1 Dateset

Life Expectancy (WHO): The dataset compiles features such as life expectancy, health factors, economic factors and social factors for 193 countries between 2000 and 2015, focusing on the main factors affecting life expectancy. The dataset consists of 2938 rows, 21 features, and one target variable, which is life expectancy.

2 Feature importance calculated by the modified ShapG

Figure 1a presents the original undirected graph G, where each node corresponds one of 21 features in the dataset. Figure 1b presents the reduced graph G' obtained by the original ShapG method, with the density of 0.76. As comparative analyses, Figures 1c and 1d present reduced graphs of the best explanation results achieved by the improved ShapG method after five iterations on the lightGBM and MLP models with densities of 0.38 and 0.26, respectively.

Figure 2 shows the experimental results of the modified ShapG method with the construction of graphs with different densities based on five iterations of the improved ShapG algorithm.

Figure 3 shows the top 10 important features of different models (LightGBM and MLP) calculated by the improved ShapG algorithm at optimal density (the optimal density is chosen based on empirical results).

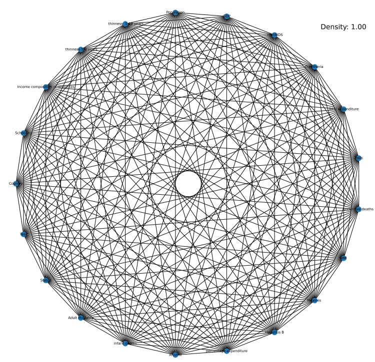
3 Comparison of feature importance ranking with different XAI methods

We numbered the features in the dataset as shown in Table 1.

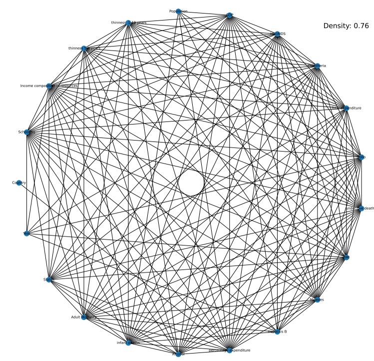
Table 1: Feature No. in “Life Expectancy” dataset

No.	Feature	No.	Feature
1	Country	12	Hepatitis B
2	Adult Mortality	13	GDP
3	Income composition of resources	14	percentage expenditure
4	HIV/AIDS	15	Total expenditure
5	Diphtheria	16	Status
6	thinness 1-19 years	17	Alcohol
7	Polio	18	Schooling
8	under-five deaths	19	Measles
9	thinness 5-9 years	20	Population
10	infant deaths	21	Year
11	BMI		

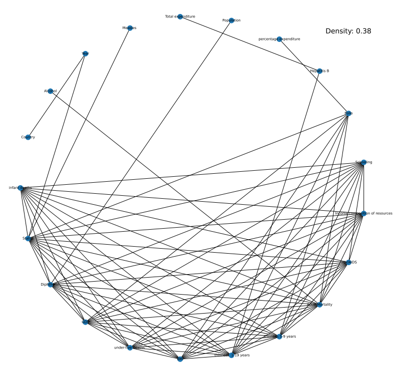
Table 2 shows the feature importance ranking results of different XAI methods for the “Life Expectancy” dataset in the LightGBM model and MLP model.



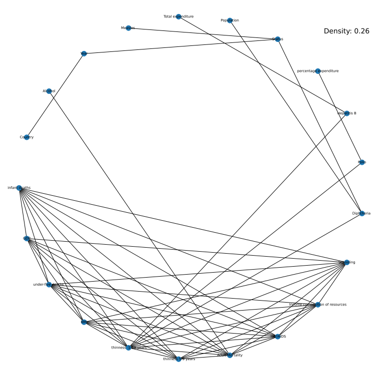
(a) Original graph G



(b) Reduced graph G' computed by original ShapG



(c) Reduced graph G' with given density 0.10 computed by improved ShapG (used for LightGBM model)

