

# XNLI: Explaining and Diagnosing NLI-based **Visual Data Analysis**





Yingchaojie Feng<sup>1</sup> Xingbo Wang<sup>2</sup>

Bo Pan<sup>1</sup>







Yi Ren<sup>1</sup>



Shi Liu<sup>1</sup>



Zihan Yan<sup>3</sup>

Yuxin Ma<sup>4</sup>



Huamin Ou<sup>2</sup>



Wei Chen<sup>1</sup>

- 1. Zhejiang University
- 2. Hong Kong University of Science and Technology
- 3. Massachusetts Institute of Technology
- 4. Southern University of Science and Technology

# Background

• Natural language interfaces (NLIs) have become a popular and effective interactive paradigm for accomplishing human tasks.







OK! When do you plan to leave?

Good morning! It is sunny.







# **Related Work**

• Prior work have introduced **interactive widgets** to help users identify ambiguities in the queries and support adjustments.





# **Related Work**

- Prior work have introduced **interactive widgets** to help users identify ambiguities in the queries and support adjustments.
  - E.g., DataTone manages ambiguity regarding attribute, dimension, etc.



DataTone (Gao et al)



			'n
ing	by	country	i I
ng (Sport)			I I
dSkating (Sport)			l
ng (Sport)			l
			l I
			1
			l I
			I

# **Related Work**

- Lack of systematic explanations for data transformation process in the context of NLI pipeline.
- Diagnosing and correcting the unexpected results remains a challenge.

Show IMDb rating of movies with gross no less than 100M and budget less than 100M.

## IMDb Dataset



## Data Attribute

IMDB Rating	Worldwide Gross	Production Budget	
8.7	33180607	37000000	
7.4	54777490	13000000	
6.1	65388	5000000	
6.9	143049560	90000000	
5.4	158908290	80000000	
5.3	78948765	85000000	

## Analytical Task

IMDB Rating	Worldwide Gross	Production Budget
8.7	33180607	37000000
7.4	54777490	13000000
6.1	65388	500000
<del>6.9</del>	<del>143049560</del>	9000000
5.4	<del>158908290</del>	8000000
5.3	78948765	85000000

## **NLI process**

 $\rightarrow$ 





# XNLI

## We present **XNLI**, an e**X**plainable **NLI** system for visual data analysis

Data View	II Query Vie	w							
movies-w-year.csv V Upload	show me the	rating by gene	of the movies wit	h g <u>ross</u> no <u>les</u>	than 100M and <u>budget</u>	under 50M			(
Data Overview	Chart					Explanation	ø = e		1
Title   A Nominal The Simpsons Movie, Deep Blue Sea, The P	8.5			0	8	Attribute Worldwide Gro	ss Production Budg	et IMDB Rating	( V Genre
Worldwide Gross	8	o 0	0	0	o 0	Title	Genre IMDB	Rating Worldwide Gross	Production Budget
Production Budget  # Quantitative 6400000, 8000000, 16000000, 64000000,	7-0-0 0	• •		° °	0 0 0	The Town The Mist Redacted Spy Game	Drama 8 Horror 7 Drama 6 Action 6	.7 33180607 .4 54777490 .1 65388 .9 143049560	37000000 13000000 5000000 90000000
Temporal         Temporal           2000/01/01, 1999/01/01, 2004/01/01, 1996         1996	6-0	o 00		o 0 o	<b>o</b> 0	Daylight	Action 5 Thriller 6	.4 158908290 .3 113622499	80000000 46000000
Content Rating   A Nominal  G, PG, R, PG–13	-5.5 -5	0		0	o	Task 1 Task 1	2) Gross > 100000000	Data Records: 709 →	357
Running Time Time Tube 2014 August 2014 Au	8 8 8 8 4					Title	Genre IMDB	Rating Worldwide Gross	Production Budget
Genre T	3.5-			0		The Mist Redacted Spy Game	Horror F Drama 6 Action 6	.4 54777490 .4 65388 .9 143049560	13000000 5000000 90000000
Creative Type The Type The Type Type Type Type Type Type Type Typ	2.5-					Daylight	Action 5 Thriller 6	.4 158908290 .3 113622499	46000000
Rotten Tomatoes Rating         T           # Quantitative	1.5					Visual Encod	er Plot v	6 o	
MDB Rating   # Quantitative 1.7, 2.2, 3.2, 2.3, 2.9, 3.3, 3.4, 3.5, 3.9, 4, 4	0.5-					X Axis Genr Y Axis IMDE	Rating V	80 4- 80 2- MI	



