Dynamic Particle Allocation to Solve Interactive POMDP Models for Social Decision Making


Background

Theory of Mind

One of the critical aspects of any system that hopes to approach the grand challenge of social machines will be a Theory of Mind. (Scaifealetti, 2001)

Theory of Mind (ToM) is the ability to
- recognise that all people act on the basis of mental states or propositional attitudes (beliefs, desires, etc)
- attribute mental states or attitudes to oneself and to others
- understand that others have beliefs, desires and intentions different from one’s own. (Premack, 1978)

Introduction

- We propose a novel formulation of computational theory of mind (ToM) to model human behavior in a repeated PGG using interactive partially observable Markov decision processes (IPOMDPs).
- Interactive particle filter (IPF) is a well known algorithm (Doshi, 2005) used to

Methodology

The Multi-Agent Interactive POMDPs

- multi-agent extension of POMDP
- Supports decision-making in both cooperative and non-cooperative settings

\[ IPOMDP_j = (S_j, A, T, \Omega, O, R) \]

- Interactive states \( S_j \) = \( S \times M \times J \) with \( S \) set of possible models of agent \( j \) at level-1

Dynamic Particle Allocation

Algorithm 1: IPF-DPA for approximating the belief update.

1. function IPF-DPA(previousBelief, currentObservation, currentWeights)
2.   \( \text{Computation of Agent-specific Particle Allocation Weights} \)
3.   for each particle in the previousBelief do
4.     Propagate the physical state forward by using the current observation and estimate other agents’ actions (using the current beliefs and transition function).
5.     end for
6.   end for
7.   Recompute weights for other agents based on the current observation and estimate other agents’ actions (using the current beliefs and transition function).
8.   end for
9.   for each particle in the previousBelief do
10.   for each possible observation of other agents do
11.     Propagate the new particle forward by using the sampled next state, physical state and updated beliefs of other agents.
12.     end for
13.   end for
14.   end for
15. end function

Recompute Weights

- In order to implement dynamic particle allocation, we maintain a set of values to keep track of how each agent is able to predict the actions of other agents.
- We maintain a numeric value which captures how well agent k is able to predict the actions of agent m when it is thinking at level l at time t. We update this variable for all agents in each round of the game

Results

We conducted several real-world experiments to

(a) compare I-POMDPs (with ℓ=1) and POMDPs (equivalent to I-POMDPs with ℓ=0) for their capability to predict human contribution in a PGG. We do so by replacing one agent in a PGG involving humans with an I-POMDP (and POMDP) model. This I-POMDP (and POMDP) model will predict contributions from the other agents by observing their past behaviour.

(b) compare IPF and IPF-DPA for their capability to efficiently solve I-POMDPs and accurately predict human contribution when an I-POMDP replaces a human agent in the 4-agent PGG game.

Conclusion

- We studied the complex problem of social decision making in multi-agent setting. In this context, we used the popular construct of social dilemma namely the public goods game to study the decision making task
- The algorithm proposed in the paper is generic and is applicable to multiple domains where appropriate IPOMDP can be formulated. We have implemented a parallelized version of IPF and IPF-DPA algorithms which basically helps us to do the computation of every particle in parallel.

For both experiments (a) and (b), we show improvement in terms of prediction accuracy, when compared with conventional practices. Both (a) and (b) were carried out under mild assumptions on the state space and the results from (a) and (b) show that our assumptions are useful in obtaining valid approximations for I-POMDP solutions.
Digital Fabrication of Soft Actuated Objects by Machine Knitting presented by Lea Albaugh at CHI 2019


With recent interest in shape-changing interfaces, material-driven design, wearable technologies, and soft robotics, digital fabrication of soft actuable material is increasingly in demand. Much of this research focuses on elastomers or non-stretchy air bladders. Computationally-controlled machine knitting offers an alternative fabrication technology which can rapidly produce soft textile objects that have a very different character: breathable, lightweight, and pleasant to the touch. These machines are well established and optimized for the mass production of garments, but compared to other digital fabrication techniques such as CNC machining or 3D printing, they have received much less attention as general purpose fabrication devices. In this work, we explore new ways to employ machine knitting for the creation of actuated soft objects.

We describe the basic operation of this type of machine, then show new techniques for knitting tendon-based actuation into objects. We explore a series of design strategies for integrating tendons with shaping and anisotropic texture design. Finally, we investigate different knit material properties, including considerations for motor control and sensing.

Funding to attend this conference was provided by the CMU GSA/Provost Conference Funding.
Voice assistants are becoming increasingly pervasive in our everyday lives. As of late 2019, estimates suggest that nearly a quarter of adults in the United States (60 million) own a smart speaker, and Google reports that over half a billion people use their Google Assistant at least once a month. In recent years, the physical embodiment of voice assistants has diversified as well, with assistants embedded not just in smartphones, but in smart speakers, cars, and a range of other smart home devices. This growing usage suggests that voice assistants will continue to play a crucial and evolving role moving forward.

In this research, we ask: How might voice assistants behave several decades in the future? Specifically, what possible futures do people imagine for voice assistants several decades from now?

To probe people’s ideas about what voice assistants might become, we used story completion.

What is story completion? Story completion is a method that has its origins in clinical psychology, which has started to see increasing use within human-computer interaction research as a design method for exploring possible future scenarios around futuristic technology. In story completion, participants are provided with a brief, deliberately ambiguous opening (or story “stem”), and are asked to complete the story.

We were interested in how manipulating the narrative of the story and number of main characters would shape the nature of stories that participants constructed, while also fixing the temporal setting of the story in the distant future (the year 2050) so participants weren’t constrained by current technical capabilities of voice assistants. This yielded five different story stems.

Study design: We recruited 149 participants from the Prolific crowd work platform to complete a Qualtrics-based task. After consenting to participate in the study, participants were randomly assigned to one of the five story scenario conditions (between-subjects; one story per participant). In the first part of the study, participants were introduced to the storytelling task, and asked to spend 90 minutes completing the story established by their assigned prompt in a large text field. After writing their story, participants were asked whether the story they wrote was a preferable future (i.e. a future they would want to live in). In the final part of the task, participants answered demographic questions and survey questions regarding their experience with voice assistants.

**ANALYSIS OVERVIEW**

We took a thematic analysis approach to analyzing the 149 stories we collected.

Through several rounds of iterative coding by three collaborators, we arrived at a final set of 23 codes, which cluster into several higher-level themes. These themes formed our codebook (pictured to the right). With the final codebook, we then independently coded all stories, and resolved any disagreements in the codes through discussion.

Findings

Overall, stories covered a wide range between utopian and dystopian visions, as well as the mundane, but skewed towards darker, more negative tones: 38% (N=56) of stories were coded as having a negative valence, compared to 11% (N=17) that were positive in nature. Here is a selection of some of the most salient themes:

- Interfacing with the brain
- Nostalgia for less powerful voice assistants
- Replacing humans
- Anthropomorphism in gender and name
- Fears and other negative outcomes of future voice assistants
- Implications and open questions

**Evolution of voice technology**

Stories suggested new capabilities and increased sophistication of voice assistants

**Replacing humans**

Many stories portrayed agents encroaching on roles that humans would otherwise hold

**Anthropomorphism in gender and name**

Participants frequently ascribed human traits to the voice assistant in their stories. While in some cases, the agent was unnamed (e.g., only referred to as “the voice assistant” throughout the story), across all stories, 59% (N=88) included a voice assistant with a human-like name like “Karen” or “Jan”.

This tendency to anthropomorphize the voice assistant was also apparent in how the assistants were gendered. Considering only the pronouns used to refer to the assistant, assistants were gendered as female (she/her/hers pronouns; 21% of stories; N=32) more often than as male (he/him/his pronouns; 8% of stories; N=12).

**Fears and other negative outcomes of future voice assistants**

Beyond the trend of job loss to automation, stories commonly described a wide range of other fears and potential negative outcomes involving voice assistants:

- Always listening
- Undisclosed
- Malfunction
- Black box, difficult to understand
- Acting as managers of people and assistants could both tune into. Few stories portrayed agents encroaching on roles that humans would otherwise hold.

**Implications and open questions**

Overall, the narratives that participants created speculate on futures in which voice assistants become considerably more sophisticated than they are today, suggesting more expansive capabilities and often substantial sociocultural consequences from their use. These stories contain echoes of present-day voice assistants, and raise many interesting questions to consider for future work. For example:

- What are preferable—and not just possible—futures for voice technology?
- How might voice assistants co-evolve with their physical environments?
- Should voice assistants strive for the mundane perfection of tools or the rich interactions of social actors?

Find my latest work on voice interface design at https://juliacambre.com

This research is currently under review at the ACM Conference on Designing Interactive Systems (DIS) 2020 and was completed with my wonderful collaborators and co-authors Samantha Reig, Queenie Kravitz, and Chinmay Kulkarni.

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A Little Annotation does a Lot of Good: A Recipe for Bootstrapping Low-resource Entity Recognizers

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Motivation

- Rapid - response required in situations of emergency.
- Understand and analyze information in local languages.
- Existing models built for high-resource languages (HRL) like English, Spanish, etc.

BUT don’t generalize well for low-resource languages (LRL)
- LRL: Insufficient good quality and quantity of training data
- Task: Named Entity Recognition (NER) → entity annotations gazetteers, lexicons
- Observations:
  - Ablation study evaluating effectiveness of partial-CRF strategies under the same experimental setting.
  - Comparing proposed method with baseline active learning-based baselines
  - A neural CRF (Ma et al, 2010) is used as NER model.
  - Since annotations are collected at span-level, constrained CRF (Bellare et al, 2007) is used instead.
  - The constrained CRF marginalizes over all possible tags for unannotated tokens and thus only computes loss for annotated tokens.
  - Greatly helps increase the recall and thus the F1.

Baselines

- Sequence-based baseline
  - SAL: Full sequence labeling [McCallum+2005]
- Span-based baselines
  - CFEAL: Confidence Field Estimation [McCallum+2004]
  - RAND: Random Span Selection

Results

- Comparing proposed method with baseline active learning strategies under the same experimental setting.
- Ablation study evaluating effectiveness of partial-CRF.
- Observations:
  - Proposed Method >> Baseline
  - Partial CRF >> Full CRF

System Overview

Our system comprises of three major components:
1. Entity-Targeted Active Learning.
2. Partial Annotation.
3. Cross-Lingual Transfer Learning

Module 1: Entity-Targeted Active Learning

- Select informative spans in a sequence.
- Why? Relatively few points of interest in a sequence.
- How? Find uncertain spans that are likely named entities using a dynamic programming.
- Span entropy is used as measure of uncertainty and aggregated across all occurrences of the token across the entire corpus.
- Allows for combining uncertainty sampling with a bias towards high frequency entities

Module 2: Partial Annotation

- A neural CRF (Ma et al, 2010) is used as NER model.
- Since annotations are collected at span-level, constrained CRF (Bellare et al, 2007) is used instead.
- The constrained CRF marginalizes over all possible tags for unannotated tokens and thus only computes loss for annotated tokens.
- Greatly helps increase the recall and thus the F1.

