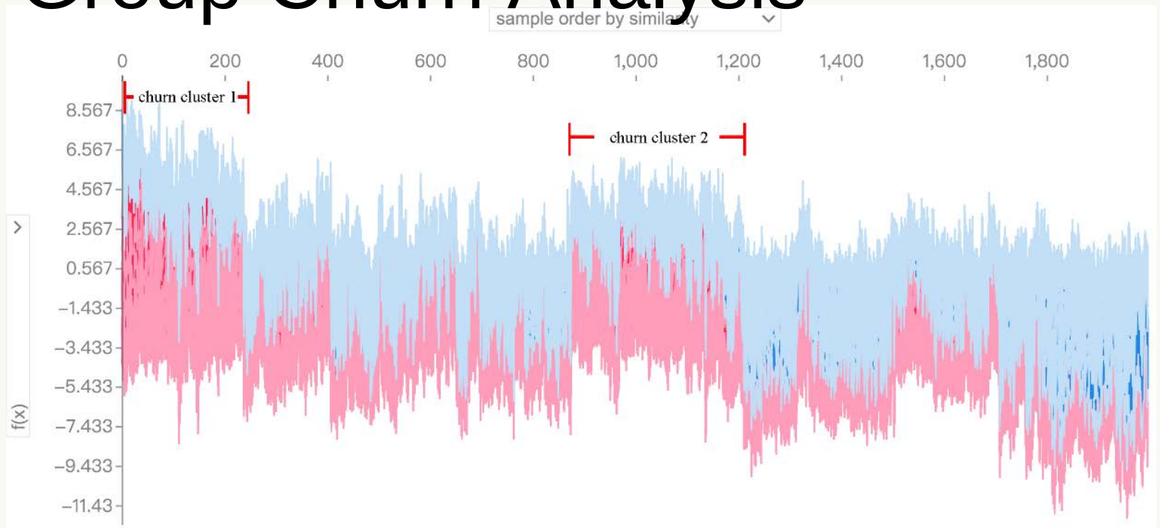
The SHAP values of churn player: features pushing the churn prediction higher are shown in red and lower are in blue

$0 \leq$ Number of titles ≤ 121.00 AND **Guild level = -1.00**
AND $0.00 <$ Daily average number of mainline tasks completed ≤ 18.24 AND $2.00 <$ Level promotion ≤ 10.00
AND $0.01 <$ Percentage of tasks abandoned ≤ 1.00

The logical rule of churn player

Explanation Analysis

Group Churn Analysis



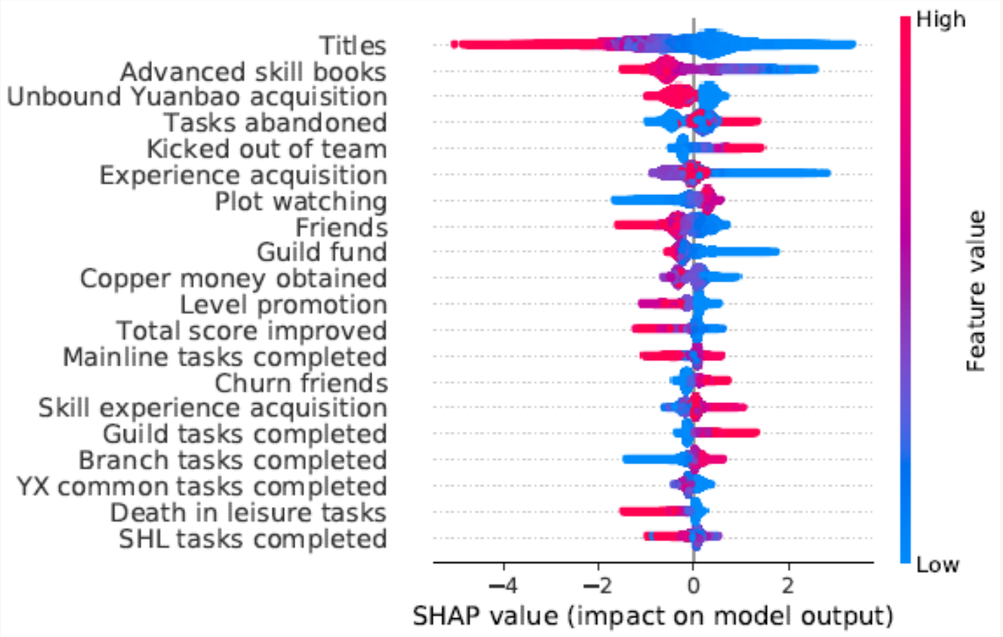
Rule	Accuracy(%)	Numbers
0 ≤ Titles ≤ 30 AND 0 ≤ Friends ≤ 6 AND 0 ≤ Guild fund ≤ 8750065 AND 0.02 < Percentage of Qiyu times ≤ 0.34	97.28	1880
0 ≤ Titles ≤ 30 AND 0 ≤ Advanced skill books ≤ 19 AND 0.02 < Percentage of Qiyu times ≤ 0.34	96.49	5984

