CS498 Computational Advertising

Ram Sundaram
Associate Professor (CS, ADV)

no technology usage policy

such use negatively impacts you and your p

Faria Sana, Tina Weston, Nicholas J. Cepeda, Laptop multitasking hinders classroom learning for both users and nearby peers, Computers & Education, Volume 62, 2013, Pages 24–31.

Susan M. Ravizza and Mitchell G. Uitvlugt and Kimberly M. Fenn, Logged In and Zoned Out: How Laptop Internet Use Relates to Classroom Learning, Psychological Science, 28(2):171–180, 2017. PMID: 28182528.

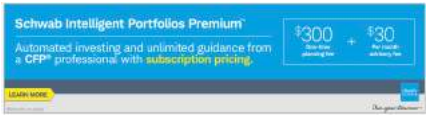
The landscape of advertising has changed dramatically

Coke commercial. –1971

https://www.youtube.com/watch?v=2msbfN81Gm0

Let's fast-forward to today

Charles Schwab bought this ad in a real-time auction



How did Charles Schwab know that it was **me**?

That I would be **receptive**?

That I would **click** on the ad?

How much to **bid**?

This is the world of computational advertising!

Google and Facebook are dominant players
critical decisions are made by algorithms

This is an **exciting** time to be in computational advertising, as there is plenty of uncharted territory; the area is ripe to support **new entrepreneurial ideas**

New CS+ADV major

get in touch with your academic advisor about transfers.

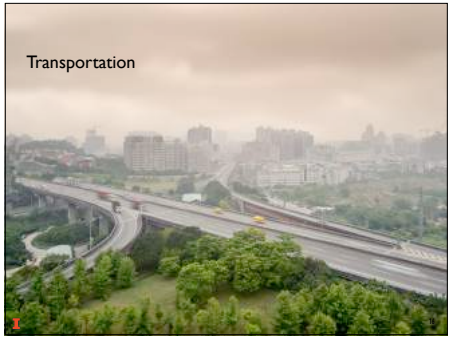
"The best minds of my generation are thinking about how to make people click ads."

Jeff Hammerbacher

CS498 Objective:

"The best minds of my generation are thinking critically about ~~how to make people click~~ ads."

a brief introduction to my research

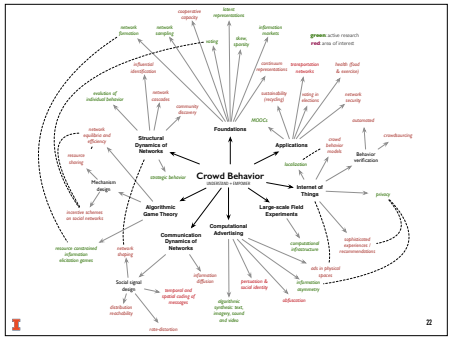


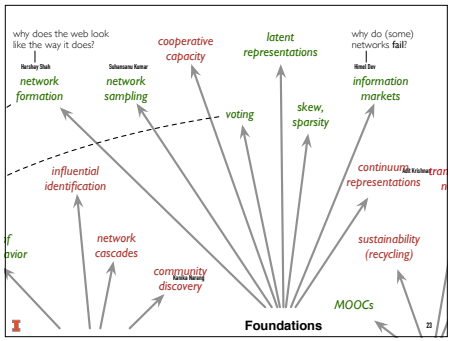
How do we **persuade millions** to adopt behaviors beneficial to them, and to society at large?

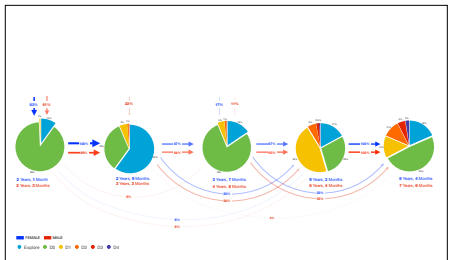
How do we reconcile an individual's **desire for agency** and choice in what they do, with what **everyone wants for society as a whole**?

My research lies at the intersection of **networks** and **computational advertising**.

The **goal**: to **understand** human behavior at scale and to **empower** better individual decisions.