Module 3: Cross-Lingual Transfer Learning

- Leverage NER model trained on English annotations to get seed data LRL (Xie et al, 2018)
- Three transfer approaches:
  - FineTune → Pre-train model on transferred data and finetune on annotated data
  - CorpusAugmentation → Train model on combined transferred and annotated data
  - FineTune + CorpusAugmentation

Evaluation and Dataset

Data Source: LDC
Data Source: CoNLL
Spanish
Spanish
Indonesian
German
Hindi
Dutch
Transferred English CoNLL data: 13k sentences

Human Results

- Compared ETAL vs SAL for Hindi, Indonesian and Spanish.
- Used two annotators per language for 20mins each.

Observations:
1. Both Hindi and Spanish annotators have higher annotation quality when compared to gold labels using ETAL.
2. ETAL has a significantly larger number of entities than SAL
3. Test Performance compares the performance of the NER models trained with these annotations. The brackets denotes the number of annotated tokens used for training. On the same number of annotated tokens ETAL outperforms SAL.

Conclusion

- Experiments on 5 languages: nl, es, de, hi, id
- With one-tenth tokens annotated:
  - Cross-lingual transfer: (avg.) +8.6 F1 over un-transferred model systems.
  - ETAL: (avg.) +9.9 F1 over other active learning baselines.
- Human annotations show annotators are more precise in annotation using ETAL vs SAL by (avg.) +4.1 F1.

https://github.com/Aditi138/EntityTargetedActiveLearning

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Towards Physical Hybrid Systems
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Presented at CADE 2019 in Natal, Brazil

ABSTRACT
Some hybrid systems models are unsafe for mathematically correct but physically unrealistic reasons. Differences in measure zero sets in models of cyber-physical systems (CPS) have significant mathematical impact on the safety of models, but have no tangible physical effect in a real system. We develop the concept of “physical hybrid systems” (PHS) to help reunite mathematical models with physical reality. We modify a hybrid systems logic, dTL, by adding a first-class operator to elide distinctions on measure zero sets of time within CPS models, and we also develop a proof calculus to help with the verification of PHS.

INTRODUCTION
Cyber-physical systems (CPS) are systems that have a cyber controller. Examples include many real-world systems, many of which are safety-critical—like self-driving cars, surgical robots, airplanes, roller coasters, and many more.

Often, it is useful to model CPS as hybrid systems, which are systems with both discrete and continuous dynamics.

Because CPS are so often safety-critical, it is very important to know that they are functioning correctly.

Modeling hybrid systems in logic allows us to prove things about them—we can use logic to formally derive safety properties of the systems. These properties are provably (!!!) guaranteed to hold.

PHYSICAL HYBRID SYSTEMS
To help reconcile logic and physics, we define physical hybrid systems (PHS) to be hybrid systems that behave safely “almost everywhere” (in a measure theoretic sense). Physically speaking, PHS are perfectly safe!

In this work, we’ll focus on a subclass of PHS: systems that are safe time almost everywhere along their execution traces.

PROOF CALCULUS
To help make PdTl practical, we develop a proof calculus.

This proof calculus: 
- Reduces formulas to structurally simpler ones
- Reduces PdTl formulas to dL formulas

Reducing to dL formulas is useful since we prove that PdTl is a conservative extension* of dL.

*Means that all valid formulas in dL are also valid in PdTl.

MOTIVATING EXAMPLE
Consider a train that accelerates until its velocity is 100 and then immediately decelerates. Does this train satisfy the safety contract that its velocity is always less than 100?

I am safe if \( v < 100 \).

What if \( v = 100 \) at a moment in time?

Logically speaking, no. Physically speaking, yes. It satisfies the contract except at a single instant in time. Our aim is design a logic that can show that this train satisfies the contract, but shows that a similar train that accelerates until its velocity is, e.g., 102 and then decelerates does not satisfy the contract.

PdTL
Our logic, physical differential temporal dynamic logic (PdTl), modifies an existing logic, differential temporal dynamic logic (dTL).

\[ \text{PdTl} \quad \text{modifies} \quad \text{dTL} \quad \text{extends} \quad \text{dL} \]

Whereas a question in dTL might be: Is this safety property true at all times along the execution trace of a system?, that question in PdTl would be: Is this safety property true almost everywhere in time along the execution trace of a system?

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SUMMARY
Physical hybrid systems (PHS) help reconcile logic’s precision with real-world imprecision.

PdTl rigorizes safety “time almost everywhere”—perhaps the closest PHS notion to safety everywhere.

PdTl does all of the work for the user and comes with a nice proof calculus.

WHAT’S THE CATCH?
Logic is minutely precise—to a level that real systems aren’t.

My precision underlies formal verification.

Yes, but are we mismatched?

\[ [\alpha] [\phi] \leftrightarrow [\alpha] [\phi] \]

Ultimately, then, some models will be classified as unsafe for physically unrealistic reasons. Worse yet, the number of counterexamples in a real case study can already be prohibitively high. Thus it’s important to identify “physical” counterexamples from “non-physical” ones.
Trade-off-Oriented Development: Making Quality Attribute Trade-offs First-Class

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Problem

- Typically, quality attribute tradeoffs are not represented as first-class entities
- Decisions might be suboptimal and lack requirements traceability as well as changeability

Solution

- Collecting implementations varying in quality attributes and solving reoccurring design decisions in a design decision library
- In Trade-off-Oriented Development, developers declaratively specify the quality attribute trade-off, which is then used to automatically select the best fitting implementation

Banking Application

- sink : Component
- source : Component
- control : Control
- a : Application Context
- q[] : Quality Attributes

Design Decision Library

- pc : Pipe Contract
- i : DeflatedStream PipeImplementation
- i2 : CipherStream PipeImplementation
- i3 : CheckedStream PipeImplementation
- s : Implementation Selector <Pipe>

1. Control needs pipe implementation and forwards quality attribute trade-off and application context to implementation selector (findSatisfying)
2. Implementation selector determines best matching implementation based on quality attribute metrics
3. Control initializes (init) the returned pipe implementation to connect source component with sink component

⇒ Traceability and changeability of quality attribute trade-offs

Client
- Send message
- Security
- Display Page

Server
- Send message

Database
- Store Data
- Performance
- Store Data

Legend
- Contract Use
- Module
- Quality Attribute Scope

The scope of quality attributes can cross-cut multiple modules (e.g., security), be limited to one single module (performance in the database module), or influence only one single contract. Quality attribute scopes can overlap with each other.

Implementations of contracts can delegate responsibilities to other contracts. Forwarding quality attribute trade-offs to delegated contract promotes configuration and late decision-making.

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https://tobiasduerschmid.github.io/TOD

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Addressing the Accessibility of Social Media

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MOTIVATION
Social media platforms are deeply ingrained in society, and they offer many different spaces for people to engage with others. Unfortunately, accessibility barriers prevent people with disabilities from fully participating in these spaces. Social media users commonly post inaccessible media, including videos without captions (which are important for people who are deaf or hard of hearing) and images without alternative text (descriptions read aloud by screen readers for people who are blind). Users with motor impairments must find workarounds to deal with the complex user interfaces of these platforms, and users with cognitive disabilities may face barriers

A WORKSHOP AT CSCW 2019

• I organized a workshop at the Computer Supported Cooperative Work conference in November 2019 to bring people with disabilities, academic researchers, and industry professionals into one room to discuss social media accessibility.
• We conducted two panels: Perspectives of Successes and Barriers to Access, and Design Process and Implementation Challenges with different stakeholders to uncover issues and solutions.
• Breakout groups discussed how social media could be improved.

SUBMISSIONS FROM WORKSHOP ATTENDEES

• We solicited position papers from workshop attendees which were presented at the workshop. These covered:
  • Making vlogging more accessible on YouTube
  • Empowering people with autism to use social media more
  • The use of conversational agents for deaf adults
  • Privacy settings on social media for people who are blind
  • Using research to inform design of social media for older adults

BREAKOUT GROUPS

• Four groups discussed the issues, related work, and possible solutions for the following areas:
  • Authoring content on social media
  • Consuming content on social media
  • Advocacy and activism: using social media as a tool to improve disability rights
  • AI and Automation: designing with automated systems in mind, and concerns with automated quality

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Load Balancing Guardrails

Keeping Your Heavy Traffic on the Road to Low Response Times

Q: How do we optimally configure a load balancer?

Solution: add Guardrails

Q1: How do we dispatch?
Q2: How do we schedule?

Dispatcher: ???

SRPT

SRPT

SRPT

Traditional policies aren’t always good

Guardrails: Analytically Guaranteed

Mean response time ($E[T]$)

Load ($\rho$)

Mean response time ($E[T]$)

Load ($\rho$)

INFORMS 2019 and SIGMETRICS 2019

Isaac Grosof, Ziv Scully, Mor Harchol-Balter

CMU, School of Computer Science

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Latent Relation Language Models
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Motivation
• Strong language models (e.g., GPT-2) make factual mistakes.
• Knowledge graphs (KG) provide large database of facts.
• We leverage KGs to alleviate this with language modeling conditioned on them.

Sonic the Hedgehog, also referred to as Sonic 1, is a platform game developed by Sonic Team and published by Sega for the Sega Genesis console.

Model
We model the joint distribution of text $X$ and the latent variable $Z$ by factorizing along each variable:

$Sonic$ is a $platform$ game
$\langle genre \rangle$ $\langle developer \rangle$ $\langle platform \rangle$

Next step predictions at generation time:

\begin{align*}
\text{Text } x & \quad \text{Source } \pi \quad \text{Word } \rho = (e, a) \\
\langle \langle \text{title} \rangle, Sonic \rangle & \quad \text{relation} \quad \langle \langle \text{genre} \rangle, \text{platform game} \rangle \\
\text{Sonic} & \quad \text{word} \quad \text{is} \quad \langle \langle \text{developer} \rangle, Sonic \rangle \\
\text{is} & \quad \text{word} \quad \text{a} \quad \langle \langle \text{platform} \rangle, Sega \rangle \\
\text{a} & \quad \text{relation} \quad \langle \langle \text{genre} \rangle, \text{platform game} \rangle \\
\text{platform} & \quad \text{word} \quad \text{developed} \\
\text{game} & \quad \text{word}
\end{align*}

Language models learn probability $P(X)$ to text $X$. We aim to model $P(X)$ using the latent variable $Z$:

$$P(X) = \sum Z P(X, Z)$$

We model the joint distribution of text $X$ and the latent variable $Z$ by factorizing along each variable:

$$P(X, Z) = \prod_{t=1}^{T} P(\sigma_t, \pi_t, \rho_t, x_{<t})$$

$$= \prod_{t=1}^{T} P(\pi_t | x_{<t}) P(\sigma_t, \pi_t, \rho_t | \pi_t, x_{<t})$$

$$P(\sigma_t, \pi_t, \rho_t | \pi_t, x_{<t}) = \begin{cases} P(z_{\sigma_t} | x_{<t}) & \pi_t = \text{word} \\ P(\pi_t | x_{<t}) P(a_{\pi_t} | x_{<t}) P(\sigma_t | x_{<t}) & \pi_t = \text{relation} \\ P(\pi_t | x_{<t}) P(a_{\pi_t} | x_{<t}) & \pi_t = \text{surface form} \end{cases}$$

Experiments

Datasets:
• WikiFacts [1]: First paragraph of Wikipedia in /film/ actor domain.
  - S(hort): first paragraph, F(ull): the entire article.

Baselines:
• LM: Language model without KG (Transformer-XL [3]).
• AliasLM: LM with KG-tuples prefixed before the articles.
• NKLM [1]: Word-by-word generation with copy mechanism over KG triples.

