AI-MIX

Using Automated Planning to Steer Human Workers Towards Better Crowdsourced Plans

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CROWDSOURCING

• Process of obtaining ideas or a needed service from a crowd of people
  • Crowd + OutSourcing

• Example: Travel Planning

Going to New York City
New York City, New York State

Who’s going:

Linda Bjma

Questions

Exciting things to do in New York City

Art & Design Lovers  Foodies  Luxury Travelers  Nightlife Lovers  Trendsetters

Like · 17 responses · Add a Recommendation · about 1 month ago ·
What must I do, eat and see in NYC? I’ve been to NYC before, so suggestions on new speakeasies, restaurants and nightlife recommendations would be awesome.
BREAK TASK INTO ACTION ITEMS
- Restaurants
- Nightlife Suggestions
- Museums

PROVIDE SUGGESTIONS
- Magnolia Bakery: If you haven’t tasted a Magnolia cupcake, your NYC visit doesn’t count.
- Katz’s Deli has certainly kept its status as the best deli in New York City serving the Lower East Side. Best pastrami sandwich in town.

GENERATE AN ACTIONABLE PLAN
- Katz’s Deli
- Times Square
- Central Park
- Magnolia Bakery
- Brooklyn Bridge
- Statue of Liberty
- The Village Underground

CRITIQUE EXISTING ACTIONS
- Katz’s Deli: It’s overhyped and over priced. I did not like it. Other places nearby are much better.
- Magnolia Bakery: It’s too crowded at most times. Impossible lines.
Is it possible to improve the effectiveness of this process using automated planning?
THE CROWDSOURCED “PLANNING” PROBLEM

REQUESTER
(Human)

COLLABORATIVE
BLACKBOARD

PLANNER

CROWD
(Turkers)

Human-Computer Interface

Task specification
Requester goals
Preferences

Crowd’s plan
Sub-goals
New actions
Suggestions

alert

FORM/MENU
SCHEDULES

structured
unstructured

ALERTS

PLANNER
ROLES: PLANNER (MACHINE)

STEER THE CROWD: SUB-GOALS
- How to get to Magnolia Bakery?
- What are the hours of Katz’s Deli?

CONSTRAINT CHECKING
- Duration of ‘Statue of Liberty’ exceeds requested time of 2 hours
- Cost of The Village Underground exceeds threshold of $20

SCHEDULE THE PLAN
- 08:00 – 10:30 Statue of Liberty
- 11:00 – 12:00 Katz’s Deli
- 12:30 – 14:00 Times Square
- 14:30 – 16:00 Central Park
- 16:30 – 17:00 Magnolia Bakery
- 17:30 – 19:30 Brooklyn Bridge
- 20:00 – 23:00 The Village Underground
... BUT AUTOMATED PLANNERS NEED MODELS

1. Full Model
   Planner can generate plans by itself
   Crowd is too expensive and cumbersome

2. No Model
   Zero knowledge – Planner cannot engage at all

3. Partial Model
   Planner can help in iterative refinement of plan
   Most likely scenario in real-world problems (travel planning)

- Domain Dynamics
- Preferences

UNSTRUCTURED  
SHALLOW MODEL 
APPROXIMATE MODEL

STRUCTURED
**Challenge: Interpretation**

- **Understanding** the goals and plans of the humans (requester + crowd) from semi-structured or unstructured text
- **Impedance Mismatch**

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**Extract from Plain Text**

- Impose structure
  - [Ling & Weld, 2010]
  - [Kim, Chacha & Shah, 2013]

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**Plan Recognition from Noisy Traces**

- Extract noisy traces first
  - [Zhuo, Yang & Kambhampati, 2012]

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**Full Plan Recognition**

- [Kautz & Allen, 1986]
- [Ramirez & Geffner, 2010]
DEALING WITH INTERPRETATION

• **Force Structure**
  - Use forms to constrain human input
  - Easier to match to planner’s expectation of structured input
  - Restricts flexibility of humans; less knowledge specified

• **Extract Structure**
  - Allow humans to use full natural language
    - Semi-structured and unstructured text
  - Extract actions and goals from human-generated input
  - Validate against partial model
  - Iteratively refine recognized goals and plan
**Challenge: Steering**

- Steering the crowd workers towards producing a plan collaboratively
  - Partial domain dynamics
  - Incomplete preferences
- Iterative Process