# **Design Process**

- Target users: **data analysts** who use NLIs for visual analysis
- Pilot study: open-ended task exploration, user interview







# requirements

# **Design Process**

• Result analysis

	<b>Unexpected Behaviors</b>	Total	Locate	Correct
Attributes	Fail to infer	17	12	9
Attributes	Unexpected types	14	5	5
	Fail to infer	9	6	1
Tasks	Unexpected types	15	9	4
	Impractical parameters	12	5	4
Visual Encoding	Chart types	8	6	4
Visual Encounig	Encoding channel	5	5	3

**Total:** total unexpected results appeared in the pilot study. **Locate:** the unexpected results located by the users. **Correct:** the unexpected results corrected by the users.

- Design requirements
- Provide an overview of the visualization process **R1** from the key aspects of the NLI pipeline.
- Leverage the representative data items to **R2** demonstrate the visualization process.
- **R3** Reveal the connections between the visualization process and the original query.
- Show the inference types of NLI to highlight the **R4** uncertainty of query interpretation.
- Support adjustment of the visualization process **R5** through directed manipulation.
- Provide hints and query examples for query **R6** phrasing and revision.



# XNLI - System Workflow



A. Support NLI-based data analysis B. Provide explanation for key NLI aspects C. Support interactive adjustments D. Provide hints for query revision



## **Interactive Adjustment T** Worldwide Gross < 10000000 Worldwide Gross Attribute: **Operator:** ● > ○ < ○ = Value: 10000000 **Query Hint** Worldwide Gross > 10000000 8 Recommend revising the guery with the supported phrases: more, over,

Data View	Quer	ry View													
movies-w-year.csv 🗸 Upload	show m	ne the <u>rat</u> i	ing by gene	of the mo	ovies witl	g <u>ross</u>	no <u>less</u>	than 10	00M and	budget und	<u>ər</u> <u>50M</u>				C
Data Overview	Chart										Explanation		Ē		ſ
Title	9										Attribute				(
A Nominal The Simpsons Movie, Deep Blue Sea, The P	8.5	0				0 8				8	Worldwide Gross	Producti	on Budget	IMDB Rating	Genre
Worldwide Gross T # Quantitative	8		0	8	0	00000				ō	Title	Genre	IMDB Rating	Worldwide Gross	Production
154832896, 108539911, 46432264, 7668121	7.5	0	0		•	ŏ o	0		8		The Town	Drama	8.7	33180607	37000000
Production Budget	7-	0		0		0		0	0	8	The Mist	Horror	7.4	54777490	13000000
# Quantitative 6400000, 8000000, 16000000, 64000000,	6.5	0		00000		8	8		0	ŏ	Redacted Spy Game	Drama Action	6.1	65388 143049560	5000000 90000000
Release Year		0		000		0	8			0	Daylight	Action	5.4	158908290	80000000
	6	8	0	00000		0	8			0	Insomnia	Thriller	6.3	113622499	46000000
Content Rating	5.5			8			0		0		Task 🕕 🔅	.)			(
A Nominal G, PG, R, PG–13	ating 2			0 0							Vorldwide Gr	oss > 1000	00000 Data	Records: 709 →	357
Running Time	ά <sub>4.5</sub> Ω											_			Production
# Quantitative 74, 75, 78, 80, 81, 82, 83, 84, 85, 86, 87, 8	<b>S</b> 4										Title The Town	Genre Drama	IMDB Rating	Worldwide Gross	Budget
Genre	3.5										The Mist	Horror	7.4	54777490	13000000
A Nominal											Redacted	Đrama	6.1	65388	500000
Drama, Action, Musical, Thriller, Romantic	3-					0	0				Spy Game Davlight	Action	6.9 5.4	143049560	80000000
Creative Type	2.5										Insomnia	Thriller	6.3	113622499	46000000
A Nominal Historical Fiction, Factual, Super Hero, Kids	2														
Rotten Tomatoes Rating											Visual Encodir	ng			(
# Quantitative 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,	1.5										Chart Scatter	Plot		6 0	
IMDB Rating	1-										X Axis Genre			4	
# Quantitative 1.7, 2.2, 3.2, 2.3, 2.9, 3.3, 3.4, 3.5, 3.9, 4, 4	0.5										Y Axis IMDB F	ating		2	
	0	Action	Adventure C	omedy Docun	mentary C	Drama Genre	Horror	Musical	Romantic Com	edy Thriller	Color		$\sim$	Thrille Gen	ler I <b>re</b>