Results and Analysis

Fig 1. Perplexity under open-vocabulary setting when using Transformer-XL as base sequence model.

![Fig 1. Perplexity under open-vocabulary setting when using Transformer-XL as base sequence model.](image)

Fig 2. Samples drawn given “Sonic the Hedgehog”.

![Fig 2. Samples drawn given “Sonic the Hedgehog”.](image)

Fig 3. Posterior probability $P(Z | X)$ showing the model’s preference of relations.

![Fig 3. Posterior probability $P(Z | X)$ showing the model’s preference of relations.](image)

Reference


* Funding to attend this conference was provided by the CMU GSA/Provost Conference Funding.
## Abstract

- Hand gestures provide a natural and an intuitive way of user interaction in AR/VR applications.
- Recently, there has been an increased focus on removing the dependence of accurate hand gesture recognition on complex sensor setups found in expensive proprietary devices.
- Most alternative methods either rely on multi-modal sensor data or deep neural networks that can benefit greatly from abundance of labelled data.
- We intend to propose a framework capable of generating photorealistic videos that have labelled hand bounding box and fingertip that can help in designing, training, and benchmarking models for hand gesture recognition.

## Method

- We train our model on the SCUT-Ego-Finger dataset. It has 93729 manually annotated frames for hand detection and fingertip detection in first-person view.
- CycleGAN based approach:
  - We adapt the architecture for our generative networks from Zhu et al.[1] that have shown impressive results for image-to-image translation.
  - The results were observed on varying number of epochs where the model was trained for 400 epochs with the same learning rate and linearly decaying the learning rate over next 100 epochs.
- Sequential Scene Generation with GANs:
  - We used the ability of the model outlined by Turkoglu et al. [2] to generate video sequences with different backgrounds but same (or controlled) fingertip and hand as in the reference input image.
  - The proposed framework sequentially composes a scene, breaking down the underlying problem into foreground and background separately.

## Proposed Framework

- Figure 1. Given an input image, we apply gesture based affine transformations to generate a sequence of video frames. These masks passed in succession to the generator network results in a video sequence with given background image.
- Figure 2. Results obtained using CycleGAN on two pairs of source and target domains. The upper row represents the real-world images and the lower row shows the synthesised images in the new domain.

## Experiment Results

- Figure 3. Results generated using same set of translated segmentation mask and fingertip location. Each row represents the synthesised images in the new domain.
- Figure 4. Generating an egocentric pointing gesture by applying orientation based mask affine transformation. Different frames depict gesture images as synthesised using the network. Note that complete gesture is obtained using a single layout mask as reference.

## Future Work

- The realisation of our end goal of generating photo-realistic videos with enough variability in background, lighting, and other such parameters that can help in designing, training, and benchmarking models for hand-gesture recognition in AR/VR applications, would involve designing a model that introduces variations in the background features and some features present on the hand.
- We would like to experiment the inclusion of a recurrent network into the current framework which could potentially help us generate photo-realistic hand movements corresponding to any given spatio-temporal sequence corresponding to an arbitrary input gesture.
- Finally, we observe that the background might change suddenly between consecutive frames leading to a jittery video and we would like to experiment with ways to make the background coherent across frames.

## Conclusion

- We have demonstrated a network capable of synthesising photo-realistic videos and show its efficacy by generating videos of hand gestures.
- We believe that this would help in the creation of large-scale annotated datasets.
- This in turn, would encourage the development of novel neural network architectures that can recognise hand gestures from single RGB streams without the need of specialised hardware such as multiple cameras and depth sensors.

## References

Introduction

• Early studies in audio chord recognition focus on major/minor chord recognition; such small chord vocabulary cannot meet practical needs.

• However, large-vocabulary chord recognition task is hard due to
  1. Large number of chord qualities in pop & jazz songs
  2. Extremely biased chord label distribution

Our Solution: A Structural Chord Representation

Chord = (Root, Triad, Bass, Seventh, Ninth, Eleventh, Thirteenth)

Example: E:min7/b3 or G:maj6?

The Advantage of This Representation

More Examples

<table>
<thead>
<tr>
<th>Chord</th>
<th>Root</th>
<th>Triad</th>
<th>Bass</th>
<th>7th</th>
<th>9th</th>
<th>11th</th>
<th>13th</th>
</tr>
</thead>
<tbody>
<tr>
<td>G:maj</td>
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<td>G:maj7</td>
<td>G</td>
<td>maj</td>
<td>G</td>
<td>7</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>G:7(b9)</td>
<td>G</td>
<td>maj</td>
<td>G</td>
<td>b7</td>
<td>b9</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>G:min7/b3</td>
<td>G</td>
<td>min</td>
<td>Bb</td>
<td>b7</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>B:dim7</td>
<td>B</td>
<td>dim</td>
<td>B</td>
<td>b7</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>A:sus4(b7)</td>
<td>A</td>
<td>sus4</td>
<td>A</td>
<td>b7</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>C:9(13)</td>
<td>C</td>
<td>maj</td>
<td>C</td>
<td>b7</td>
<td>9</td>
<td>N</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Discussion & Future Work

• The model still has a strong bias towards negative classes for some chord components (e.g., 9, 11, 13) even if class re-weighting is adopted;

• Some “ground truth” chord labels are oversimplified (e.g., C:13 → C:maj) in the training dataset, making the model hard to learn these labels.
Machine-Aided Annotation for Fine-Grained Proposition Types in Argumentation

Yohan Jo¹, Elijah Mayfield¹, Eduard Hovy¹, Chris Reed²

¹School of Computer Science, Carnegie Mellon University, ²Centre for Argument Technology, University of Dundee

INTRODUCTION

We built a corpus of the 2016 U.S. presidential debates and commentary containing 4,648 argumentative propositions annotated with fine-grained proposition types. Modern machine learning pipelines for analyzing argument have difficulty distinguishing between types of propositions based on their factuality, rhetorical positioning, and speaker commitment. We demonstrate an approach to annotating for four complex proposition types. We develop a hybrid machine learning and human workflow for annotation that allows for efficient and reliable annotation, and demonstrate preliminary analysis of rhetorical strategies and structure in presidential debates.

PROPOSITION TYPES

- **Normative**: Proposes that a certain situation should be achieved or an action should be carried out
- **Desire**: Desires to own something, do something, or desires for a situation to be achieved
- **Future Possibility**: A possibility or prediction that something may be the case in the future
- **Reported Speech**: Conveys an explicit or implicit predicate borrowed from a source external to the speaker

"the major media outlets should not be the ones dictating who wins the primaries"

"I'd like to see everyone get a fair shot at expressing themselves"

"US shooting down a Russian jet could easily turn ugly"

"many in the Black Lives Matter movement believe that overly-aggressive police ...

ANALYSIS OF U.S. PRESIDENTIAL DEBATES

- We developed a human-machine hybrid annotation protocol, which significantly reduced annotation time by 53-77% and increased reliability by 12-30%
- 4,628 propositions are annotated (normative=602, desire=147, future possibility=453, rep. speech=242)
- Correlation analysis of proposition types between claim-premise pairs may inform argument generation systems of what kind of premise should likely follow a certain type of claim in natural speech.
- This corpus may allow for interesting corpus studies about argumentation and advance the state of the art in the field of computational argumentation.

CONCLUSION
**Toolkit for Modeling Nested Trees** traces the divergent and convergent cell specific gene expression patterns across tissue types and species.

Michael Kleyman*, Cathy Su, Jing He, Esin Ozturk, Leah Byrne, William Stauffer, Andreas Pfenning

**Abstract**

- **Question:** How do we compare single cell data between different tissues and/or tissue?
- **Previous Approaches:** Pairwise Comparisons:
  - Why is this not sufficient?
    - Can lose sight of a higher level structure
    - No obvious way to combine statistics between tests
    - Repeated statistical testing can make you underpowered to detect real expression shifts
- **Novel Approach:** Utilize the inherent hierarchies present in biological systems

**Experiential Methodology**

- Isolate cells/nuclei from each sample
- Single cell sequencing
- Sample-wise Hierarchical Clustering
- Archetypal Analysis for each cluster

**Nested Tree Construction**

- Nested Tree is constructed using a bottom up super tree construction
- Clusters that are Mutual Nearest Neighbors are merged in each super cluster
- Distances between clusters is based on average of pairwise distances
- Supercluster is created via Smallest Common Supercluster solution

**Nested Tree Parametrization**

- Each internal node is a gain or a loss
- Archetypes are the leaves of tree
- The model is penalized for each non-zero value in the vector, that means if a change happens higher in the tree it is penalized less

**Model Variable Definitions**

- **Input Parameters**
  - $X$ = n cells by g genes expression matrix, $X \in \mathbb{R}, X \geq 0$
  - $X$ is obtained via the normalization step
  - $M$ = Cell-type assignment matrix, $M \in \{0, 1\}$
  - $S$ is obtained via the hierarchical clustering
  - $\theta = \text{Archetypal assignment matrix}, S \in \mathbb{R}, S \geq 0, |S|_0 = 1$

- **Inferred Parameters**
  - $\beta = \text{Gene coefficient matrix (mean shift value for each node)}, \beta \in \mathbb{R}$
  - $\Delta = \text{Archetypal Divergence weights}, \Delta \in \mathbb{R}, \Delta \geq 0$
  - $M, S$ are also updated

**Optimized Via EM Algorithm**

- **E-step (Cell Assignment)**
  - $f \left[ T \mid X, M, \theta \right] = \prod_{ij} N \left( \text{Laplace} \left( x_j \mid \theta \right) \right)^{N_{ij}}$

- **M-step (Optimize $\theta$ and $A$)**
  - $\Theta_{\text{exp}} = \left[ M, S \right]$
  - $\argmin \sum_{i=1}^{n} \text{Dirichlet} \left( S_{ij} \right) \prod_{j} \sum_{a} \left( \theta_{ij,a} \right)^{S_{ij,a} - 1}$

- **Full Likelihood**
  - $P(X, \beta, M, A, \Omega, \Lambda) = \prod_{ij} \text{Laplace} \left( x_j \mid \theta \right)^{N_{ij}}$

**References:**

- Macosko et al. 2015
- GNGT1
- Theis et al. 2016
- Pericycle
- Angerer et al. 2016
- Tissue/Species Tree
- Mammals
- Vascular Endothelium
- Dorsal Rodents
- Macaque
- Rat
- Mouse
- Supported by Molecular Evolution: Wu et al., 2017

**Macaque Striatum Spatial Analysis**

- Clustering of $\beta$
- Upregulated Gene Clusters
- Downregulated Gene Clusters

**Retina Evolutionary Analysis**

- Rod Archetypes: Evolutionary Changes

**Contact info:** mkleyman@cs.cmu.edu, apfenning@cmu.edu

Funding to attend this conference was provided by the CMU GSA/Provost Conference Funding

Bioconda package will be available soon!
Introduction and Problem Statement

- Identifying groups and their stances (view on an issue) is critical for understanding the spread of information as is the detection of rumors.

- Machine learning on semantic and social networks can help classify stances and rumors automatically.

- On non-tree social media data, LSTMs are commonly used.

- For social media we need different methods. We developed:
  1) Branch LSTM
  2) Tree LSTM
  3) Binarized Tree LSTM

- Our Tree based models are faster and more accurate [5].