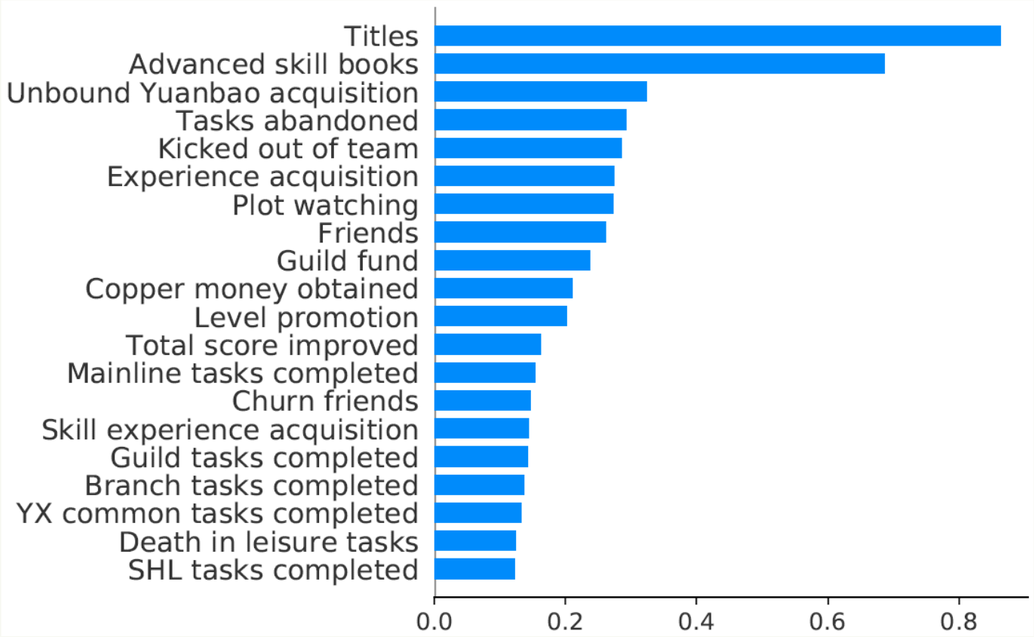
Supervised clustering based on SHAP values (cluster 1: difficulties in upgrading skills and equipment; cluster 2: friendship and guild are in a bad state)