- NLI Data Analysis
- Process Explanation
- Query Revision Hint



# • Interactive Adjustment

## XNLI **EXPLAINING AND DIAGNOSING NLI-BASED VISUAL DATA ANALYSIS** Data View **Query View** Q movies-w-year.csv Upload show me the rating by gene of the movies with gross no less than 100M and budget under 50M Data Overview Chart Title A Nominal 8.5 The Simpsons Movie, Deep Blue Sea, The P.. Worldwide Gross # Quantitative 154832896, 108539911, 46432264, 7668121... 7.5-0 Production Budget # Quantitative 8 6400000, 8000000, 16000000, 64000000, 6.5 Release Year Temporal -0 2000/01/01, 1999/01/01, 2004/01/01, 1996. 5.5 Content Rating 0 A Nominal G, PG, R, PG-13 ен 4.5 Running Time # Quantitative 74, 75, 78, 80, 81, 82, 83, 84, 85, 86, 87, 8. Genre 3.5 A Nominal Drama, Action, Musical, Thriller, Romantic ... Creative Type 2.5 A Nominal Historical Fiction, Factual, Super Hero, Kids... Rotten Tomatoes Rating # Quantitative 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, . IMDB Rating # Quantitative 0.5 1.7, 2.2, 3.2, 2.3, 2.9, 3.3, 3.4, 3.5, 3.9, 4, 4... Action Adventure Comedy Documentary Drama Horror Musical Romantic Comedy Thriller Genre

- NLI Data Analysis
  - NL4DV
- Process Explanation
- Query Revision Hint



# • Interactive Adjustment

		Attribute				$\odot$						
		Worldwide Gross	Productio	n Budget	MDB Rating	Genre	ING AND D					
Data View	Q											
movies-w-year.csv 🗸 Upload	sho	Title	Genre	IMDB Rating	Worldwide Gross	Production Budget	budget und	der <u>50M</u>				
	Ohar	The Town	Drama	8.7	33180607	37000000		. Employed		_		~
ita Overview	Char	The Mist	Horror	7.4	54777490	13000000		Explanation	ב 🕫 ו	<u>}</u>		Û
		Redacted	Drama	6.1	65388	5000000		Attribute				$\bigcirc$
		Spy Game	Action	6.9	143049560	9000000	0	Worldwide Gro	ss Product	ion Budget	IMDB Bating	Genre
		Daylight	Action	5.4	158908290	8000000	8					Come
		Insomnia	Thriller	6.3	113622499	46000000		Title	Genre	IMDB Rating	Worldwide Gross	Production Budget
ction Budget								The Town	Drama	8.7	33180607	37000000
		Taak	2			0	8	Redacted	Drama	6.1	65388	5000000
			2)					Spy Game	Action	6.9	143049560	90000000
lease Year  Temporal 00/01/01. 1999/01/01. 2004/01/01. 1996		▼ Worldwide G	ross > 10000	0000 Data	Records: 709 →	357	0	Daylight Insomnia	Action Thriller	5.4 6.3	158908290 113622499	80000000 46000000
ontent Rating		Title	Genre	IMDB Rating	Worldwide Gross	Production Budget		Task 🕕	2			$\odot$
	atinç	The Town	Drama	8.7	33180607	3700000		T Worldwide	Gross > 1000	00000 Data	Records: 709 →	357
	С Ш	The Mist	Horror	7.4	54777490	1300000			_			Production
	QWI	Redacted	<del>Drama</del>	<del>6.1</del>	65388	500000		Title	Genre	IMDB Rating	Worldwide Gross	Budget
		Spy Game	Action	6.9	143049560	90000000		The Hown	Brama Horror	<del>8.7</del> <del>7.4</del>	54777490	13000000
		Daylight	Action	5.4	158908290	80000000		Redacted	Đrama	6.1	65388	5000000
		Insomnia	Thriller	6.3	113622499	46000000		Spy Game	Action	6.9	143049560	90000000
tive Type Type	l				· · · · · · · · · · · · · · · · · · ·		J	Insomnia	Thriller	6.3	113622499	46000000
orical Fiction, Factual, Super Hero, Kids	(	Visual Encodi	ng			$\bigcirc$		Visual Encod	ling			0
		Chart Scatte	r Plot		6-0			Chart Scatt	ter Plot	~ 2	o <sup>6</sup>	
				ting				X Axis Genre	e	Rati	4	
		X Axis Genre		B Rat	4-			Y Axis IMDE	8 Rating	V MDB	2	
		Y Axis IMDB I	Rating	V IO	2		edy Thriller	Color		~	0	ller <b>hre</b>
		Color			0⊥ Thrille	er		~ `				



