Learning Script Knowledge with Web Experiments

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Selected Topics in Semantics and Discourse

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How do you order pizza?

1. Take menu of your favorite delivery service
2. Decide for a pizza
3. Call number on the menu
4. Tell which pizza you want
5. Wait some time
6. Get your pizza
7. Pay pizza
8. Eat pizza

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Script:

standardized sequence of events that describes some stereotypical human activity

Script Knowledge

- Implicit knowledge
- Shared between all members of a culture
- Benefit for text understanding systems
  - Manual creation not feasible
  - Must be created automatically

Focus of this paper:

- Data acquisition: Where to find training data?
- How to compute graphs that show:
  - Paraphrases: Which phrases describe the same event?
  - Temporal order: Which event happens before another one?

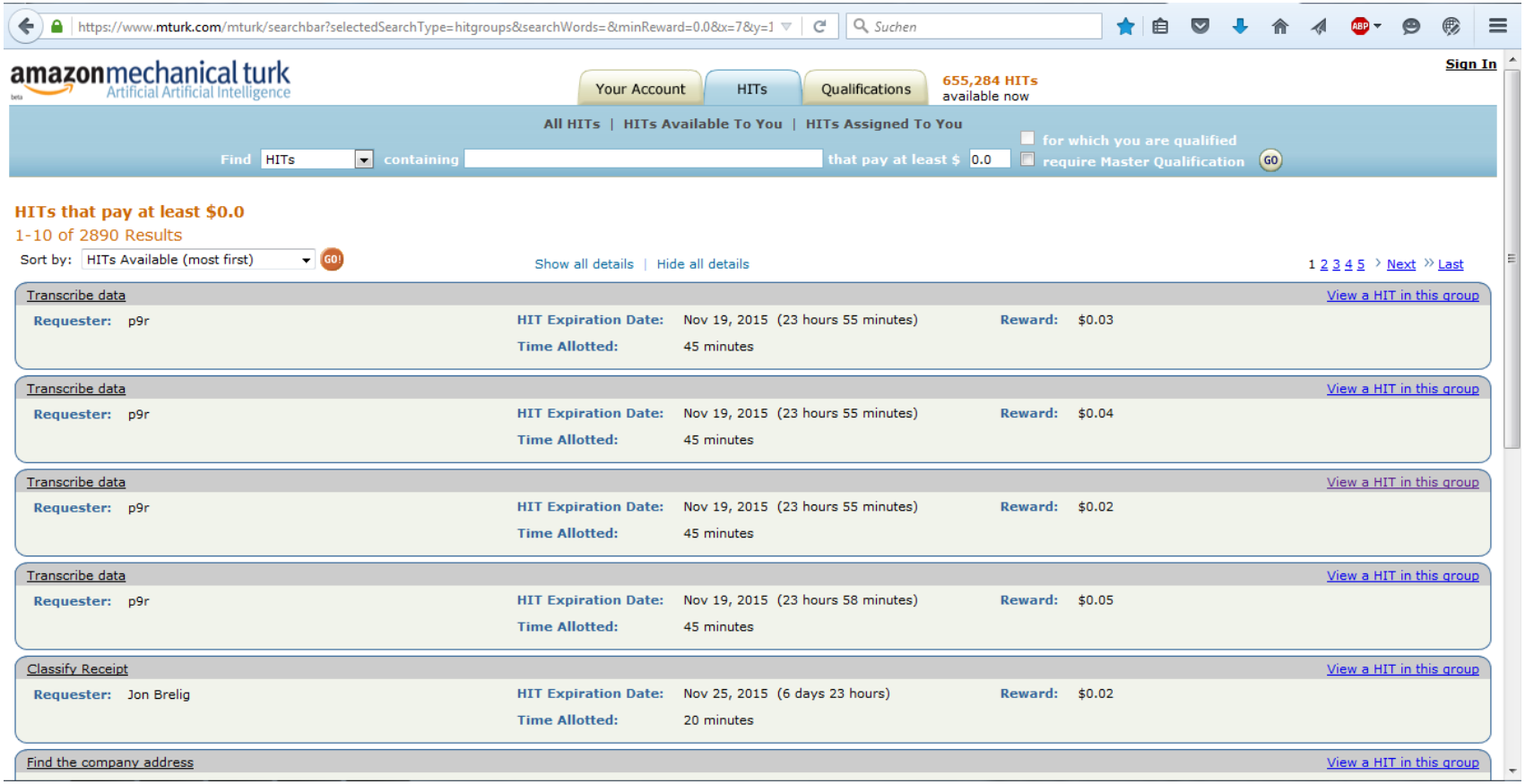
Terminology

- Script:
  - Stereotypical models of activities (actions 1-8 for ordering pizza)
- Scenario:
  - A class of activities (ordering pizza)
- Event:
  - Abstract part of a script (paying)
- Event Description:
  - Linguistic realization of an event ("pay the bill", "pay for food")
- Event Sequence Description (ESD)
  - Ordered list of event descriptions (first slide)

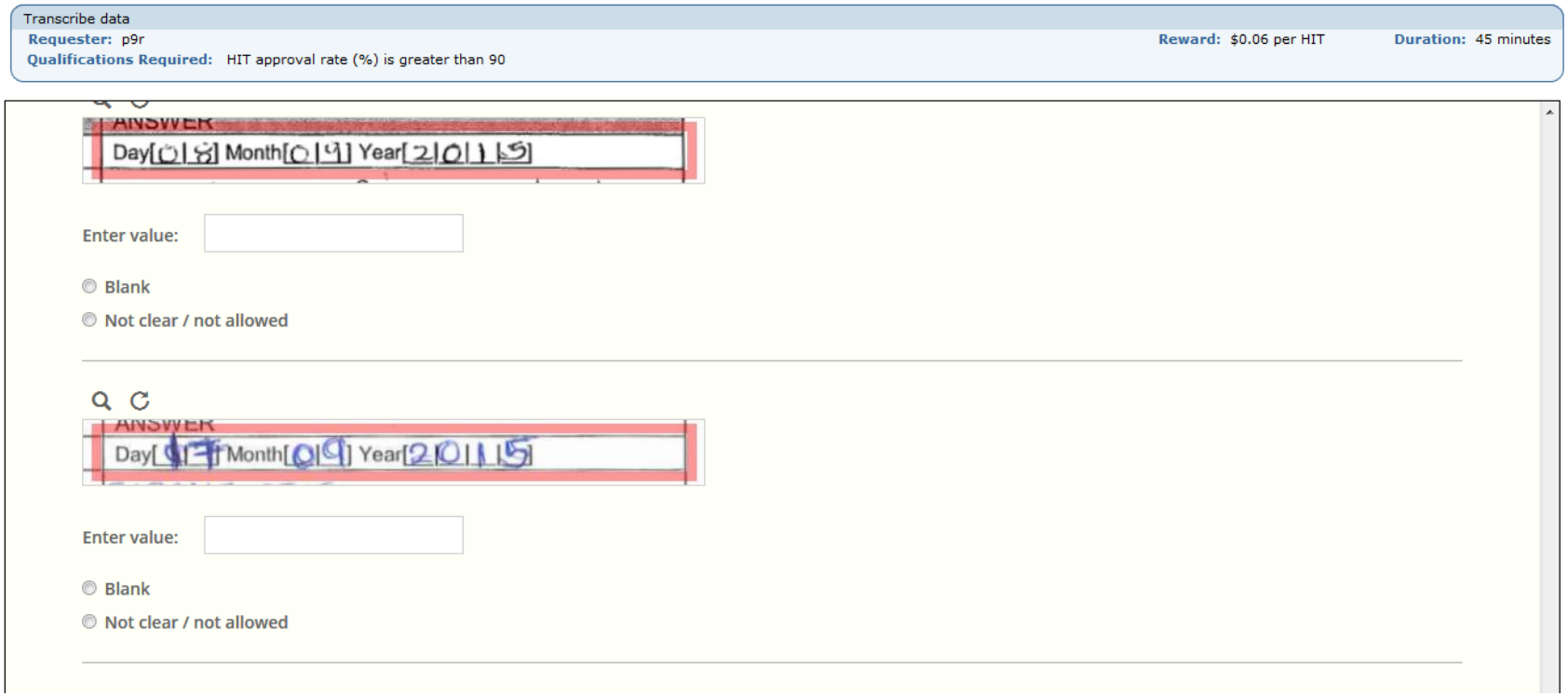
Training Data

- Ask experts:
  - Not feasible on large scale
- Learn from corpora:
  - Most knowledge is implicit
  - Only special scenarios can be found in texts
- Ask non-experts:
  - Explicit data
  - Any domain, any granularity