The set of churn rules with clear accuracy and covered player numbers

Explanation Analysis

Global Churn Analysis

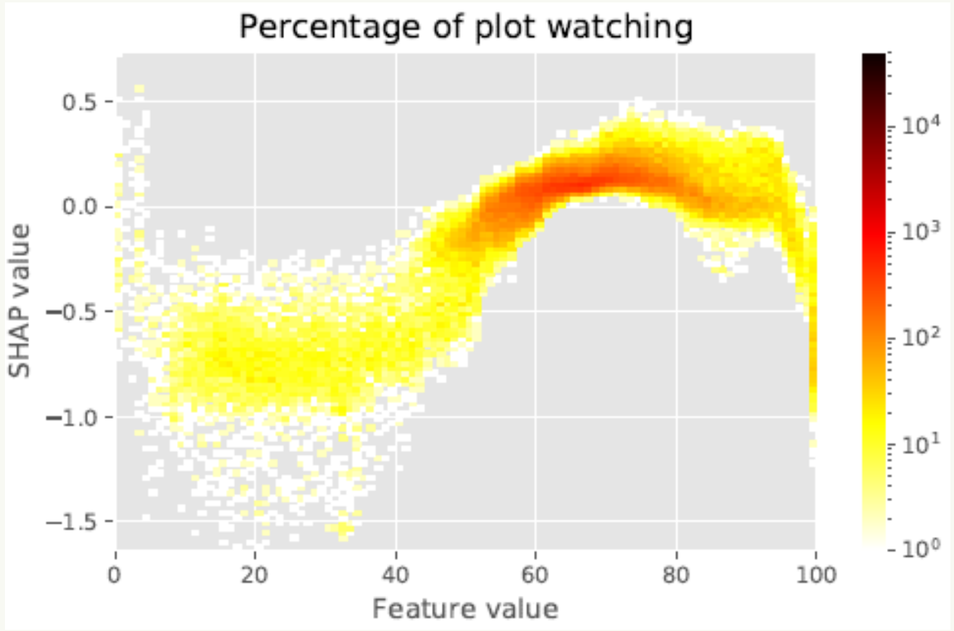


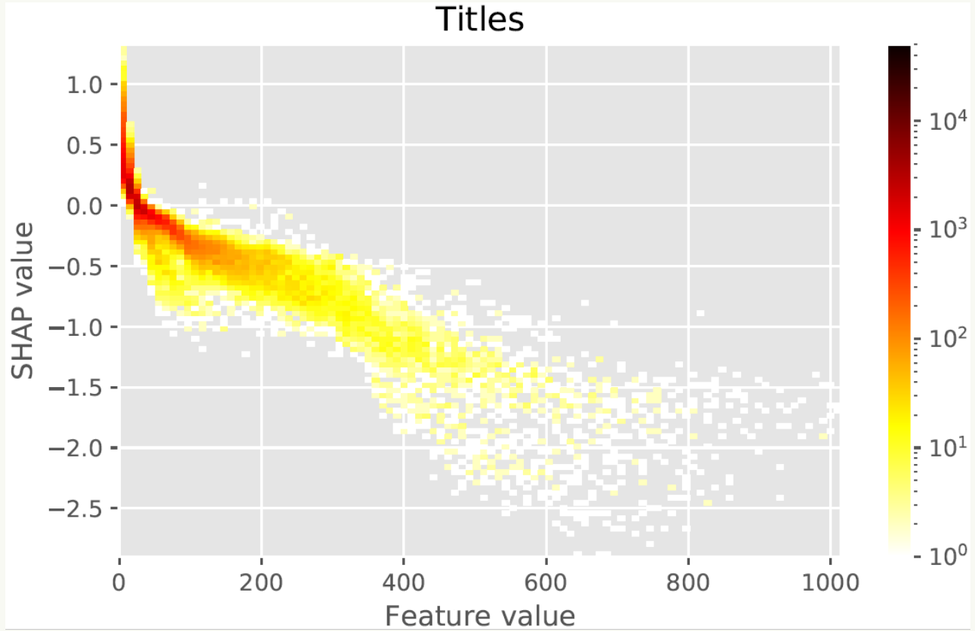


SHAP values summary plot: sorting features by the sum of the SHAP value magnitudes in all samples, using SHAP values to show the distribution of the impact of each feature