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**Plan Generation**

**Plan Critiquing**

**Constraint & Arithmetic Checking**
- Mobi [Zhang et al., 2012]
- Cobi [Zhang et al., 2013]

**Problem Decomposition**
- [Nau et al., 2003]

**SHALLOW MODEL**

**APPROXIMATE MODEL**

- Regression
  - Match sub-goals with actions

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DEALING WITH STEERING

• **Constructive Critiques**
  • Actively participate in refinement of plan
  • Generate sub-goals for suggested activities
  • Highlight unfulfilled requester goals
  • Create actionable schedule / plan

• **Constraint Checking**
  • Check quantitative constraints
    • Travel Planning: Cost, Duration
  • Choose best set of activities fulfilling requester constraints
AI-MIX: A DEPLOYED SYSTEM

• Automated Improvement of Mixed Initiative eXperiences

• Works on multiple platforms
  • Amazon’s Mechanical Turk (mTurk)
  • Google App Engine

• Input
  • High level task description by requester

• Output: Two kinds
  • Set of activity suggestions from crowd
  • Scheduled plan that can be executed
AI-MIX: SYSTEM SCHEMATIC

REQUESTER (Human)

COLLABORATIVE BLACKBOARD

Task specification
Requester goals
Preferences

FORM/MENU SCHEDULES

Unstructured
Structured

PLANNER

Analyze the extracted plan in light of $M$, and provide critiques

M: Planner’s Model (Partial)

INTERPRETATION

CROWD (Turkers)

Human-Computer Interface

ALERTS

STEEERING

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TOUR REQUEST

Going to New York City for one week at a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are other things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakeasies, restaurants and night life recommendations would be appreciated.

- Have a breakfast at a good local restaurant. #breakfast
- Maybe a museum to visit for around 2 hours maximum. #museum
- Visit some iconic places with rich architecture. #architecture
- Have a quick light lunch. Budget is 30$. #lunch
- Do some shopping for a maximum of 3 hours. #shopping
- Take a walk in some touristic places.
- Have dinner and drinks at a good local restaurant.

HOW TO SUBMIT A HIT

You can contribute by
- Suggesting a new activity
- Critiquing an existing activity

The "TO DO Tags" column contains information about the requester demands, and plan critiques that are yet to be satisfied.

- To add a new activity, click on the "Add new activity" button, fill out the title, description and approximate duration, attach the tag corresponding to this activity and click "Submit".
- To critique an existing activity, click on the "Critique existing activity" button, click on the activity that you want to critique, enter your note, attach an appropriate tag (which will then be added to the list of TO DO Tags) and click "Submit".

For each option you may add more than one suggestion if you wish. Activities with existing suggestions appear in green; otherwise, they are red.
TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakeasies, restaurants and nightlife recommendations would be awesome.

- Have a breakfast at a good local restaurant. #breakfast
- Maybe a museum to visit for around 2 hours maximum. #museum
- Visit some iconic places with rich architecture. #architecture
- Have a quick light lunch. Budget is 30$. #lunch
- Do some shopping for a maximum of 2 hours. I can spend upto 300$ on shopping. #shop
- Take a walk in some touristy place. #walk #touristy
- Have dinner and drinks at a good local restaurant. I want to spend a maximum time of 3 hours here. #dinner
TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakeasies, restaurants and night life recommendations would be awesome.

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- Visit some iconic places with rich architecture. #architecture
- Have a quick light lunch. Budget is 30$. #lunch
- Do some shopping for a maximum of 2 hours. I can spend up to 150$. #shop
- Take a walk in some tourisy place. #walk #touristy
- Have dinner and drinks at a good local restaurant. I want to try something different. #dinner #lunch

TO DO Tags:

- macys_whattobuyin
- macys_gettingto
- manhattan_gettingto
- museum
- lunch

Add new activity »

Critique existing activity »
TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakesies, restaurants and night life recommendations would be awesome.

- Have a breakfast at a good local restaurant. #breakfast
- Maybe a museum to visit for around 2 hours maximum. #museum
- Visit some iconic places with rich architecture. #architecture
- Have a quick light lunch. Budget is 30$. #lunch
- Do some shopping for a maximum of 2 hours. I can get a map that shows all main shopping areas. #shop
- Take a walk in some touristy place. #walk #touristy
- Have dinner and drinks at a good local restaurant.