Machine Learning Models to Classify Stance and Rumor

Branch LSTM Model

In branch LSTM, the encodings of source-tweet text and the replies text along a tree branch are used as the input and the stance-labels and rumor-labels are used as the output.

Tree LSTM Model

Tree LSTM is similar to the Branch LSTM except the entire tree conversation is used as input, and to merge information from children, Sum/Convolve+MaxPool operations are used.

Binarized Constituency Tree (BCTree) LSTM Model

BCTree LSTM is similar to Tree LSTM except the original tree is binarized which allows new ways to combine the information from the children e.g. Sum/Convolve/Concat operation.

Experiments, Results and Conclusion

Table 1. Dataset: Conversation threads and the rumor type labels in the Pheme Rumor Dataset [4]

<table>
<thead>
<tr>
<th>Events</th>
<th>True</th>
<th>False</th>
<th>Unverified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlie Hebo (CH)</td>
<td>193</td>
<td>116</td>
<td>149</td>
</tr>
<tr>
<td>Sydney siege (SS)</td>
<td>382</td>
<td>86</td>
<td>54</td>
</tr>
<tr>
<td>Ferguson (FG)</td>
<td>10</td>
<td>8</td>
<td>266</td>
</tr>
<tr>
<td>Ottawa shooting</td>
<td>329</td>
<td>72</td>
<td>69</td>
</tr>
<tr>
<td>Germanwings-crash (GC)</td>
<td>94</td>
<td>111</td>
<td>33</td>
</tr>
</tbody>
</table>

Table 2. Results and Comparison. (F1 Score) Higher is better. SKP [1], EMT [2] and BERT [3] are embeddings

<table>
<thead>
<tr>
<th>CellType</th>
<th>Feature</th>
<th>SKP</th>
<th>EMT</th>
<th>BERT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch LSTM - Multitask</td>
<td>0.358</td>
<td>0.359</td>
<td>0.392</td>
<td></td>
</tr>
<tr>
<td>Tree LSTM - Multitask</td>
<td>0.364</td>
<td>0.348</td>
<td>0.384</td>
<td></td>
</tr>
<tr>
<td>MaxPool Convolve+MaxPool</td>
<td>0.369</td>
<td>0.352</td>
<td>0.379</td>
<td></td>
</tr>
<tr>
<td>BCTree LSTM - Multitask</td>
<td>0.379</td>
<td>0.365</td>
<td>0.389</td>
<td></td>
</tr>
<tr>
<td>Convolve</td>
<td>0.367</td>
<td>0.335</td>
<td>0.337</td>
<td></td>
</tr>
<tr>
<td>Convolve+Sum</td>
<td>0.355</td>
<td>0.329</td>
<td>0.323</td>
<td></td>
</tr>
<tr>
<td>Binerized Prior Research</td>
<td>0.329</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Kochkina et al., 2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NiteTMRG (Emary and El-Beltagy, 2017)</td>
<td>0.339</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotions</td>
<td>0.223</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusions:

- Using the whole conversation tree improves our ability to automatically classify rumor and stance.

- Our best Tree models classify the Pheme dataset better than previous work by 11% for rumors and 14% for stances.

- We can use the Tree based in a batch which are much faster to execute. Please read the full paper at [5].

- Next, we would like to include algorithm based fact-checking in our models.

References:


The funding to attend the ACL 2019 conference was provided by the CMU GSA/Provost Conference Funding. This research work was supported in part by the Office of Naval Research (ONR) through, Grant N00014182106 and the Center for Computational Analysis of Social and Organization Systems (CASOS). The views and conclusions contained in this document are those of the authors and should not be interpreted as representing official policies, either expressed or implied, of the Office of Naval Research or the U.S. government.
Characterizing intratumor heterogeneity (ITH) is crucial to understanding cancer development, but it is hampered by limited access to available data sources. Bulk DNA sequencing is the most common technology to assess ITH, but mixes many genetically distinct cells in each sample, which must then be computationally deconvoluted. Single-cell sequencing (SCS) is a promising alternative, but its limitations make it impractical for studying cohorts of sufficient size to identify statistically robust features of tumor evolution. We have developed strategies for deconvolution and tumor phylogenetic reconstruction limited to bulk and single-cell data to gain some advantages of single-cell resolution with much lower cost. We developed a mixed membership model for clonal deconvolution via a non-negative matrix factorization (NMF) balancing deconvolution quality with similarity to single-cell samples via an associated efficient coordinate descent algorithm. We then improve on that algorithm by integrating deconvolution with clonal phylogeny inference, using a mixed integer linear programming (MILP) model to incorporate a minimum evolution phylogenetic tree cost in the problem objective. We demonstrate the effectiveness of these methods on semi-simulated data of known truth, showing improved deconvolution accuracy relative to bulk data alone. In the most recent work, we have further improved the model by integrating the fraction information and ploidy change gained from FISH data.

Methods

1. NMF Deconvolution Model [5]
   \[ \text{Objective function:} \quad \min_{X,Y} \| X - BY \|_F^2 + \lambda \| Y - D \|_F^2 \]

2. Extending general NMF to work with SCS data
   \[ \text{Objective function:} \quad \min_{X',Y} \| X' - BY \|_F^2 + \lambda \| Y - D \|_F^2 \]

3. Extending the NMF Model with a Single-Cell Phylogeny Objective
   \[ \text{Objective function with phylogeny:} \quad \min_{X,Y} \| X' - BY \|_F^2 + \lambda \| Y - D \|_F^2 + \sum \sum \| \text{node } j \| \| \text{node } i \| \]

4. Extending the NMF Model with FISH and SCS
   \[ \text{Objective function with FISH and SCS:} \quad \min_{X,Y} \| X' - BY \|_F^2 + \lambda \| Y - D \|_F^2 + \sum \sum \| \text{node } j \| \| \text{node } i \| \]

Results

1. Integrating Real SCS data into Deconvolution

2. Visualization of Copy Number and Phylogeny

3. Application on the Real Bulk Data with SCS data

Conclusions and Future work

- Limited amounts of single-cell sequencing data improve accurate copy number deconvolution from simulated bulk tumor data
- Novel methods for deconvoluting clonal copy number variation from bulk tumor genomic data assisted by small amounts of SCS data
- Substantial improvement by joining clonal phylogenies indicates the values of a principled evolutionary model in inferring accurate clonal structure
- Information from FISH data would further improve the model
- We would like to incorporate more sophisticated models of mixture composition
- We would like to integrate other classes of genomic data: single-nucleotide variant (SNV), structural variant (SV)
- We would like to improve the simulation method to better represent the ploidy change and fraction reference.
### The Online Submodular Cover Problem

**Anupam Gupta**  
**Roie Levin**

**Introduction**

We consider the problem of maintaining a minimum cost submodular cover online. In the offline Submodular Cover problem (SubCov) first introduced in the seminal work of Wolsey [6], we are given a monotone, submodular function $f$ over a universe $N$ along with a linear cost function $c$, and we wish to select a set $S$ that is a solution to:

$$\min_{S \subseteq N} c(S) \text{ s.t. } f(S) = f(N)$$

We may interpret $f$ as modeling an abstract notion of coverage, and $S$ as a subset of elements guaranteeing full coverage.

However, for many applications it does not suffice to solve a single static instance of SubCov. Instead, the function $f$ — the notion of coverage — changes over time, so we need to update our cover $S$.

For example [2], given a network equipped with flow demand at every vertex, we want to designate the minimum number of vertices as servers, such that every vertex can simultaneously route its demand to some server without violating edge capacities.

If $f(S)$ is the maximum demand satisfied by selecting $S$ as the set of servers, then $f$ is submodular and the problem can be solved using the SubCov framework. In the likely scenario that communication demand evolves over time, revoking prior decisions may be expensive or prohibitive, hence we want to only add servers to $S$ and not remove any.

**Our Contribution**

We show that we can solve the online submodular cover problem (OSubCov) with best possible competitive ratio unless $P = NP$ [4]. This matches previous results for the special case of Set Cover [1], and significantly generalizes them.

**Theorem: Main Theorem**

There exists an efficient randomized algorithm for the OSubCov problem which guarantees that for each time $t$, the expected cost of solution $S$ is within

$$O\left(\ln n \cdot \ln \left(\frac{T \cdot f_{\text{max}}}{f_{\text{min}}}\right)\right)$$

of the optimal submodular cover solution for $f$ at time $t$.

**Key Definitions**

A set function $f : 2^N \to \mathbb{R}^+$ is submodular if

$$f(A \cap B) + f(A \cup B) \leq f(A) + f(B)$$

for any $A, B \subseteq N$. Intuitively, $f$ being submodular means $f$ has decreasing marginal returns. In a picture:

$$f\left(\begin{array}{c} \text{A} \\ \text{B} \end{array}\right) \geq f\left(\begin{array}{c} \text{A} \cup \text{B} \\ \text{A} \cap \text{B} \end{array}\right)$$

**Definition (Mutual Coverage).** The mutual coverage and conditional mutual coverage with respect to a set function $f : 2^N \to \mathbb{R}^+$ are defined as:

$$I_f(A; B) := f(A) + f(B) - f(A \cup B)$$

$$I_f(A; B | C) := I_{fC}(A) + I_{f}(B) - I_{fC}(A \cup B)$$

This generalizes mutual information from information theory: if $N$ is a set of random variables, and for $S \subseteq N$, the quantity $f(S)$ is the joint entropy of the random variables in the set $S$, then $I_f$ is the mutual information.

**Techniques**

A natural approach is to maintain a solution to the LP relaxation of SubCov using the online primal-dual framework [3], and then perform randomized rounding with alterations online. Unfortunately, the only known relaxation is exponential-sized and it is not known how to solve it efficiently, nor how to analyze randomized rounding given a fractional solution. We show that we can overcome these concerns and make the technique work.

The rounding we use is the natural one, where we sample from the fractional solution multiple times (in an online fashion). In particular, we exploit the relationship between the multilinear extension and the linearizations of submodular functions [5] to reinterpret the constraints in the LP as statements about expected coverage under randomized rounding.

For the more refined analysis in our paper, we use a fractional charging scheme. The intuition behind this refined analysis is that we charge each element selected by the algorithm to the elements $o_i \in \text{OPT}$ that “cover the same part of the space”.

It turns out that mutual coverage is the right abstract quantity to focus on as the notion of “contribution”. For the analysis we also have to strengthen the submodular cover LP slightly with additional constraints.

Finally, we show how to implement everything in polynomial time. The difficulty is two-fold: firstly, we do not know how to solve the submodular cover LP even in the offline setting, since the separation problem itself is APX-hard. Secondly, even if we could separate in the offline setting, naively solving the exponential-sized LP online requires us to give exponentially-many constraints one at a time to the online primal-dual LP-solving framework.

To remedy this, we use a “round-or-separate” approach: we use the rounding algorithm itself as an approximate separation oracle. Indeed, we give an approximate separation oracle that given an arbitrary solution promises to either round it to a feasible integer solution with a similar objective value, or else to output a constraint violated by the solution. This approach to blur the line between rounding and separation may prove useful for other problems in online algorithms, where we are faced with an exponential number of new constraints at each step. Lastly, we use a potential function argument to conclude that we only need a polynomial number of calls to the separation oracle in the worst case.