Explanation Analysis

Feature Dependence Analysis



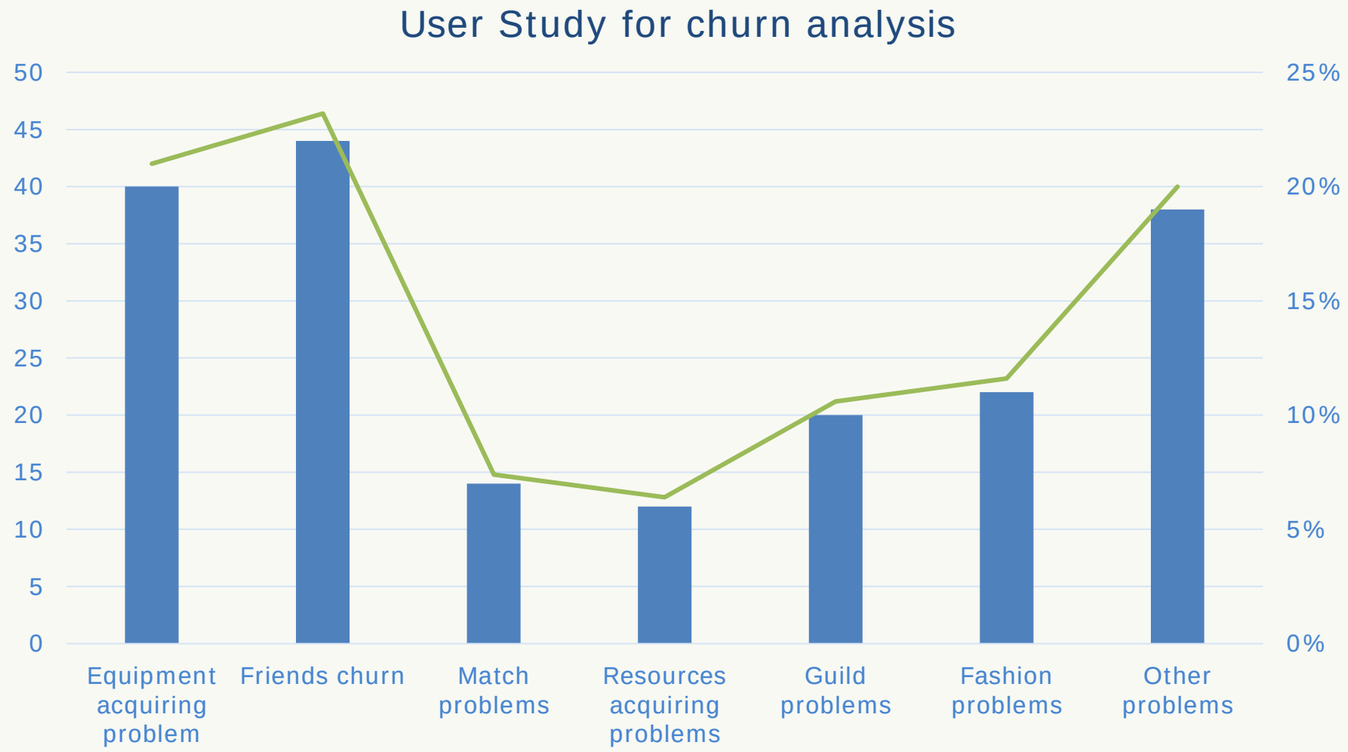


Feature dependence plot: use SHAP value of a feature for the y-axis and value of feature for the x-axis. The dark the color is, the higher the player density is

Evaluation

User Study

- **Case:** Collect 200+ feedback from Justice Online
- **Major churn types:** Difficulty in equipment acquiring, friends churn, matching problems, difficulty in resources acquiring, problems in fund activities of guild



Evaluation

Case Matching

(a) Individual churn explanation.

Player	Feature	Value	SHAP Values	Rules
Player A	**Guild fund**	**-1**	**0.7266**	0 ≤ Number of titles ≤ 121.00 AND **Guild level = -1.00** AND 0.00 < Daily average number of mainline tasks completed ≤ 18.24 AND 2.00 < Level promotion ≤ 10.00 AND 0.01 < Percentage of tasks abandoned ≤ 1.00
	Percentage of churn friends	**0.6000**	**0.4057**	
	Total times of Qiyu tasks completed	**130**	**0.3970**	
	Percentage of tasks abandoned	0.0370	0.3176	
Player B	**Percentage of churn friends**	**1**	**0.4931**	0 ≤ Percentage of experience acquisition ≤ 0.34 AND **0 ≤ Number of friends ≤ 3.00** AND 0 ≤ Number of titles ≤ 121.00 AND 80.52 < Percentage of plot watching ≤ 96.64 AND 0.58 < Percentage of teams created ≤ 1.00
	Percentage of time of PVP tasks completed	0.0282	0.3850	
	Number of friends	**1**	**0.3616**	
	Number of daily re-forging equipment	0.1100	0.2711	

(b) Player feedback.

Player	Feedback
Player A	I used to play the game with my friends, but now **most of them have left**. **My guild goes from bad to worse**. By the way, I **played Qiyu task (encounter tasks)** many times and the gameplay is boring now. These made me disappointed.
Player B	There is nothing new when I go up to full level in the game. Moreover, **most of my friends have left**. I feel bored and lonely to continue the game.

Evaluation

Matching Result

- About **61%** of feedback of churn cause match our XAI-enhanced analysis results

Logistic Regression	Decision Tree	Survival Forest	Ours
20.69	36.21	37.07	**61.21**

Human accuracy comparison of several main churn analysis methods

- Iterate the cause features according to the difference between the churn explanations and the feedback