# oata Analysis ss Explanation obtrusive

v Revision Hint

# **XNLI - Process Explanation**

Attribute				$\odot$
Worldwide Gros	s Productio	on Budget	IMDB Rating	Genre
Title	Genre	IMDB Rating	Worldwide Gross	Production Budget
The Town	Drama	8.7	33180607	37000000
The Mist	Horror	7.4	54777490	13000000
Redacted	Drama	6.1	65388	5000000
Spy Game	Action	6.9	143049560	90000000
Daylight	Action	5.4	158908290	80000000
Insomnia	Thriller	6.3	113622499	46000000

Worldwide	Gross > 1000	000000 Data	Records: 709 $\rightarrow$	357
Title	Genre	IMDB Rating	Worldwide Gross	Productior Budget
The Town	Đrama	8.7	33180607	3700000
The Mist	Horror	7.4	54777490	13000000
Redacted	Ðrama	6.1	65388	500000
Spy Game	Action	6.9	143049560	90000000
Daylight	Action	5.4	158908290	80000000
Insomnia	Thriller	6.3	113622499	46000000



- Provide data provenance to demonstrate the process
  - Extract the process from Vega-Lite specification
  - Select representative data items
  - Add visual cues to emphasize the changes

{
"\$schema": " ",
"data": {
"url": "assets/data/movies-w-year.csv"}
"mark": {
"type": "bar" },
"encoding": {
"x": { "field": "Genre" },
"y": {
'aggregate': "mean",
"field": "Worldwide Gross" }},
"transform": [{
"filter": {
"field": "Creative Type",
"oneOf": [ "Super Hero" ]
}
}]
}

Creative Type: Super Hero									
Genre	Title	Creative Type	Worldwide Gros						
Drama	The Town	Contemporary Fiction	33180607						
Horror	The Mist	Science Fiction	54777490						
Action	Iron Man	Super Hero	582604126						
Action	Hellboy	Super Hero	99823958						
Adventure	Spider-Man	Super Hero	821708551						
Adventure	Spider-Man 3	Super Hero	890871626						

Mean	Mean Worldwide Gross by Genre										
Genre	Title	Worldwide Gross	mean of Worldwide Gross								
A	Hellboy	99823958	041014040								
Action	Iron Man	582604126	341214042								
Advorturo	Spider-Man	821708551	956000099 5								
Adventure	Spider-Man 3	890871626	630290068.5								





# **XNLI - Process Explanation**

Attribute				$\odot$
Worldwide Gro	oss Produc	ction Budget	IMDB Rating	∨ Genre
Title	Genre	IMDB Ratir	ng Worldwide Gro	production Budget
The Town	Drama	8.7	33180607	37000000
The Mist	Horror	7.4	54777490	13000000
Redacted	Drama	6.1	65388	5000000
Spy Game	Action	6.9	143049560	9000000
Daylight	Action	5.4	158908290	8000000
Insomnia	Thriller	6.3	113622499	46000000

Worldwide	Gross > 1000	00000	Data	Records: 709 $\rightarrow$	357
Title	Genre	IMDB	Rating	Worldwide Gross	Production Budget
The Town	Drama	8	3.7	33180607	3700000
The Mist	Horror	7	.4	54777490	1300000
Redacted	Drama	6	<del>3.1</del>	65388	500000
Spy Game	Action	6	6.9	143049560	90000000
Daylight	Action	5	5.4	158908290	80000000
Insomnia	Thriller	6	6.3	113622499	46000000