**References**


Funding to attend this conference was provided by the CMU GSA/Provost Conference Funding.
Reconstructing cell lineages that lead to the formation of tissues and organs is of crucial importance in developmental biology. Recent studies combine two novel technologies, single-cell RNA-sequencing and CRISPR-Cas9 barcode editing, for elucidating developmental lineages at the whole organism level. These studies raise several computational challenges:

- lineages are reconstructed based on noisy and often saturated random mutation data using Maximum Parsimony (multiple optimal trees)
- resulting lineage tree sometimes fails to separate different types of cells
- due to the randomness of the mutations, lineages from multiple experiments cannot be combined to reconstruct a consensus lineage tree

To address these issues, we developed a novel method, LinTIMaT:

- reconstructs cell lineages using a maximum-likelihood framework by integrating mutation and expression data
- enables the integration of different individual lineages for the reconstruction of a consensus lineage tree

**RESULTS**

LinTIMaT can refine subtrees in which all cells share the same barcode, can cluster cells with different barcodes together based on their cell types.

Clusters in LinTIMaT reconstructed lineages display better spatial enrichment.

Consensus lineage improves on the individual lineages by uncovering more functionally significant neuronal, blood, and progenitor cell clusters.

**CONCLUSION & FUTURE WORK**

- Incorporating complementary data types into a likelihood-based framework improves cell lineage reconstruction.
- In-silico validation study on c. elegans cell lineage
- Analyzing other CRISPR-Cas9 barcode lineage datasets
- LinTIMaT is freely available at https://github.com/jessica1338/LinTIMaT

*This work was partially funded by the National Institutes of Health (NIH) [grants 1R01GM122886 and 1OT2GM11682 to Z.B.J.].
Adaptive Auxiliary Task Weighting for Reinforcement Learning

Xingyu Lin*, Harjatin Singh Baweja*, George Kantor, David Held
Robotics Institute, Carnegie Mellon University

Introduction

• For complex tasks, the reinforcement learning algorithms often require a prohibitively large number of samples to learn. The sample complexity issue is even further exacerbated when learning from image or other high dimension observation.

• Training on self-supervised auxiliary tasks in conjunction with the RL objective is a popular approach to learn environment-relevant features [2] more quickly.

• Challenge: How to determine auxiliary task weights? Approaches in previous works include:
  – Balance the gradients from all the task [1]
  – Non-optimal: some auxiliary tasks might be more useful than others
  – Heuristics = grid search [3]
  – Requires large computation
  – Need to perform the optimization multiple times; Not feasible for learning one-off tasks

• We propose an adaptive learning algorithm that dynamically determines the importance of different auxiliary tasks for the specific task at hand.

Approach

The total loss we used to update the model is $L(\theta) = L_{\text{main}}(\theta) + \sum_{i=1}^{K} \alpha_i L_{\text{aux},i}(\theta)$.

We learn auxiliary task weights to minimize the main task loss:

$Y(w) = \frac{\partial L_{\text{main}}(\theta(t))}{\partial \alpha_i} = L_{\text{main}}(\theta(t)) - L_{\text{main}}(\theta(t-1))$

The training curves of our method compared to other baselines. Top: Atari environments with A2C as the base learning algorithm. Bottom: Manipulation environments with DDPG+HER as the base learning algorithm.

OL-AUX gives significant improvement over the baselines, including: No auxiliary tasks, treating all auxiliary tasks as equally important (Gradient Balancing), and using cosine similarity.

Experiments

1. Our method automatically ignores harmful auxiliary tasks

OL-AUX on a simple optimization problem

2. OL-AUX gives significant improvement in a variety of environments

Comparing training OL-AUX with all tasks to the one with Changes of each task weights a single auxiliary task and no during training of OL-AUX. auxiliary tasks.

3. More auxiliary tasks is better!

OL-AUX effectively combines all auxiliary tasks and outperforms using any single auxiliary task.

OL-AUX gives meaningful task importance. For example, predicting inverse dynamics ($x$) and predicting optimal flow (pink) are shown to be the auxiliary tasks that are most useful when used individually and OL-AUX automatically discovers these tasks and gives them higher weights.

References


Acknowledgment

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Contact

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Harjatin Baweja Email:harjatin@cs.cmu.edu
EXPRESSIVE BIOSIGNALS: authentic social cues for social connection

Fannie Liu | Carnegie Mellon University SCS | fannie@cmu.edu

**definition**
Expressive biosignals are sensed physiological data, such as heart rate and brain activity, displayed as social cues.

**research goal**
Explore the potential for expressive biosignals to facilitate social connection between people in communication.

---

**why share or not share biosignals?**
A 2-week field study (N=13) showed that heart rate can be shared in text messages as a means to express and validate emotions and daily activities to close friends/family.

"By sharing heart rate I’m implying that I might need help...so this is a very indirect way of sharing my emotions. So I’m interested if they can sense it." - P9

"Because he’s interested in my life in general... we pretty much know what each other’s up to...so it was usually a commentary on what I was doing." - P1

---

**how to interpret other people’s biosignals?**
Fig 2. Participants (N=32) saw 6 visualizations of the same EEG data of a user and interpreted that user’s mental states, albeit with some ambiguity.

"...it takes quite a lot effort to analyze and interpret...the person’s brain activity." - P2

"[I]t may be easier to trust someone else by watching his actual brain activity.... You feel like you know this person." - P7

---

**what communication patterns can expressive biosignals afford?**
A 2-week field study (N=34) deploying Animo showed that communicating biosignals on smartwatches can promote lightweight social connection through increased presence and awareness, and mood-centric interactions.

"...just to say ‘hey I’m remembering you’ or say hi or ping you or whatever...all of those things." - P24

"...it prompted other conversation...to check in with each other and see what we’re up to." - P13

---

**how can expressive biosignals influence empathy and social support?**
Preliminary results from a vignette experiment show that the presence of biosignals information (e.g., elevated heart rate graph) can increase empathy for another person in the form of emotional perspective-taking. Next steps: explore potential downstream effects on prosocial behavior.

---

**icon references**
From the Noun Project
- poke by icon 54
- Conversation by Xinh Studio
- boy by Moxilla, girl by Moxilla

---

**Figures**
- Fig 1. Screenshots and quotes from participants who shared their heart rate as an emotional expression (top) or as an activity update (bottom).
- Fig 2. Participants (N=32) saw 6 visualizations of the same EEG data of a user and interpreted that user’s mental states, albeit with some ambiguity.
- Fig 3. Challenges: biosignals are ambiguous and contain a lot of information to process (top). Opportunities: understanding at a deeper level (bottom).
- Fig 4. Animo: a smartwatch app where users can share “animos,” or heart rate mood representations, with each other.
- Fig 5. Vignette prompt: “CMU Pulse,” a website for collecting students’ personal stories with recordings of their heart rate.
- Fig 6. Sketch for mobile app integrating expressive biosignals and gestures to signal stress and provide lightweight yet effortful social support to anonymous peers.
Distributed Environmental Modeling and Adaptive Sampling for Multi-Robot Sensor Coverage

Wenhao Luo¹, Changjoo Nam², George Kantor¹, and Katia Sycara¹

¹Robotics Institute, Carnegie Mellon University, USA
²Center for Robotics Research, Korea Institute of Science and Technology, Korea

Motivation

Multi-Robot Sensor Coverage: Robots move to optimal configurations where the static sensing/monitoring performance is maximized.

Challenges: Existing works always assume distribution of environmental phenomena known beforehand!

Questions: Can we enable robots to simultaneously learn the distribution of environmental phenomena online in a fully distributed manner, while approaching to the estimated optimal configurations?

Contribution

1) Combining adaptive sampling with coverage control for efficient online distribution learning and simultaneous locational optimization with less number of samples in an unknown environment.
2) Distributed learning of Mixture of GPs that provides improved prediction accuracy and reduced model uncertainty with local training data only.

Problem Formulation

Goal: To minimize

\[ H(x_1, \ldots, x_n) = \sum_{i=1}^{n} \int_{\mathbb{R}^2} ||q - x_i||^2 \phi(q) dq \]

where \( q \) in \( \mathbb{R}^2 \) is any discretized map point and density function evaluates the value at \( q \).

Conventional Coverage Controller:

\[ x_i = k_p(C_{V_i} - x_i) \]

\[ C_{V_i} = \frac{\int_{V_i} \phi(q) dq}{\int_{V_i} \phi(q) dq} \]

Our sub-goals:
- take as few samples online to distributedly learn \( \phi(q) \)
- with the learned \( \phi(q) \), derive alternative coverage controller to take next best sample for improving model accuracy and approaching to optimal positions.

Approach

Value of each map point \( h(q) \) and new controller:

\[ h(q) = \text{predicted } \phi(q) + \beta \text{uncertainty (GP-UCB)} \]

\[ \tilde{C}_{V_i} = \frac{\int_{V_i} qh(q) dq}{\int_{V_i} h(q) dq} \quad \dot{x}_i = k_p(\tilde{C}_{V_i} - x_i) \]

Mixture of GPs to learn the density function (Robot 2):

\[ \text{GP 1} \]
\[ \text{GP 2} \]
\[ \text{GP 3} \]

Local estimation

Local gating function

Learned merged density function for robot 2

Results

(a) Initial
(b) Distribution of Mixture of GPs
(c) Local GPs
(d) Uni-model GP

(a) Control with known model
(b) Variance by distribution mix of GPs
(c) Variance by Local GPs
(d) Variance by uni-model GP

(a) RMS error
(b) Sensing cost

Improved model accuracy and sensing performance.

AAMAS 2019

* Funding to attend this conference was partially provided by the CMU GSA Provost Conference Funding
Differentiable histogram layers can bridge the gap between GCN modules and CNN classifiers, leading to SotA results in Graph Classification.

Graph-Hist: Graph Classification from Latent Feature Histograms with Application to Bot Detection

Thomas Magelinski, David Beskow, Kathleen M. Carley

Funding to attend AAAI20 was partially provided by the CMU GSA/Provost Conference Funding

Introduction

- Graph-classification is the problem of correctly identifying the label of an entire graph. This problem has applications in a wide range of areas, from biology to social media.
- Traditional convolutional architectures are great at image classification, but are not applicable to graphs due to their irregular geometry and inconsistent input size.
- Graph convolutions solve the problem of the graph's geometry, but not of its size.
- Previous work uses CNNs for graph classification, but relies on pre-computed embeddings.
- We introduce a differentiable histogram layer which approximates the distribution of embedded nodes through 1-d projections
- This multi-channel histogram is then classified using a traditional convolutional architecture.
- The entire model, then, can be trained in an end-to-end fashion.

The Model

- Given graph Laplacian, \( L \), and node feature matrix, \( X \), we modified the typical graph-convolutional model, as shown in Equation 1.

\[
Z^{(l)} = \sigma(L^T X W^{(l)} + b^{(l)})
\]

- The final embedding can be discretized and approximated by taking a series of 1-dimensional projections, giving a multi-channel histogram.
- The histogram is updated during back-propagation according to the derivative shown in Equation 2, where \( \ell \) is the loss function, \( C \) is the embedding matrix, \( H \) is the histogram matrix, and \( B \) is the bin location matrix.

\[
\frac{\partial \ell}{\partial C_{i,j}} = \frac{1}{\sum_{m=0}^{k} e^{-\gamma |C_{i,m} - H_{i,j}^k| \cdot \text{sign}(H_{i,j})}} \frac{\partial \ell}{\partial H_{i,j}}
\]

- Finally, the histogram is classified using a 1-d variant of LeNet-5.