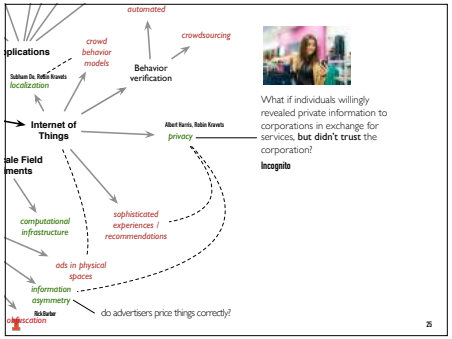






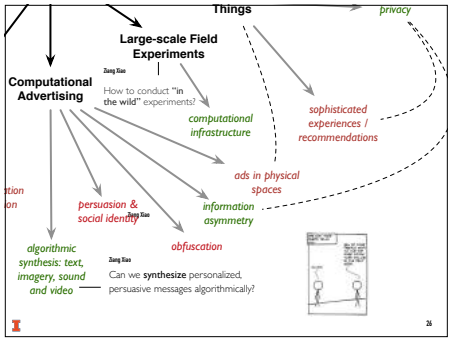
how do individuals evolve?

applications to journey optimization



What if individuals willingly revealed private information to corporations in exchange for services, **but didn't trust** the corporation?

Incognito



If you are interested in my research, drop me an email! I'll be happy to meet

Logistics

Course information:

Website: https://wiki.illinois.edu/wiki/display/CS498HS4FA19/

Piazza signup: piazza.com/illinois/fall2019/cs498hs


TA's: Subham De (de5), Aravind Sankar (asankar3)
office hours: Fridays 3-4pm 2113 Siebel Center

Prof. Sundaram's office hours: 4-5pm, Wednesdays, 2126 Siebel Center

Class components

3 credit
- HW = 90% (6 assignments)
- In class presentation: 5%
- class participation: 5%
- Extra credit final project: 5%

4 credit
- HW scaled to weigh 60%
- In class presentation: 5%
- class participation: 5%
- final project: 30%

Individual assignments

HW's (90%)

Each HW is related to the topic taught in the previous two weeks

Goal: understand a key concept / algorithm

will have a written and a coding part

10 min + 5 min Q&A

typically on Fridays

In-class presentations (5%)

group work

pick a company in the comp-ad space; describe the advertising business model;

what is the product, what is the value proposition? who are the customers?

who are the competitors? what are the weaknesses?

example presentations on wiki

presentation group formation

groups of at most 3 people

we will randomly form groups for in-class presentation

email will be sent on 09/09

class participation (5%)

students evaluate all peer presentations

3 positives

1 suggestion for improvement

Final project

4 credit

3 credit

(5% bonus or 30%)

Goal: exposure to non-trivial aspects of comp-adv

Two different project ideas:

- Location based advertising
- Advertising recommendation

mid-term checkpoint

final presentation

final report

expect that best projects be submitted to conferences

final project group formation

groups of at most 3 people

you form groups

3 credit and 4 credit students cannot be in the same group

The group gets a **common** grade for the work

MP's are individual assignments
groups are for
presentations and
final project

Will grade undergrads and grads on the **same** curve—there is no difference in performance.

will grade on a curve

Cutoff	Grade
Top 1%	A+
next 24%	A
next 25%	A-
next 50%	depends on the empirical distribution

your absolute scores don't matter*

What if you find that your partners are free-riding? or if you have a free-rider?

Give two weeks notice, **before** the assignment is due, to your partners, that you are leaving.

Inform the TA's that you are leaving this group

Then, you will work by yourself,
and the remainder of your group
will submit separately

You cannot form a new group, or join another

academic integrity

zero tolerance policy!

since the grades are determined on a curve, academic dishonesty affects other students' grades

---

You are encouraged to form a study group to discuss the homework and the programming assignments but are expected to compete the homework and programming assignments **completely on your own, without recourse to notes from the group discussions**.

CS Honor code http://www.cs.uiuc.edu/academics/honor-code

Plagiarism: It is an academic violation to copy, to include text from other sources, including online sources, without proper citation.

CS Honor code http://www.cs.uiuc.edu/academics/honor-code

Any student found to be violating this code will be subject to **disciplinary** action.

CS Honor code http://www.cs.uiuc.edu/academics/honor-code

Computational advertising: a **brief** tour



Introduction Web search Game Theory Auctions

Outline



Data flows Display Ads

Recommender systems

Behavioral targeting

Emerging areas

Final Presentations

Computational advertising: a **new** discipline

A new scientific sub-discipline, bringing together
- Information retrieval
- Machine learning
- Economics and Game theory
- Computer Systems

Advertising is a market where each side cares about the **type** of the other side

Advertisers want the attention of certain people

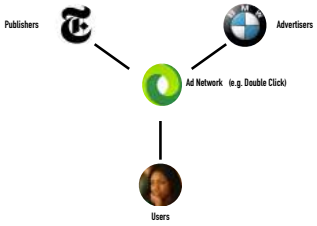
People are only open to certain ads (whether or not in the market for the advertised good)

A key challenge:

Find the "best match" between a given user in a given context and a suitable advertisement.