- Provide data provenance to demonstrate the process
- Show the inference types of NLI (explicit and implicit or ambiguous)
- Reveal the relevant trigger words in the original queries.

how me the	<u>rating</u>	by	<u>gene</u>	of the	movies	with	gross no	less tha	an <u>100M</u> a	and <u>budget</u>	under <u>5</u> 0
							Task 1	2 Gross < 10000	00000 Data F	Records: 709 $\rightarrow$	352
							Genre	Title	IMDB Rating	Worldwide Gross	Production Budget
							Drama	The Town	8.7	33180607	37000000
							Horror	The Mist	7.4	54777490	13000000
							Drama	Redacted	6.1	65388	5000000
							Action	Spy Game	6.9	143049560	9000000
							Action	Daylight	5.4	158908290	8000000
							Comedy	Showtime	53	780/19765	8500000





		Attribute				$(\land)$		
		Worldwide Gross	Production	Budget	IMDB Rating	Genre	IING AND DI	IAGNOSING NLI-BASED VISUAL DATA ANALYSIS
Data View	Q				Content Rating	duction		
movies-w-year.csv V Upload		Title	Genre	IMDB Ratin	Rotten Tomatoe	ludget	budget und	<u>ler 50M</u>
Data Overview	Char	The Town The Mist	Drama Horror	8.7 7.4	IMDB Rating	000000	N	ົ∖ Explanation 🧭 📃 🗵 🛛 🗯
Title		Redacted	Drama	6.1	65388	5000000		Attribute
A Nominal The Simpsons Movie, Deep Blue Sea, The P		Spy Game	Action	6.9	143049560	90000000		Worldwide Green Braduction Rudget
		Daylight	Action	5.4	158908290	8000000	Ö	Wondwide Gross Production Budget WiDb hatting V Genre
# Quantitative 154832896, 108539911, 46432264, 7668121		Insomnia	Thriller	6.3	113622499	46000000		Title Genre IMDB Ratir Rotten Tomatoe
Production Budget								The Town         Drama         8.7         00000           The Mist         Horror         7.4         IMDB Rating         00000
# Quantitative 6400000, 8000000, 16000000, 64000000,		Task 1	)			$\odot$		Redacted         Drama         6.1         65388         5000000           Spy Game         Action         6.9         143049560         90000000
Release Year Temporal		Y Worldwide Gro	oss > 100000	000 Dat	a Records: 709 $\Rightarrow$ 3	357		Daylight         Action         5.4         158908290         8000000           Insomnia         Thriller         6.3         113622499         4600000
Content Rating		Attribute:	Worldwide	Gross	e Gross	Production		Task 1 2
	ating	Operator:	● > ○ <	< () =	607	37000000		▼ Worldwide Gross > 100000000 Data Records: 709 → 357
	В	Value	400000000		490	1300000		Attribute: Worldwide Gross
	M	, and the	10000000	)	88	500000		Operator: • > < = 80000 Budget
Genre		ору баше	Action	0.9	140049560	9000000		Value: 100000000
A Nominal Drama Action Musical Thriller Romantia		Daylight	Action	5.4	158908290	80000000		<u>ве 5000000</u> эру салие Астол с.э 143049560 9000000
		Insomnia	Thriller	6.3	113622499	46000000		Daylight Action 5.4 158908290 8000000
A Nominal								Insomnia Thriller 6.3 113622499 4600000
Historical Fiction, Factual, Super Hero, Kids		Visual Encodin	a			$\bigcirc$		Visual Encoding
# Quantitative			9			$\smile$		Chart Scatter Plot - 6
		Chart Scatter	Plot	$\sim$	ទ្រ			
IMDB Rating T		X Axis Genre		$\sim$	4- 			X Axis Genre
			oting		<b>80</b> <sup>2</sup>		Jecky Thriller	T AXIS IMUDB Hating Color Thriller
		Y AXIS IMDB R	aung	~	≧ _		ieuy minier	Genre
	_	Color		$\sim$	Thrille Genr	r A		