Results

Benchmark Datasets

- 6 popular benchmark datasets were analyzed, with results in Table 1.
- Graph-Hist was developed for social media networks, and achieves the highest accuracy on all 3 social media benchmarks.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>F1</th>
<th>Precision</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bot-Hunter Tier1</td>
<td>0.683</td>
<td>0.843</td>
<td>0.683</td>
</tr>
<tr>
<td>Bot-Hunter Tier2</td>
<td>0.687</td>
<td>0.821</td>
<td>0.683</td>
</tr>
<tr>
<td>Bot-Hunter Tier3</td>
<td>0.599</td>
<td>0.837</td>
<td>0.466</td>
</tr>
<tr>
<td>Graph-Hist</td>
<td>0.740*</td>
<td>0.863</td>
<td>0.807</td>
</tr>
</tbody>
</table>

Bot Detection

- Social media increasingly shapes our society, from trends in culture to the nature of our political discourse
- Automated bot accounts use sophisticated techniques to manipulate the conversation
- Previous methods of bot detection rely on account attributes such as account name, age, tweet frequency, etc.
- Bots are known to rely on other bots to amplify their message, creating a bot-net
- Graph-Hist can use the account attributes like previous models, but can also account for the structure of the account’s communication network
- Graph-Hist achieved the top F1 score of all previous modeled studies on held-out validation data

Download the paper:

CASOS
Problem and Approach

Knowledge Component (KC) modeling is useful in a wide range of learning tasks in intelligent tutoring systems.

Digital learning games are a new area with much enthusiasm but scarce empirical evidence.

- Most games follow a one-size-fits-all approach, without personalized instruction in mind.
- Adopting KC modeling in games is an important first step in improving their effectiveness.

We present our work on constructing a KC model in a post-hoc manner in the game Decimal Point.

1. Construct two baseline models based on the game’s design
   - DecimalMisc: 4 KCs, each representing a common decimal misconception.
   - ProblemType: 5 KCs, each representing a mini-game type.

2. Select the model with better fit

<table>
<thead>
<tr>
<th>Model (# of KCs)</th>
<th>AIC</th>
<th>BIC</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DecimalMisc (4)</td>
<td>30,699.27</td>
<td>34,379.97</td>
<td>0.3292</td>
</tr>
<tr>
<td>ProblemType (5)</td>
<td>29,504.09</td>
<td>33,202.12</td>
<td>0.3231</td>
</tr>
</tbody>
</table>

ProblemType outperforms DecimalMisc in all three metrics → selected model.

3. Identify model improvement through learning curves

- Addition and Sequence are decreasing but not smooth.
- Sorting is neither decreasing nor smooth.

4. Decompose the KCs to obtain better learning curves

- Addition:
  - carry digit in the tenth place
  - carry digit in the ones place
  - other digits

- Sequence:
  - item with carry
  - item without carry

- Sorting:
  - items with latent misconceptions
  - other sorting items

Model (# of KCs) | AIC     | BIC     | RMSE  |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ProblemType (5)</td>
<td>29,504.09</td>
<td>33,202.12</td>
<td>0.3231</td>
</tr>
<tr>
<td>NumberLine (6)</td>
<td>29,492.48</td>
<td>33,207.83</td>
<td>0.3233</td>
</tr>
<tr>
<td>Sorting (6)</td>
<td>29,272.18</td>
<td>32,987.53</td>
<td>0.3215</td>
</tr>
<tr>
<td>Sequence (8)</td>
<td>29,159.27</td>
<td>32,909.25</td>
<td>0.3234</td>
</tr>
<tr>
<td>Addition (7)</td>
<td>29,025.77</td>
<td>32,758.43</td>
<td>0.3235</td>
</tr>
<tr>
<td>Combined (12)</td>
<td>28,436.07</td>
<td>32,255.34</td>
<td>0.3196</td>
</tr>
</tbody>
</table>

Results

New Learning Curves

- KCs with issues
- Low and flat KCs
- Good KCs

Model (# of KCs) | AIC     | BIC     | RMSE  |
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<td>28,436.07</td>
<td>32,255.34</td>
<td>0.3196</td>
</tr>
</tbody>
</table>

Discussion

Lessons learned:
- Arrange the easy Addition problems at the beginning.
- Provide more scaffolding in Sorting problems.
- Design questions that address latent misconceptions identified by the new Sorting KCs.

Post-hoc KC modeling:
- Domain knowledge remains critical for the interpretation of the improved model.
- KC modeling can guide changes to the types, contents and order of problems used in a digital learning game.
- We can now perform knowledge tracing based on the new KC model.

The full content of this poster can be viewed at Nguyen, H., Wang, Y., Stamper, J., & McLaren, B. M. Using Knowledge Component Modeling to Increase Domain Understanding in a Digital Learning Game. In International Conference on Educational Data Mining, pp. 139–148. Funding to attend this conference was provided by the CMU GSA/Provost Conference Funding.
What is the reason for a sentiment value?

Many studies have focused on the aspect & valence of a sentiment. Everything is always cooked to perfection. *(Food Quality, P)*

The waiter was rude at times. *(Service, N)*

but have paid little attention to **the reasons** for holding a sentiment.

Aspects are typically limited to properties of entities and do not show why and how such aspects cause sentiments.

→ **Clues** to better respond to the sentiments.

We assume that a sentiment is triggered by whether the holder’s motive is satisfied. *(Hovy, 17)*

**Humans motive detection as the first step.**

Everything is always cooked to perfection. *(Food Quality, P)*

Feeling satisfied *(Self-fulfillment)*

The waiter was rude at times. *(Service, N)*

Being treated well *(Social Relation)*

**Highlights**

- Define six basic motives covering a wide range of topics in reviews.
- Annotate 1,600 restaurant & laptop reviews by crowdsourcing.
- Empirically show that underlying motives are universal across domains.

**Representation of Human Motives**

We use the hierarchical taxonomy defined by Tallevich et al. (2017)

![Diagram](Diagram)

**Annotation by Crowdsourcing**

Based on preliminary annotations, we choose seven motive categories.

- Self-Fulfillment
- Appreciating Beauty
- Social Relation
- Health
- Ambition & Ability
- Finance

**Data:** SemEval 2016 Aspect-based Sentiment Analysis *(Pontiki, 16)*
Restaurant and Laptop reviews, 800 sentences w/≤ 25 tokens from each domain.

**Quality Control:** worker qualification + redundancy (3 workers/text)

<table>
<thead>
<tr>
<th>200 texts* in each domain</th>
<th>600 texts in each domain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Qualified</strong></td>
<td><strong>X</strong></td>
</tr>
</tbody>
</table>

Annotation agreement (Krippendorff’s α): 0.51 (restaurant), 0.61 (laptop)

**Human Motive Detection**

Given a sentence, predict relevant motives. *(Multi-label classification)*

**Predictive Models:**

- Linear SVM
- Multi-layer Perceptron (MLP)

**Training:**

Transfer learning across domains

Human motives will be universal across domains although distributions can be different.

**Experiments**

**Settings:**

- Primary measure: macro-F1
- 3-fold CV: in each fold
  - Train/valid/test = 1:1:1
  - Tune hyperparameters using the train and valid sets.
  - Train a model on the train+valid set and evaluate on the test set.

**Results:**

- Out-of-domain training data helps.
  - The precision of MLP classifiers.
  - This indicates the universality of underlying motives across domains.

**Error Analysis:** Errors concentrate on ambiguous examples.

<table>
<thead>
<tr>
<th>Gold</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>SVM</td>
<td>MLP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Text</th>
<th>Gold</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>I had to ask her three times before she finally came back with the dish I've requested. (restaurant service)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English must have been his third or fourth language. (laptop customer service)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Motivation
Over the past few years a number of research groups have made rapid advances in dense 3D alignment from 2D video and obtained impressive results.

- How these various methods compare is relatively unknown.
- Previous benchmarks addressed sparse 3D alignment and single image 3D reconstruction.
- No commonly accepted evaluation protocol exists for dense 3D face reconstruction from video with which to compare them.

Contributions
The 2nd 3D Face Alignment in the Wild from Video (3DFAW-Video) Challenge extends the previous 3DFAW 2016 competition to the estimation of dense 3D facial structure from video.

- We present a new large corpora of profile-to-profile face videos recorded under different imaging conditions and annotated with corresponding high-resolution 3D ground truth meshes.
- We introduce the ARMSE evaluation metric on the 3DFAW-Video dataset.
- We report results of the 3DFAW-Video challenge held in conjunction with ICCV 2019 in Seoul, Korea.

3DFAW-Video Dataset

The 3DFAW-Video dataset has 3 main components per subject as shown in the figure to the left:

1. Unconstrained 2D video from an iPhone (top)
2. A high resolution 2D video from a DI3D system (middle)
3. High-resolution 3D ground truth mesh (bottom)

The demographics of the dataset are shown in the pie chart below. The dataset contains N=66 subjects, with ages 18-28 (mean 19.7), and gender distribution of 36 females to 30 males.

Data Acquisition

- High Resolution video: DI3D imaging system with RGB & stereo monochrome cameras. Captures ~5-10s 3D sequence from profile to profile at 25fps, and 2D texture images of resolution 1040x1932px
- Unconstrained mobile video: iPhone 6 camera moves around stationary subject from profile to profile. Each video is 30 fps, and ~5-10s long, with ambient indoor lighting.
- 3D meshes: Using dense passive stereo photogrammetry method to recover the 3D model from DI3D imaging system, each frame provides a corresponding mesh with ~30K-50K vertices at a precision of 0.2mm RMS

Dataset Generation: Ground Truth Reconstruction

3DFAW-Video Challenge

The participants were asked to produce 3D reconstructions of the test subjects, given the datafolds shown to the left. The above figure shows the videos, and ground truth reconstructions with the annotations that were provided for the datafolds.

The competition was hosted on Codalab, and submissions were evaluated against the ground truth meshes.

3DFAW-Video Evaluation Protocol/Metric

\[ E(A, B) = \min\{ |A - B|_1, |A - B|_2, |A - B|_3 \} \]

\[ D(A, B) = 1 - \frac{2}{N} \sum_{i=1}^{N} E_A(A_i, B_i) \]

\[ \text{ARMSE}(X, Y) = \frac{1}{N} \sum_{i=1}^{N} |X_i - Y_i|^2 \]

The predicted meshes were trimmed to 95mm and aligned using ICP, before the average root mean square error (ARMSE), the average of the point-to-mesh distance from the ground truth to the predicted and vice-versa, was calculated. The equations to the right describe the ARMSE metric between 2 meshes. ARMSE is also robust to handling biases due to density, as compared to commonly used 3D-RMSE.

3DFAW-Video Challenge Methods & Results

Of eight teams that participated, only four completed the challenge by submitting a technical description of their methods, and the CED curves and a table of results are to the right. The best method by Zheng was based on traditional 3D dense reconstruction using structure from motion (SFM), that was improved by utilizing facial prior knowledge. Shaoh et al. [2] proposed an ensemble of independent regression networks to create a framework consisting of multiple reconstruction branches and a subsequent mesh retrieval module. Finally, Maldonado et al. [3] proposed a learning based method employing siamese neural networks that reconstructs 3D faces from either single or multiple images.
Where New Words Are Born:
Distributional Semantic Analysis of Neologisms and Their Semantic Neighborhoods

**Summary**
We analyze neology, the process by which new words emerge in a language, using large diachronic corpora of English. We compare language-internal and language-external factors by testing the following two hypotheses:

**Supply:** Neologisms are more likely to emerge in sparser areas of the semantic space
**Demand:** Neologisms are more likely to emerge in semantic neighborhoods of growing popularity

We find both factors to be predictive of word emergence although we find more support for the demand hypothesis.