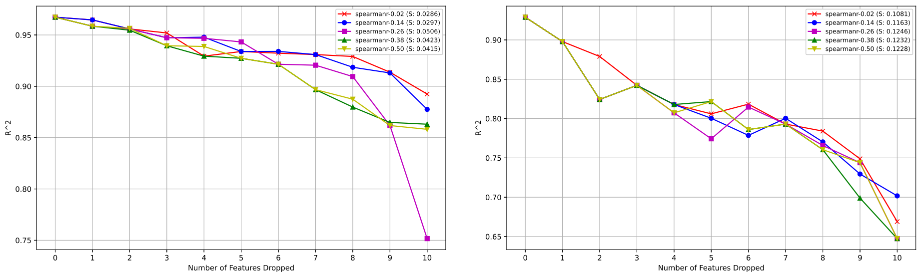


(d) Reduced graph G' with given density 0.19 computed by improved ShapG (used for MLP model)

Fig. 1: Graph connecting features in "Life Expectancy" dataset

4 Perturbation analysis and comparison of XAI methods with S metric

Table 4 shows the comparison of all XAI methods for perturbation analysis and S metrics.

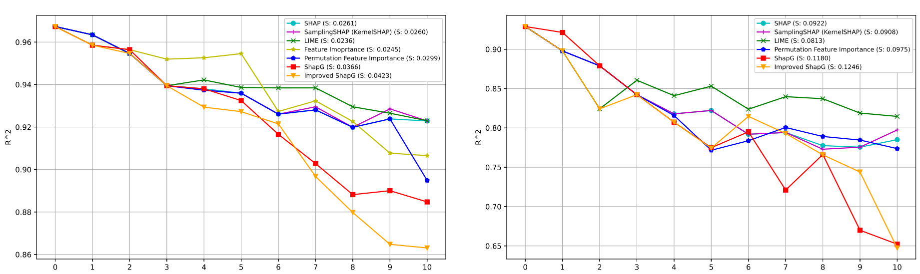


(a) LightGBM model (b) MLP model

Fig. 2: Comparison of accuracy after dropping features given by the improved ShapG method with different densities. In terms of explanation accuracy, the higher the value of S, the more accurate the explanation.

(a) LightGBM model (b) MLP model

Fig. 3: Feature importance in "Life Expectancy" dataset calculated with the modified ShapG method



(a) LightGBM model (b) MLP model

Fig. 4: Comparison of accuracy after dropping features based on different XAI methods. In terms of explanation accuracy, the higher the value of S, the more accurate the prediction of the XAI method.

Table 2: Feature importance ranking for "Life Expectancy" dataset across models

XAI / Rank	SHAP		SamplingSHAP KernelSHAP		LIME		Feature Importance		Permutation FI		ShapG		Improved ShapG	
	LGB	MLP	LGB	MLP	LGB	MLP	LGB	MLP	LGB	MLP	LGB	MLP	LGB	MLP
Top 1	4	2	4	2	4	2	2	-	4	2	2	3	2	2
Top 2	2	3	2	3	2	4	3	-	2	3	3	2	4	4
Top 3	3	4	3	4	3	20	1	-	3	4	4	4	3	3
Top 4	18	5	8	5	9	8	15	-	8	8	18	18	1	18
Top 5	8	14	18	14	21	13	17	-	18	10	10	11	6	6
Top 6	9	8	9	8	5	1	4	-	9	14	8	7	18	5
Top 7	21	9	11	9	11	7	9	-	21	16	11	5	9	11
Top 8	11	6	21	13	18	11	11	-	11	9	6	8	11	8
Top 9	17	13	5	6	10	18	18	-	17	5	5	10	8	7
Top 10	5	16	17	21	17	17	14	-	1	13	7	13	5	9

5 Running time

Table 3 shows the running time of the XAI methods based on cooperative game theory for LightGBM and MLP models. We compare the running time of KernelSHAP, SamplingSHAP, ShapG, and improved ShapG methods.

Table 3: Running time of XAI methods for "Life Expectancy" dataset

LightGBM model

XAI method	KernelSHAP	SamplingSHAP	ShapG	**Improved ShapG**
Running time	3532.37 s	385.85 s	232.08 s	54.24 s

MLP model

XAI method	KernelSHAP	SamplingSHAP	ShapG	**Improved ShapG**
Running time	220 min 14 s	29 min 48 s	103 min 31 s	26 min 14 s

6 Conclusions

Improved ShapG method achieves highly significant breakthroughs in running efficiency(see the results described in Section 5), maintaining high explanation accuracy (see the results described in Section 4), while significantly reducing computational complexity.