TO DO Tags:

- macys_whattobuyin
- macys_gettingto
- manhattan_gettingto
- museum
Adding an Activity

- Crowd workers can provide any number of activity suggestions.
- Both unstructured and semi-structured input handled.
- Each activity is in service of a “to-do” tag.
  - An activity satisfies a to-do tag.
- After submission:
  - Planner checks for constraint violations.
  - Planner generates sub-goals if applicable.
  - Crowd workers critique the activity submission.

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TOUR REQUEST
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- Have a quick light lunch. Budget is 30$. #lunch
- Do some shopping for a maximum of 2 hours. I can spend upto 300$ on shopping. #shop
- Take a walk in some touristy place. #walk #touristy
- Have dinner and drinks at a good local restaurant. I want to spend a maximum time of 3 hours here. #dinner

TO DO Tags:
macys_whattobuyin
macys_gettingto
manhattan_gettingto
museum

Existing Activities:

Manhattan Walk near the NY public library and the charging bull (14:00 hrs) #walk

Add new activity »
Add a New Suggestion
• Planner uses a high level PDDL action model
• Action examples: visit, lunch, shop ...
• Generic preconditions
• Unsatisfied sub-goals thrown as alerts
TOUR REQUEST
Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.
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- Take a walk in some touristy place. #walk #touristy
- Have dinner and drinks at a good local restaurant. I want to spend a maximum time of 3 hours here. #dinner

TO DO TRACKER
- manhattan_gettingto
  - manhattan_gettingto
  - Getting to manhattan
  - museum
  - lunch

Macys: Awesome clothes and the head quarters (10:00 hrs) (1 hours) #shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk
ACTIVITY CRITIQUES

• **Automated Critiques**
  • Constraint checking on quantitative values (cost, duration) input by crowd workers
  • If violated, added to list of outstanding alerts

• **Human Critiques**
  • Crowd workers can critique existing activities
  • Each critique gets a new tag, with a pointer to the parent tag / activity

• Both kinds of critiques **resolved by future crowd workers in further iterations**

• **AI-MIX continues until no unresolved alerts**
TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakeasies, restaurants and night life recommendations would be awesome.

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TO DO Tags:

- macys_whattobuyin
- macys_gettingto
- manhattan_gettingto
- museum

Existing Activities:

- Macys: Awesome clothes. #shop
- Manhattan: Walk near the NY public library and the charging bull (14.00 hrs) #walk

Critique existing activity »
ADDING A CRITIQUE

TourPlanner Instructions

TOUR REQUEST
Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakeasies, restaurants and night life recommendations would be awesome.
- Have a breakfast at a good local restaurant. #breakfast

Existing Activities Your Critiques

Select to provide orderings among activities

*Select your options from the column on the left.
*All times must be in 24-hr format.

Macys: Awesome clothes and the head quarters (10:00 hrs) (1 hours) #shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk

Click on the existing activities to enter your critiques. All fields are required. Hit Submit when you are finished.

Submit Go Back

Submit your hit
ADDING A CRITIQUE

Tour Planner Instructions

TOUR REQUEST
Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakeasies, restaurants and nightlife recommendations would be awesome.
- Have a breakfast at a good local restaurant. #breakfast

Existing Activities

Select to provide orderings among activities

Macys: Awesome clothes and the head quarters (10:00 hrs) (1 hour) #shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk

Your Critiques

Tag: #shop Location: Macys
Description: Awesome clothes and the head quarters
Time: 10:00
Duration: 1 Cost: -remove-

*Select your options from the column on the left.
*All times must be in 24-hr format.

Click on the existing activities to enter your critiques. All form fields are required. Hit Submit when you are finished.

Submit Go Back
ADDING AN ORDERING CONSTRAINT

Tour Request
Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and nightlife recommendations would be awesome.
- Have a breakfast at a good local restaurant. #breakfast

Existing Activities
- Select to provide orderings among activities
- Macys: Awesome clothes and the head quarters (10:00 hrs) (1 hours) #shop
- Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk

Your Critiques
- Lunch ▼
- Touristy ▼
- Before ▼
- After ▼
- Remove

*Select your option and place mn on the left.
*All times must be in 24-hr format.