**Neologisms and control sets**
We select 1000 nouns that are 20 times more frequent in the modern corpus (COCA) than in the historical one (COHA).

OED: ~58% of words (latest sense) emerged in the 20th century.

<table>
<thead>
<tr>
<th>Neologism</th>
<th>(f_m \times 10^6)</th>
<th>(f_h \times 10^6)</th>
<th>OED</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>voice-over</td>
<td>9.46</td>
<td>0.21</td>
<td>1966</td>
<td>experience</td>
</tr>
<tr>
<td>video</td>
<td>8.13</td>
<td>2.34</td>
<td>1981</td>
<td>henry</td>
</tr>
<tr>
<td>software</td>
<td>4.71</td>
<td>1.01</td>
<td>1958</td>
<td>capacity</td>
</tr>
<tr>
<td>gender</td>
<td>4.23</td>
<td>1.09</td>
<td>1984</td>
<td>method</td>
</tr>
<tr>
<td>e-mail</td>
<td>4.11</td>
<td>0</td>
<td>1979</td>
<td>artist</td>
</tr>
<tr>
<td>teaspoon</td>
<td>2.45</td>
<td>0.99</td>
<td>1791</td>
<td>element</td>
</tr>
<tr>
<td>infrastructure</td>
<td>1.66</td>
<td>—</td>
<td>1927</td>
<td>—</td>
</tr>
<tr>
<td>feedback</td>
<td>1.61</td>
<td>0.33</td>
<td>1943</td>
<td>academy</td>
</tr>
<tr>
<td>lifestyle</td>
<td>1.52</td>
<td>0.57</td>
<td>1929</td>
<td>alliance</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

**Methodology**
1. Align embedding spaces by rotating and then project the neologisms into the historical embedding space:
2. Compare characteristics of the embedding space neighborhoods of the neologisms and the control words:
   - Density: number of words in a neighborhood
     \[
     d(w, \tau) = |\{u : \text{cosine}(v_u, v_n) \geq \gamma\}| \quad \Leftarrow \text{supply}
     \]
   - Frequency growth rate: average Spearman correlation between decades and frequency by decade in COHA
     \[
     r(w, \tau) = \frac{1}{d(w, \tau)} \times \sum_{u, \text{cosine}(v_u, v_n) \geq \gamma} \frac{r_s(\{1:18\}, f_{1:18}(u))}{18} \quad \Leftarrow \text{demand}
     \]

**Results and analysis**
(GLM: \(y(w) \sim \sigma(\beta_0^{(s)} + \beta_1^{(s)} d(w, \tau) + \beta_2^{(s)} \cdot r(w, \tau))\))

- **Supply:** density is predictive with negative weight
- **Demand:** frequency growth rate is predictive with positive weight

Significant at \(p < 0.01\) for larger neighborhood sizes (stable control set) or for all neighborhoods (relaxed control set).

**Qualitative examples of nearest historical neighbors:**

<table>
<thead>
<tr>
<th>Neologism</th>
<th>Nearest neighbors</th>
</tr>
</thead>
<tbody>
<tr>
<td>email</td>
<td>telegram letter</td>
</tr>
<tr>
<td>pager</td>
<td>beeper phone</td>
</tr>
<tr>
<td>blogger</td>
<td>journalist columnist</td>
</tr>
<tr>
<td>spokeswoman</td>
<td>spokesman director</td>
</tr>
<tr>
<td>sushi</td>
<td>caviar risotto</td>
</tr>
<tr>
<td>e-book</td>
<td>paperback hardcover</td>
</tr>
<tr>
<td>hip-hop</td>
<td>jazz rock-n-roll</td>
</tr>
<tr>
<td>daycare</td>
<td>day-care childcare</td>
</tr>
<tr>
<td>vibe</td>
<td>ambience ambience</td>
</tr>
<tr>
<td>chemo</td>
<td>chemotherapy dialysis</td>
</tr>
</tbody>
</table>

Presented at SCiL 2020. Funding to attend this conference was provided by the CMU GSA/Provost Conference Funding.
Structural variability analysis of TADs as revealed by Hi-C
Natalie Sauerwald1, Akshat Singhal2, and Carl Kingsford1
nsauerwald@cmu.edu, aksinghal@cs.stonybrook.edu, carlk@cs.cmu.edu
1Computational Biology Department, School of Computer Science, Carnegie Mellon University
2Department of Computer Science, Stony Brook University

Abstract
One of the central questions in the field of three-dimensional chromosome structure is the degree to which topologically associating domains (TADs) are conserved or vary between conditions. We analyze a set of 137 Hi-C samples from 9 different studies under 3 measures in order to quantify the effects of various sources of biological and experimental variation. We quantify the dynamic nature of TADs, and show that genetic similarity does not appear to drive TAD similarity. The effects of experimental protocol differences are also measured, demonstrating that samples can have protocol-specific structural changes, but that TADs are generally robust to lab-specific differences and choice of restriction enzyme. This study represents a systematic quantification of the key factors influencing comparisons of chromosome structure and suggests that genetic sequence alone is not sufficient to describe three-dimensional chromosome architecture.

Data and comparison measures

![Diagram of data and comparison measures](image)

Data from nine different studies covering 52 unique biological sources and a variety of experimental conditions were analyzed with three similarity measures:
- HiCRep [1] – statistical similarity score for full Hi-C matrices
- Jaccard Index (JI) – fraction of boundaries shared
- TADsim [2] – fraction of the genome with similar TADs

References

In situ and dilution Hi-C
Hi-C matrices of in situ replicates are statistically significantly more similar than dilution replicates, yet the TAD sets only show statistically significant differences under the JI measure.

Lab-specific differences
A comparison of same-cell-type pairs from different labs shows that these pairs are generally more similar than non-replicate pairs, with similarity values near those of replicate pairs.

Funding to attend this conference was provided by the CMU GSA/Provost Conference Funding.
Ontology-aware Models for Neural Summarization

Karan Saxena
karansax@cs.cmu.edu

Problem and Motivation

Abstractive summarization methods require sophisticated abilities that are crucial to high-quality summarization, such as paraphrasing, generalization, or the incorporation of real-world knowledge.

Even then, these systems exhibit undesirable behavior such as inability to deal with out-of-vocabulary (OOV) words and repeating themselves.

Our hypothesis is that Ontology-aware models are a low-hanging fruit to mitigate these problems.

Dataset

We use non-anonymized version of CNN/Daily Mail dataset.

Results

<table>
<thead>
<tr>
<th></th>
<th>R_1</th>
<th>R_2</th>
<th>R_3</th>
<th>Meteor</th>
<th>Avg p_gen (train)</th>
<th>Avg p_gen (test)</th>
<th>Attention Corr</th>
<th>Timesteps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cov_off</td>
<td>35.00</td>
<td>14.86</td>
<td>32.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cov_on</td>
<td>38.82</td>
<td>16.81</td>
<td>35.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random Init</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cov_off</td>
<td>37.31</td>
<td>16.05</td>
<td>32.39</td>
<td>16.29</td>
<td>42.22</td>
<td>0.184</td>
<td>0.60</td>
<td>605k</td>
</tr>
<tr>
<td>Cov_on</td>
<td>37.76</td>
<td>15.88</td>
<td>32.21</td>
<td>17.02</td>
<td>59.19</td>
<td>0.199</td>
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<td>16.48</td>
<td>32.87</td>
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<td>0.228</td>
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Contributions

Pointer Generator networks, or Copy-Nets, have been used to ensure baseline levels of grammaticality and accuracy but the models quickly fall back to the space of only copying sentences (extractive) rather than being truly abstractive.

We show that Retrofitting Word Vectors, a cheap but useful way of infusing knowledge for NLP tasks, and show one such application for Summarization.

This (ongoing) work focuses on the trade-off between copying vs generating words and we show that the coverage vector/loss (as in MT) is not as useful as Ontology-aware models.

Our hypothesis is that Retrofitting Word Vectors can be achieved by enriching the vectors (retrofitting) while reducing the complexity of learning (i.e. without using coverage loss).

Key Ideas

1. Retrofitting: Vector space word representations are learned from distributional information of words in large corpora. Although such statistics are semantically informative, they disregard the valuable information that is contained in semantic lexicons such as WordNet. We add this knowledge explicitly by retrofitting the initial Glove vectors on WordNet and PPDB.

Note that we use the script from Faruqui et al. directly without modifications.

2. Label Smoothing: The reason behind using this is akin to adding Gumbel Noise to the model. We hypothesize that adding (uniform) label smoothing will push the model towards robustness and a non-uniform label smoothing (inspired by semantic-distance) will help learning even more. Results are awaited.

3. Weight Tying and L2 normalized vectors: From our initial experiments, we see gains after sharing weights between encoder, decoder and the prediction layer and using L2 norm vectors (esp. for words not found in Glove).

Conclusion/Future-work

1. We show that infusing semantic knowledge helps the models learn better (and faster by almost 2x).
2. We don’t use any custom loss and our summaries are significantly shorter but getting the same scores.
3. Adding knowledge boosts the probability of generating novel words, thereby preventing the model from becoming extractive.

As part of our ongoing work, we are exploring different Label Smoothing techniques. We are also analyzing why our models are giving comparable scores with almost 30% shorter summaries (novel n-grams etc.)

Acknowledgement

This work was done under the supervision of Kartik Goyal (kartikgo@cs.cmu.edu), PhD, LTI, CMU.

References

Fictional, Interactive Narrative as a Foundation to Talk about Racism

Authors: Hillary Carey (School of Design), Alexandra To (HCII), Jessica Hammer (HCII), Geoff Kaufman (HCII)

Objective

We propose that a fictional interactive narrative can serve as a grounding experience for participants to safely engage with the emotional and psychological reality of racist interactions.

Creating the Interactive Fiction as a Relatable Story

We created an interactive fiction about a college student who experiences what Sue (2010) defines as a racial microaggression. We built the immersive narrative in Twine (Freedman et al., 2018; Klimas, 2020), an open-source interactive, narrative platform. Participants in our workshops were given a link and asked to complete the task of moving through the story in advance of the workshop session. (View: www.alexandrapro.com/projects/care-vignettes)

In Winter 2020 we conducted the workshop six times with a total of 26 racially diverse participants (21 female; ages 18-56, avg. 25 y/o) living in Pittsburgh, PA, USA. Preliminarily, we found that participants highly related to the narrative (affirmative idea).

Preliminary Evidence

In each of six workshops, participants wrote color-coded sticky notes based on the elements of the fictional story and then brainstormed ways to intervene in racist interactions.

In response to the fictional microaggression narrative, we heard comments like, “Yeah, that’s happened to me 4,000 times in my life” and, “I find for brown people like me, people make a lot of assumptions about where I’m from.”