Intervention

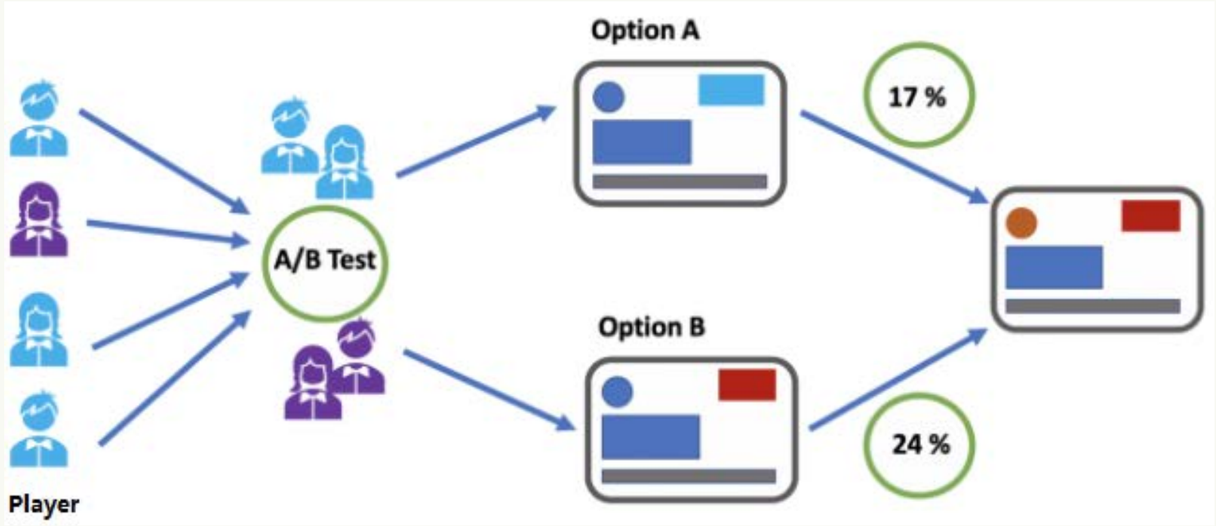
Targeted Intervention

- **Personalized Recommendation**
  - Social
  - Gameplay
  - Promotion
  - Activity
- **Targeted Guide**
  - Class matching evaluation
  - Growth
  - Play teaching
  - Battle replay
- **Dynamic numerical adjustment**
  - Rate increased
  - Reward improve
  - Content triggered
- **External intervention linkage**
  - Artificial care
  - Customized push
  - Targeted reward

Intervention

Evaluate Intervention

- We implement A/B testing to evaluate the effectiveness of interventions



Two independent samples t-test

$$Z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Intervention

Skip The Game Plot

- Two independent samples t-test average online time in recent two weeks: **players in experimental group can skip the plot at any time**

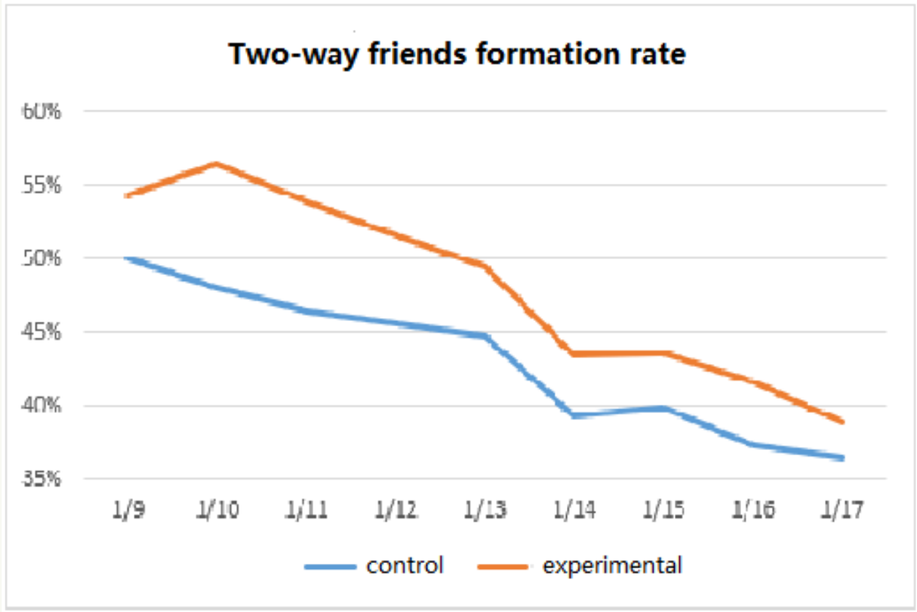
Group	Size	Mean	P-value
experimental vs *control*	28873 vs 26714	18,738s vs 18,392s	0.001

Strong statistical evidence proves the churn cause!