Ask non-experts: Amazon Mechanical Turk



Ask non-experts: Amazon Mechanical Turk



Ask non-experts

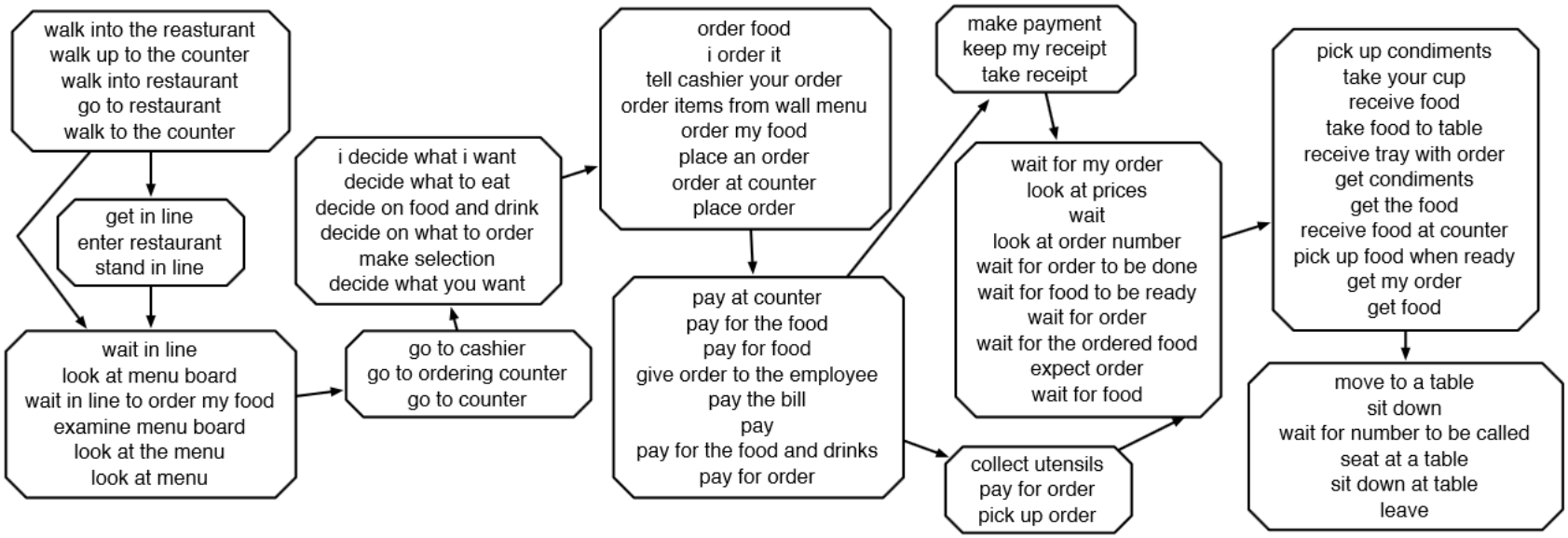
- 25 people
- 22 scenarios
- Task:
  - Describe scenario
  - 5-16 bulletin points
  - Temporal ordering
- Results:
  - Event Sequence Descriptions
- Manual correction

1. look at menu
2. decide what you want
3. order at counter
4. pay at counter
5. receive food at counter
6. take food to table
7. eat food

1. walk to the counter
2. place an order
3. pay the bill
4. wait for the ordered food
5. get the food
6. move to a table
7. eat food
8. exit the place

1. walk into restaurant
2. find the end of the line
3. stand in line
4. look at menu board
5. decide on food and drink
6. tell cashier your order
7. listen to cashier repeat order
8. listen for total price
9. swipe credit card in scanner
10. put up credit card
11. take receipt
12. look at order number
13. take your cup
14. stand off to the side
15. wait for number to be called
16. get your drink