References


Designing the Participatory Workshop to Ideate on Ways to Cope with Racist Interactions

To use the fictional story as a tool for brainstorming new technology, we drew on the concept of a Future Workshop (Brandt, 2006, Muller 2007), in which participants create a shared understanding of problems of the present state, then envision a better future, and then prototype it. In our case, the fictional narrative became the common problem (before, during, and after the visiting professor’s offensive questions). Throughout the workshop, participants could refer to moments in the fictional story, or share their personal experiences inspired by the story if they wished. To build a shared understanding of the problem of the raci instantions), openly shared their personal experiences (voluntary self-disclosure), and generated many ideas envisioning future technologies for coping with racism (sticky-note brainstorms and storyboards of their favorite ideas).

We observed that the use of fiction provided participants with:

- Space to disclose their personal experiences at their own comfort level
- Time to establish a shared understanding of what makes racist experiences difficult

In Winter 2020 the workshop six times with a total of 26 racially diverse participants (21 female; ages 18-56, avg. 25 y/o) living in Pittsburgh, PA, USA. We observed that the use of fiction provided participants with:

- Space to disclose their personal experiences at their own comfort level
- Time to establish a shared understanding of what makes racist experiences difficult

In the Coping After Racist Experiences (CARE) project, we aim to gain insights on how socio-technical tools can be used to address the aftermath of interpersonal racism. We utilize participatory design as a means of centering people of color in the design of future technologies. At the same time, we acknowledge that discussions of racism must be handled with care and sensitivity.

Participatory Design (PD) often asserts that we begin by soliciting participants’ real lived experiences. However, for personally vulnerable issues such as experiences of racism, it may be asking too much of participants to disclose real lived experiences to a group of strangers. To provide a more safe environment, we use a fictional narrative to ground and center our conversation.

In particular, the interactivity (participants can choose their responses to different moments in the story) is powerful for their engagement with it.

For their engagement with it.
Multi-modal Transfer Learning for Grasping Transparent and Specular Objects

Thomas Weng¹, Amith Pallankize², Yimin Tang³, Oliver Kroemer¹, David Held¹

Abstract

State-of-the-art object grasping methods rely on depth sensing to plan robust grasps, but commercially available depth sensors fail to detect transparent and specular objects.

To improve grasping performance on such objects, we introduce a method for learning a multi-modal perception model by bootstrapping from an existing uni-modal model. This transfer learning approach requires only a pre-existing uni-modal grasping model and paired multi-modal image data for training, foregoing the need for ground-truth grasp success labels nor real grasp attempts. Our experiments demonstrate that our approach is able to reliably grasp transparent and reflective objects.

Method

We use a dataset of paired RGB-D images and a pre-existing depth-based grasping model to train an RGB-based network.

The loss for the network is defined as

\[ \mathcal{L}(\phi) = \| G(q, I_d) - G_q(q, I_s) \|^2 \]

Where \( q \) is the grasp configuration, \( I_d \) is the depth image, \( I_s \) is the color image, and \( \phi \) are the network weights.

We evaluate three variants of our method (RGB-ST, RGBD-ST, and RGBD-M) against a depth-only grasping method FC-GQCNN[1]. The variants explore RGB-only and combined RGB-D approaches to grasping transparent and specular objects.

Results

We evaluate our method on top-down grasping for three sets of 15 objects.

Methods incorporating RGB outperform or perform similarly to the baseline in both isolated object grasping and grasping in clutter.

<table>
<thead>
<tr>
<th>Method</th>
<th>Opaque</th>
<th>Transparent</th>
<th>Specular</th>
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<tr>
<td>FC-GQCNN*</td>
<td>0.92 ± 0.06</td>
<td>0.40 ± 0.08</td>
<td>0.48 ± 0.17</td>
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<tr>
<td>RGB-ST¹</td>
<td>0.94 ± 0.04</td>
<td>0.77 ± 0.09</td>
<td>0.71 ± 0.04</td>
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<tr>
<td>RGBD-ST¹</td>
<td>0.91 ± 0.06</td>
<td>0.77 ± 0.08</td>
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<td>RGBD-M¹</td>
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<td>0.91 ± 0.05</td>
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</table>

*Trained on simulated grasps ¹Trained on simulated grasps and opaque object images

TABLE II: Grasping in clutter, averaged over five trials

<table>
<thead>
<tr>
<th>Method</th>
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<tr>
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<td>0.80 ± 0.09</td>
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<tr>
<td>RGBD-M¹</td>
<td>0.97 ± 0.15</td>
<td>0.61 ± 0.02</td>
<td>0.63 ± 0.12</td>
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</table>

*Trained on simulated grasps ¹Trained on simulated grasps and opaque object images

Acknowledgements

This work was supported by the National Science Foundation Smart and Autonomous Systems Program (IIS-1849154), the Sony Corporation, the Office of Naval Research (N00014-18-1-2775), the NSF Graduate Research Fellowship Program (DGE-1745016), the Efort Intelligent Equipment Company, and ShanghaiTech University, and CMU GSA/Provost Gush Funds. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the ONR and NSF.
Forms of Work

“I think it’s tempting to look purely at the number of commits or number of lines of code that you added, and that’s a good metric sometimes. But for us it’s more been about who’s pulling our weight in terms of what we actually wanted to achieve.” (P8)
Overview

- Missing data can compromise statistical inference, thus hindering downstream network analysis.
- Existing methods assume how the data are missing is either independent from the observed variables or depends on some variables which do not have missing values.
- In biological data often how the data are missing is dependent on some variables which have missing values. This paradigm results in Missing Not at Random (MNAR) data.
- Traditional missing data methods have been shown to produce biased estimates for MNAR data, which are passed on to causal network analysis.
- All Terrain graph-learner-CPC (ATG-CPC) learns causal graphs from MNAR data. ATG-CPC uses all of the observed data to directly impute causal edges.
- Using simulated data we show ATG-CPC to be an effective tool for recovering causal graphs masked by MNAR values.

ATG-CPC Method

- ATG-CPC extends the conservative PC (CPC) based causal graph learning algorithm for MNAR datasets.
- The key to our approach is learning and applying a conditional independence test transformation to calculate sample size adjusted conditional independence p-values for every potential edge.

Edge Adjacency Accuracy

We evaluated the ability of ATG-CPC and other missing data approaches to learn causal graphs using 480 simulated datasets. We generated these simulated datasets from 20 different ground truth directed graph topologies using the Lee and Hastie simulation method as implemented in Tetrad VI.

On 480 simulated MNAR datasets ATG-CPC achieves a 2.3 - 6.3% higher recall and 1.0 - 4.0% higher F1 score than vanilla CPC after pre-processing with missing data methods.

Edge Direction Accuracy

- ATG-CPC has a 4.2 - 19.5 lower Structural Hamming Distance than the other evaluated missing data methods.

Conclusion

ATG-CPC is a novel causal learning algorithm which can accurately learn from incomplete data.

- ATG-CPC significantly improves upon existing methods to identify causal models from MNAR continuous data, by increasing recall without sacrificing precision.
- One very promising application domain for this is scRNA-seq data.
- We suspect that applying ATG-CPC to MNAR biological data will result in more accurate network analysis, causal insights, and novel biological discoveries.

Funding

- Funding towards this research was provided by NIH T32 training grant T32 EB009403 as part of the HHMI-NIBIB Interfaces Initiative.
- Funding to attend this conference was provided by CMU GSA/Provost Conference Funding.

References

The Laplacian in RL: Learning Representations with Efficient Approximations

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Motivation

Learning state representations in RL:
- State representations can affect:
  - Reward shaping.
  - Exploration.
  - ... 
- Raw representations may be suboptimal.

Desired property of learned representations:
- Distances between state representations roughly correspond to the ability of the agent to reach one state from another.

Goal:
Learn useful representations from interactions with the environment without any reward information.

Laplacian based Representations

Graph Laplacian:
- Graph adjacency matrix \( W \).
- Diagonal degree matrix \( D \).
- Laplacian \( L = D - W \).

Getting representations:
- Take the \( d \) eigenvectors corresponding to the smallest eigenvalues of \( L \).
- Stack these eigenvectors as columns of a matrix.
- Each row of the matrix is a \( d \) dimensional representation of a node in the graph.
- Have been used in graph visualization [1] and spectral clustering [5].

RL environment as a graph:
nodes — states, edges — transitions.

Method

An optimization view of finding the first \( d \) eigenvectors (subject to rotations) of the Laplacian:

\[
\min_{X \in \mathbb{R}^{n \times d}} \sum_{i,j} W_{ij} \| X_i - X_j \|_2^2 \quad \text{s.t.} \quad X^T X = I_d. 
\]

Turning the hard orthonormality constraint into a penalty:

\[
\min_{X \in \mathbb{R}^{n \times d}} \sum_{i,j} W_{ij} \| X_i - X_j \|_2^2 + \beta \| X^T X - I_d \|_F^2.
\]

Generalized to the reinforcement learning context with (possibly) continuous state space:

\[
\min_{\phi} \mathbb{E}_{\omega \sim \rho, \omega \sim P^*} \left[ \| \phi(u) - \phi(v) \|_2^2 + \beta \mathbb{E}_{\omega \sim P^*} \left[ (\phi(u)^T \phi(v))^2 - \| \phi(u) \|_2^2 - \| \phi(v) \|_2^2 \right] \right],
\]

where \( \phi \) is the representation mapping to be learned, \( \rho \) and \( P^* \) are the stationary and the transition distributions given a policy \( \pi \).

(2) is optimizable by minibatch stochastic gradient descent with samples from the agent’s experience.

Experiments — Quality of Approximations

We evaluate the gap between our learned representations and the ground truth eigenvectors in terms of the objective (1) in a Four-Room Gridworld environment.


Contributions

- Existing work on applying the Laplacian framework to RL [2, 3, 4]:
  - Only justified in tabular cases.
  - Not scalable.
  - Lack of quantitative evaluation in RL.
- We propose a general framework for learning Laplacian based representations in RL:
  - Works with both discrete and continuous state spaces.
  - Efficiently trainable by SGD.
  - Significantly improves the performance of an RL agent when the learned representations are applied to reward shaping.

Experiments — Reward Shaping

Goal Achieving tasks:
- State space \( S \), goal space \( Z \) (\( S \) and \( Z \) are possibly equal).
- A goal vector \( z_g \in Z \).
- Known function \( h : S \rightarrow Z \) that maps any state \( s \in S \) to a goal vector \( h(s) \in Z \).
- Learning objective: a policy that controls the agent to get to some state \( s \) such that \( \| h(s) - z_g \| \leq \epsilon \).

Learned embedding based reward shaping:
- If \( S = Z \), let \( r_1 = -\| \phi(s+1) - \phi(z_g) \| \).
- If \( S \neq Z \), (i) learn an embedding of \( S \) and let \( r_1 = -\| \phi(s+1) - \phi(h^{-1}(z_g)) \| \) or (ii) learning an embedding of \( Z \) and let \( r_1 = -\| \phi(h(s+1)) - \phi(z_g) \| \).
- Better performance when half-half mixed with the sparse reward \( r_2 = -\| h(s+1) - z_g \| > \epsilon \).

GridWorld:
Mujoco control navigation:

References

Algorithms are increasingly being deployed in public settings, often without knowledge, understanding, or input of the public. These deployments can often have positive effects on citizens, such as increasing traffic through CRMS, game-theoretic control of traffic lights, but can also be a source of concern or controversy (e.g., use of crime data for predictive policing, or risk assessment).

This project aims to bring broader awareness and spark discussion on these systems, and invite public opinion on what technologies serve their interests, and how technology should be governed in their own communities.

Explore more local algorithms at mappingthemachine.com