Intervention

Social Recommendation

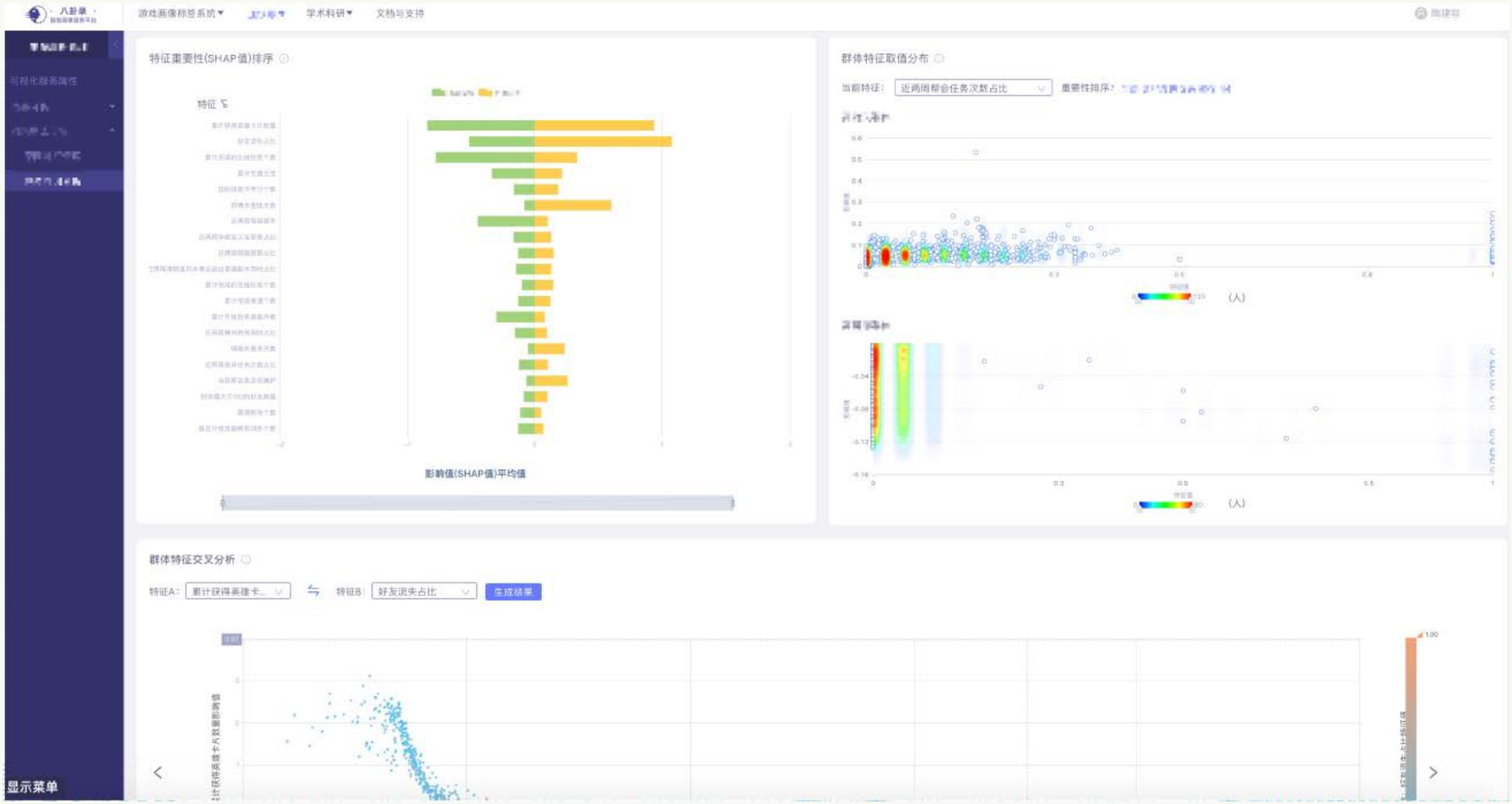
- Two independent samples t-test average online time in recent two weeks: **experimental group provided social recommendation services to players with friends churn tag**



Group	Size	Mean	P-value
experimental vs *control*	33086 vs 34122	18,819s vs 18,573s	0.002

The specific intervention for friends churn make a significant improvement!

Churn Analysis Platform



Credits

Yu Xiong	AI Researcher	NetEase Fuxi AI Lab
Runze Wu	AI Researcher	NetEase Fuxi AI Lab
Manhu Qu	AI Engineer	NetEase Fuxi AI Lab
Jianrong Tao	AI Researcher	NetEase Fuxi AI Lab
Xudong Shen	AI Engineer	NetEase Fuxi AI Lab
Qiaozhi Shen	AI Product Designer	NetEase Fuxi AI Lab

THANK YOU!