Temporal Script Graphs



Computing Temporal Script Graphs

- Positive:
  - Each ESD is already ordered
- But:
  - Different ESDs use different words
  - Not every ESD contains every step

Task:

- Identify phrases from different ESDs that describe the same event

→ Multiple Sequence Alignment (MSA)

Multiple Sequence Alignment (MSA)

row	s_1	s_2	s_3	s_4
1	⊘	walk into restaurant	⊘	enter restaurant
2	⊘	⊘	walk to the counter	go to counter
3	⊘	find the end of the line	⊘	⊘
4	⊘	stand in line	⊘	⊘
5	look at menu	look at menu board	⊘	⊘
6	decide what you want	decide on food and drink	⊘	make selection
7	order at counter	tell cashier your order	place an order	place order
8	⊘	listen to cashier repeat order	⊘	⊘
9	pay at counter	⊘	pay the bill	pay for food
10	⊘	listen for total price	⊘	⊘
11	⊘	swipe credit card in scanner	⊘	⊘
12	⊘	put up credit card	⊘	⊘
13	⊘	take receipt	⊘	⊘
14	⊘	look at order number	⊘	⊘
15	⊘	take your cup	⊘	⊘
16	⊘	stand off to the side	⊘	⊘
17	⊘	wait for number to be called	wait for the ordered food	⊘
18	receive food at counter	get your drink	get the food	pick up order
19	⊘	⊘	⊘	pick up condiments
20	take food to table	⊘	move to a table	go to table
21	eat food	⊘	eat food	consume food
22	⊘	⊘	⊘	clear tray
22	⊘	⊘	exit the place	⊘

Multiple Sequence Alignment (MSA)

1. Calculate pairwise similarity
2. For 2 sequences
3. Find cheapest alignment:
   minimize:
   $c(A) = c_{gap} * |gap| + \sum_{i=1}^{n} \sum_{j=1, a_{ij} \neq gap}^{m} \sum_{k=j+1, a_{ki} \neq gap}^{m} cost_m(a_{ij}, a_{ki})$
4. Consider result as one sequence
5. Back to 2

Semantic Similarity ($cost_m$)

$$sim = \alpha * pred + \beta * subj + \gamma * obj$$

- Identify subject, object(s) and predicate
- Similarity scores based on Wordnet
- Optimized weights, $\alpha > \beta$, $\alpha > \gamma$

Multiple Sequence Alignment (MSA)

row	s_1	s_2	s_3	s_4
1	⊘	walk into restaurant	⊘	enter restaurant
2	⊘	⊘	walk to the counter	go to counter
3	⊘	find the end of the line	⊘	⊘
4	⊘	stand in line	⊘	⊘
5	look at menu	look at menu board	⊘	⊘
6	decide what you want	decide on food and drink	⊘	make selection
7	order at counter	tell cashier your order	place an order	place order
8	⊘	listen to cashier repeat order	⊘	⊘
9	pay at counter	⊘	pay the bill	pay for food
10	⊘	listen for total price	⊘	⊘
11	⊘	swipe credit card in scanner	⊘	⊘
12	⊘	put up credit card	⊘	⊘
13	⊘	take receipt	⊘	⊘
14	⊘	look at order number	⊘	⊘
15	⊘	take your cup	⊘	⊘
16	⊘	stand off to the side	⊘	⊘
17	⊘	wait for number to be called	wait for the ordered food	⊘
18	receive food at counter	get your drink	get the food	pick up order
19	⊘	⊘	⊘	pick up condiments
20	take food to table	⊘	move to a table	go to table
21	eat food	⊘	eat food	consume food
22	⊘	⊘	⊘	clear tray
22	⊘	⊘	exit the place	⊘

Evaluation

- 10 scenarios
- Paraphrase set
  - 30 pairs classified as paraphrases
  - 30 pairs random selected
- Happens-before-set
  - 30 pairs classified as happens-before
  - 30 pairs random selected
  - All 60 pairs in reverse order
- Gold standard: 5 non-experts

Baselines

- Upper bound
  - Random selected human annotation
- Clustering
  - One node per event description
  - Semantic similarity: as before
- Levenshtein
  - Semantic similarity: Levenshtein Distance
  - Character-wise distance / length