VIS 2023

# LI Data Analysis ocess Explanation nteractive Adjustment Add / Update / Delete uery Revision Hint

Data view	Query view	Hint List	111		
movies-w-year.csv V Upload	show me the <u>rating</u> by <u>ger</u>	Query Hint	<u>budget</u> <u>under</u> ~	<u>50M</u>	
ata Overview	Chart		E	Explanation	↓ <sup>4</sup>
		Chart Scatter Plot		Attribute	Hint List
		Recommend to specify the chart with the	0	Worldwide Gross Prod	Query Hint
		supported phrases: scatter plot, scatter.	<u> </u>		Chart Scatter Plot
				Title Genre	Recommend to specify the chart with the
		Query Hint		The Town Drama	supported phrases: <u>scatter plot</u> , <u>scatter</u> .
		Query mint	0 0	Redacted Drama	Query Hint
		Worldwide Gross > 10000000			Worldwide Gross > 100000000
		Recommend to revise the query with the	•		Recommend to revise the query with the supported phrase: more, over.
tent Rating		supported phrase: more, over.		Task 1 2	Query Hint
	5- ij			Y Worldwide Gross > 10	cating
	е <sub>4.5</sub>	Query Hint		Title Genre	The word <u>rating</u> seems ambiguous.
	≧ 4-	rating -> Content Rating			Query Hint
re Y ominal na, Action, Musical, Thriller, Romantic		The word <u>rating</u> seems ambiguous.			gene → Genre The word gene seems likes a typo.
ominal				Daylight Action Insomnia Thriller	
rical Fiction, Factual, Super Hero, Kids		Query Hint	(	Viewel Frankrike	
en Tomatoes Rating Y uantitative 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16		g <u>ene</u> -> Genre		Chart Scatter Plot	
		The word gene seems likes a typo.		X Axis Genre	
		L. Descriptore Descriptore Majori Descriptor	medy Thriller	Y Axis IMDB Rating	

- NLI Data Analysis
- Process Explanation
- Query Revision Hint
  - Ruled-based
  - Interaction-based •



# • Interactive Adjustment

# **XNLI - Query Revision Hint**





Case Study	



. .

o

To evaluate the effectiveness of XNLI and the impacts of added **explanations** on the analysis process, we conduct a comparative study (XNLI vs. a ablated version without explanations)

- 12 participants from a tech company and a national lab of a local university
- Tasks
  - Target replication (30 min)
  - Open-ended exploration (30 min)



Target replication: task completion quality

On average, our system significantly helped users to achieve a higher task **accuracy** (p = 0.0066)

Our system generally reduces completion time compared to the baseline, although no significance is observed (p = 0.2036)





Open-ended exploration: user behavior

We identified three kinds of user behaviors in response to system results:

- Use (view only)
- Use (view & adjust)
- Not use

Distribution of participants' use of explanation components in response to system's parsing results.

Parsing results	Use (only view)	Use (view and adjust)	Not use	Total
Expected	80	45	24	149
Unexpected	37	42	16	95
Total	117	87	40	244

The process explanations were frequently used (80+45=125 out of 149) to confirm the expected system results, and sometimes (45 out of 149) supported interactive adjustments for follow-up exploration

Participants relied on the process explanations to locate the problems (37+42=79 out of 95)

Sometimes problems were located and corrected without using explanation components (16 out of 95)



User feedback

## **Effectiveness & usability**

- **Process explanations** helped them assess the correctness of the visualization results
- **Interactive widgets** supported flexible adjustments to get the desired results
- **Query hints** helped them phrase and revise the queries
- Overall system workflow was considered reasonable

## **Impacts on visual data analysis** The explanations help understand the NLI process (6/12 strongly agree, 6/12 agree), do not

disrupt NLI-based data analysis (9/12 strongly agree, 3/12 agree), and increase trust

P4 remains suspicious of the current NLI-based analysis tools because they still require human understanding and intervention



# **XNLI - Discussion**

## **Lessons learned**

- Provide a preview of query results for NLI debugging
- Use explanations for NLI to promote system discoverability