web search;
publisher page
(e.g. NY Times);
mobile; billboard
etc.

key actors



Computational advertising **is** the new oil

Alphabet Q2 report, 2018

Revenues

The following table presents our revenues, by segment and revenue source (in millions, unaudited):

	Three Months Ended June 30,		Six Months Ended June 30,	
	2017	2018	2017	2018
Google segment				
Google properties revenues	$ 18,425	$ 23,262	$ 35,828	$ 45,260
Google Network Members' properties revenues	4,247	4,825	8,255	9,469
Google advertising revenues	22,672	28,087	44,083	54,729
Google other revenues	3,241	4,425	6,448	8,779
Google segment revenues	25,913	32,512	50,531	63,508
Other Bets				
Other Bets revenues	97	145	229	295
Revenues	$ 26,010	$ 32,657	$ 50,760	$ 63,803

Google's ad revenue is 86% of total

For Facebook, this is 97%

Advertising is the primary mechanism that sustains "free" online services and content

should content be free?

There are huge privacy implications too

June 1994: Netscape makes a cookie

at each website, we leave a digital **trail** of our activities

Is all or nothing the **only** option?

we don't have fine grained control

despite the cookie being created nearly **25** years ago, we've only started

Over the past 10 years, traditional advertising agencies are consolidating, and are transforming themselves

how do we get here?

should we?

Ads on the web are not as compelling as the ones in glossy magazines

we don't yet understand how to synthesize, personalized, compelling ads on the fly

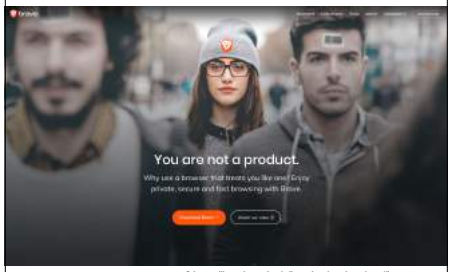
today, we are **exchanging** our privacy for free services

does it have to be that way?

but didn't trust the corporation that we revealed it to?

incognito
hari sundaram & robin kravets

is it possible to hide?



Privacy, will remain a major challenge for a long time https://brave.com

Why computational advertising?

Classic advertising has a rich history


branding

create a distinct favorable image

to drive sales

Classical.

- Relatively few venues – magazines, billboards, newspapers, handbills, TV, etc.
- High cost per venue (e.g., $3M for a Super Bowl TV ad)
- Limited personalization possible
- Targeting by the wisdom of ad-people
- Hard to measure ROI

"Half the money I spend on advertising is wasted; the trouble is, I don't know which half."

John Wanamaker (1838-1922)

why go computational?

Computational – almost the exact opposite:

- Billions of opportunities
- Billions of creatives
- Totally personalized
- Tiny cost per opportunity
- Much more quantifiable

Decomposing the challenge:

Find the "best match" between a given user in a given context and a suitable advertisement.

web search; publisher page (e.g NYTimes); mobile; billboard etc.

related challenges

Design markets and exchanges that help in this task, and maximize value for users, advertisers, and publishers

Build the infrastructure to support this process

Decomposing the challenge:

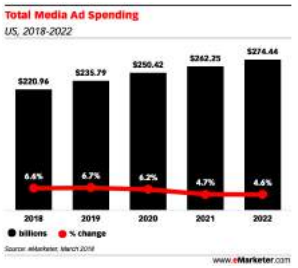
Find the "best match" between a given user in a given context and a suitable advertisement.

Represent the user, the context, and the ads in an effective & efficient way

Solve the optimization problem in an effective & efficient way

Define the mathematical optimization problem to capture the actual marketplace constraints and goals

The landscape



77

Average Daily Time Spent with Media Among US Consumers, 2014-2020

minutes

	2014	2015	2016	2017	2018	2019	2020
TV	**297.8**	**289.0**	**287.4**	**282.1**	**276.8**	**271.5**	**266.2**
Internet	**154.9**	**180.0**	**189.0**	**217.0**	**239.9**	**265.2**	**274.0**
—Mobile*	88.1	124.0	136.0	164.0	187.9	214.2	223.0
—Desktop	66.9	56.0	53.0	53.0	52.0	51.0	51.0
Radio	**111.0**	**109.0**	**104.5**	**102.0**	**100.0**	**99.0**	**97.3**
Magazines	**19.6**	**18.6**	**17.6**	**16.5**	**15.2**	**14.0**	**12.7**
Newspapers	**19.6**	**17.0**	**15.0**	**14.0**	**12.4**	**11.0**	**9.5**

*Note: *includes browsers and apps*
Source: comScore Inc., Media Dynamics Inc., Nielsen, Nielsen Audio and Zenith forecasts as cited in Zenith, "Media Consumption Forecasts 2018," May 29, 2018