Paraphrase task

	Scenario	Precision			Recall			F-Score			
		sys	base$_{cl}$	base$_{lev}$	*sys*	base$_{cl}$	base$_{lev}$	*sys*	base$_{cl}$	base$_{lev}$	upper
MTurk	pay with credit card	0.52	0.43	0.50	0.84	0.89	0.11	**0.64**	0.58	• 0.17	0.60
	eat in restaurant	0.70	0.42	0.75	0.88	1.00	0.25	**0.78**	• 0.59	• 0.38	• 0.92
	iron clothes I	0.52	0.32	1.00	0.94	1.00	0.12	**0.67**	• 0.48	• 0.21	• 0.82
	cook scrambled eggs	0.58	0.34	0.50	0.86	0.95	0.10	**0.69**	• 0.50	• 0.16	• 0.91
	take a bus	0.65	0.42	0.40	0.87	1.00	0.09	**0.74**	• 0.59	• 0.14	• 0.88
OMICS	answer the phone	0.93	0.45	0.70	0.85	1.00	0.21	**0.89**	• 0.71	• 0.33	0.79
	buy from vending machine	0.59	0.43	0.59	0.83	1.00	0.54	**0.69**	0.60	0.57	0.80
	iron clothes II	0.57	0.30	0.33	0.94	1.00	0.22	**0.71**	• 0.46	• 0.27	0.77
	make coffee	0.50	0.27	0.56	0.94	1.00	0.31	**0.65**	• 0.42	○ 0.40	• 0.82
	make omelette	0.75	0.54	0.67	0.92	0.96	0.23	**0.83**	• 0.69	• 0.34	0.85
	Average	0.63	0.40	0.60	0.89	0.98	0.22	**0.73**	0.56	0.30	0.82

Figure 4: Results for paraphrasing task; significance of difference to *sys*: • : $p \leq 0.01$, ○ : $p \leq 0.1$

Happens-before-task

	Scenario	Precision			Recall			F-Score			
		sys	base$_{cl}$	base$_{lev}$	*sys*	base$_{cl}$	base$_{lev}$	*sys*	base$_{cl}$	base$_{lev}$	upper
MTurk	pay with credit card	0.86	0.49	0.65	0.84	0.74	0.45	**0.85**	• 0.59	• 0.53	0.92
	eat in restaurant	0.78	0.48	0.68	0.84	0.98	0.75	**0.81**	• 0.64	0.71	• 0.95
	iron clothes I	0.78	0.54	0.75	0.72	0.95	0.53	**0.75**	0.69	• 0.62	• 0.92
	cook scrambled eggs	0.67	0.54	0.55	0.64	0.98	0.69	0.66	***0.70***	0.61	• 0.88
	take a bus	0.80	0.49	0.68	0.80	1.00	0.37	**0.80**	• 0.66	• 0.48	• 0.96
OMICS	answer the phone	0.83	0.48	0.79	0.86	1.00	0.96	0.84	• 0.64	***0.87***	0.90
	buy from vending machine	0.84	0.51	0.69	0.85	0.90	0.75	**0.84**	• 0.66	○ 0.71	0.83
	iron clothes II	0.78	0.48	0.75	0.80	0.96	0.66	**0.79**	• 0.64	0.70	0.84
	make coffee	0.70	0.55	0.50	0.78	1.00	0.55	**0.74**	0.71	○ 0.53	○ 0.83
	make omelette	0.70	0.55	0.79	0.83	0.93	0.82	0.76	○ 0.69	***0.81***	• 0.92
	Average	0.77	0.51	0.68	0.80	0.95	0.65	**0.78**	0.66	0.66	0.90

Figure 5: Results for happens-before task; significance of difference to *sys*: • : $p \leq 0.01$, ○ : $p \leq 0.1$

Summary

- Better than baselines
  - Levenshtein: too restrictive: low recall, high precision
  - Clustering: can't use sequential information: high recall, low precision
  - Close to upper bound in most cases
- Results depend on scenarios
  - Complexity
  - Variable orderings

Improvements

- Scale to any number of scenarios
- Less supervision:
  - Restrict user input
  - Heuristics for filtering data
- More elaborate data structures
  - Optional events
  - Alternative events
  - Events with arbitrary order

References

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Thank you for your attention!