Click on the existing activities to enter your critiques. All form fields are required. Hit Submit when you are finished.

Submit  Go Back
Plan Generation: Making a Schedule

• Answer Set Programming (ASP) used to put suggested activities together into a schedule / actionable plan
  • Knowledge base that models common sense information
    • Object Declarations
    • State Declarations
    • Domain Independent Axioms

• For Travel Planning domain:
  • Temporal Constraints
    • Typical time ranges of activity types like breakfast, lunch, dinner
  • Existential Constraints
    • At least one instance of each requested activity type
  • Contiguity Constraints
    • Same activity occurring at two different time points implies it also occurs in between
  • Uniqueness
    • Same activity over multiple time points is at the same location
PRELIMINARY EXPERIMENTS

• Evaluated on Amazon’s mTurk platform

• Human Intelligence Tasks (HITs) were available only to crowd workers:
  • From the United States
  • HIT approval rate > 50%
    • Paid 20c. per HIT

• Travel Planning scenarios for six US cities
  • Washington D.C., Chicago, New York, San Francisco, Los Angeles, Las Vegas

• 150 turkers (crowd workers)
EXPERIMENTAL CONDITIONS

• **NO-AUTO**
  - No automated critiques
  - All suggestions in free, unstructured text format

• **AUTO-SCHED**
  - Constraint violations checked for cost and duration

• **AUTO-SCHED + SUB-GOAL**
  - Constraint violations checked for cost and duration
  - System processes unstructured text
  - Generates alerts for missing preconditions (unsatisfied sub-goals)
RESULTS: TOUR-PLAN QUALITY

AUTO-SCHED

AUTO-SCHED + SUB-GOAL

Show: Go to TKTS half ticket discount booth. You have to stand in line early but it's an authentic nyc experience #show(3 hours)(200.0 $)
Show: Go to show #show(3 hours)(200.0 $)
Show: ABSOLUTELY CANNOT go wrong with Phantom of the Opera #show(3 hours)(200.0 $)
Lunch: Alice's Tea Cup #lunch(20.0 $)
Design: Walk around the Garment District (go into shops) just south of Times Square. They often print their own fabrics. #design(2 hours)(0.0 $)
Dessert: Serendipity #dessert(1 hours)(10.0 $)

Piccolo angolo: Italian in the Village - real deal #italiandinner(2 hours)(60.0 $)
Lombardi's Pizza: #italian_dinner #italiandinner_todo1
Ice Cream: http://www.chinatownicecreamfactory.com/ #italiandinner_todo0
#lunch: Mangia Organics #lunch_todo0
#watch: Wicked (musical): Do watch Wicked the musical. It's a fantastic show and one of the most popular on Broadway right now! #broadwayshow(3 hours)(150.0 $)
watch How to Succeed in Business: Also a great show, a little less grand than Wicked. #broadwayshow(3 hours)(150.0 $)
Activity Steamer: #lunch #lunch_todo1
Paradis To-Go: Turkey & Gruyere is pretty delicious. The menu is simple, affordable, but certainly worth the time #lunch(1 hours)(10.0 $)
cupcakes: Magnolia Bakery on Bleecker in the Village #dessert(1 hours)(10.0 $)
Results: Role of Planner Module

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Voted ICAPS 2014 Best Demo By ... The Crowd!

2014 ICAPS System Demonstration

People’s Choice Award

Presented to
L. Manikonda, T. Chakraborti, S. De, K. Talamadupula, S.

For the ICAPS 2014 System Demonstration

AI-Mix: How a Planner can Help Guide Humans Towards a Better Crowdsourced Plan

June 24, 2014, Portsmouth, New Hampshire, USA
AI-MIX: A SUMMARY

• Automated Planning for Crowdsourced Planning
  • Interaction between Requester, Crowd, Planner

• Interpretation & Steering
  • Unstructured text
  • Impedance mismatch
  • Incomplete and unstructured domain models

• Effective plan generation
  • Sub-goal generation
  • Constraint verification
  • Constructive critiquing

• Preliminary results from TourPlanning domain
  • Beneficial to include planner
    • Number of turker responses (engagement)
    • Critiques addressed (usefulness)
    • More detailed suggestions (steering)

POSTER (Near EAAI posters)
Room: 200B/C
Time: 5:30pm – 7:00pm TODAY!