## Generalizability

Major components of XNLI are independent of different NLI implementations

ttribute						(
Vorldwide Gros	s Produc	tion Budget	IN	1DB Rating	$\vee$	Genre
			Content Rating Rotten Tomatoe IMDB Rating			duction
litle	Genre	IMDB Ratin			э	ludget
The Town	Drama	8.7				000000
The Mist	Horror	7.4				000000
Redacted	Drama	6.1	_	65388		5000000
Spy Game	Action	6.9		143049560	9	90000000
Daylight	Action	5.4		158908290	8	30000000
Insomnia	Thriller	6.3		113622499	4	46000000

**Uncertainty Highlighting** 

Worldwide	Gross > 1000	00000	Data	Records: 709 →	357
Title	Genre	IMDB	Rating	Worldwide Gross	Production Budget
The Town	Drama	8.7		33180607	37000000
The Mist	Horror		7.4	54777490	1300000
Redacted	Drama	+	<del>6.1</del>	65388	500000
Spy Game	Action	6	6.9	143049560	9000000
Daylight	Action	Ę	5.4	158908290	80000000
Insomnia	Thriller	(	5.3	113622499	46000000



**Provenance Generator** 

Hint Generator



# XNLI – Limitations & Future Work

**Improve the query hint examples.** Use LLMs to improve diversity and naturalness of query examples for revision

**Provide explanations for follow-up queries.** Besides one-off queries, the system can explain how the NLIs leverage the context information to interpret the follow-up queries

**Improve the system evaluation.** Consider a stronger baseline (e.g., NLI with ambiguity widgets) for comparison





## XNLI: Explaining and Diagnosing NLI-based Visual Data Analysis

XNLI®	EXPLAINING	AND DIAGNOSING NLI-BASED VISUAL DATA A	NALYSIS
📰 Data View	II Query View		
movies-w-year.csv V Upload	show me the rating by gene of the movies with gross no less than 100M and bud	get <u>under 50M</u>	
Data Overview	Chart	Explanation 🧭 📃 📃	
Title	9	Attribute	Vingchapijo Eongl Vingk
A Nominal The Simpsons Movie, Deep Blue Sea, The P	8.5-0	Openation         Openation         Implementation           %         Worldwide Gross         Production Budget         IMDB Rating	
Worldwide Gross	8 0 0		
# Quantitative 154832896, 108539911, 46432264, 7668121	75	Title Genre IMDB Rating Worldwide Gross	Production Budget
		The Town Drama 8.7 33180607	37000000
Production Budget	7- 0- 8	The Mist Horror 7.4 54777490	
# Quantitative	° 8 8	Redacted Drama 6.1 65388	500000
	6.5	Opening         Davight         Action         5.4         158908290	8000000
Release Year		o Insomnia Thriller 6.3 113622499	46000000
2000/01/01, 1999/01/01, 2004/01/01, 1996			
Content Rating	8 0	Task 1	∧ I YI Ken <sup>⊥</sup> SI
A Nominal G, PG, R, PG–13		▼ Worldwide Gross > 10000000         Data Records: 709 → 3	57
Bunning Time	۳ 4.5- ۲		
# Quantitative		Title Genre IMDB Rating Worldwide Gross	Production Budget
74, 75, 76, 60, 61, 62, 65, 64, 65, 60, 67, 6		The-Miet Herror 7-4 54777400	
Genre	3.5-	Redacted         Drama         6.1         65388	500000
A Nominal Drame Action Musical Thriller Demontio	2	Spy Game Action 6.9 143049560	9000000
Drama, Action, Musical, minier, Romantic	0 0	Daylight Action 5.4 158908290	80000000
Creative Type	2.5-	Insomnia Thriller 6.3 113622499	4600000
A Nominal Historical Fiction, Factual, Super Hero, Kids	2-		Huamin Qu <sup>2</sup> We
Rotten Tomatoes Rating		Visual Encoding	⊘
# Quantitative	1.5-	Chart Scatter Plot	
1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,			1 7hejiang University
IMDB Rating		X Axis Genre V	
# Quantitative	0.5		2. Hong Kong Univers
1.7, 2.2, 3.2, 2.3, 2.9, 3.3, 3.4, 3.5, 3.9, 4, 4		Y Axis IMDB Rating V	
	o Action Adventure Comedy Documentary Drama Horror Musical Romantic Comedy Genre	Color V Thriller	4. Southern University
1			







Wei Chen<sup>1</sup>

Kong University of Science and Technology achusetts Institute of Technology ern University of Science and Technology