239561 www.eMarketer.com

78

CPM = cost per millie (thousand impressions)
- Typically used for graphical/banner ads (brand advertising)
- Could be paid in advance ("Guaranteed delivery")

CPC = cost per click
- Typically used for textual ads

(some) terminology

CPT/CPA = cost per transaction/action
a.k.a. referral fees or affiliate fees
- Typically used for shopping ("buy from our sponsors"), travel, etc.
- But now also used for textual ads (risk mitigation)

we'll introduce additional terminology as needed

79

Ads driven by search keywords = "sponsored search" (a.k.a. "keyword driven ads", "paid search", "adwords", etc)

Advertiser chooses a "bid phrase" = query on which to display

textual ads

Can also subscribe to "advanced match" (display ad on related queries)
- Needed to achieve volume
- Huge challenge

Ads driven by the content of a web page—"content match" (a.k.a. "context driven ads", "contextual ads", "adsense", etc)

80

text ads: a brief history

Late 1990s, Alta Vista tried the Sponsored Search model
- Rejected by the early search engine users

Goto.com (acquired later by Overture) develops a search engine for paid ads
- Users with commercial interest go to this engine
- At the peak, a billion dollar business

Google tries the Sponsored Search model again
- This time a success

Advertisers cannot get enough volume
- Content match to provide more impressions

Two types of online graphical advertising
- Guaranteed delivery (GD)
- Performance graphical advertising (non-guaranteed delivery, NGD)

display ads

Guaranteed delivery (GD)
- Contract booked based on targeting attributes of an impression: age, income, location, …
- Each contract has a duration and a desired number of impressions

Issues in GD
- Contract pricing
- Traffic forecasting
- Impression allocation to the active contracts

Graphical ads can also be placed based on performance -- CPM/CPC/CPA

Assume that the Optimization Problem is to maximize CTR

Ads represented by achieved CTR/page + weights

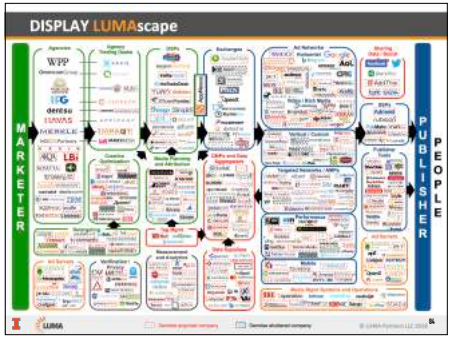
Matching approaches:

1. Reactive: explore the placement of a particular ad on different pages; for each page observe achieved CTR; once the CTRs are learned, given page, pick the ad with highest observed CTR
2. Predictive: generate features for the ad using related ads (same advertiser), landing page, or advertiser metadata -- predict performance based on page and ad features

display ads

Hybrid: (1) and (2) are complementary and can be combined

Ads (pages) represented by features of ads (pages) + weights

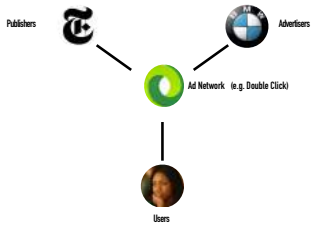


A preview of the next few lectures

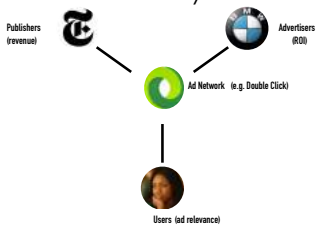
A key challenge:

Find the "best match" between a given user in a given context and a suitable advertisement.

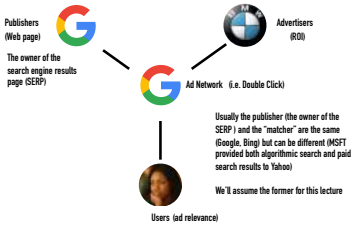
key actors



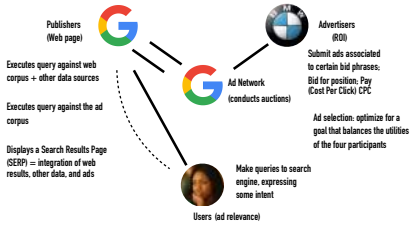
each actor has a different utility function



Sponsored Search



Sponsored Search



Billions of individual ads in sponsored search and content match

Billions of unique queries/millions of searches per hour

Trillions of page impressions (content match and graphical advertising)

Billions of users

scale and costs

Requests served while the user 'waits': no more than 100ms response time

Serving each requests require some CPU amount

Data usually needs to be in memory

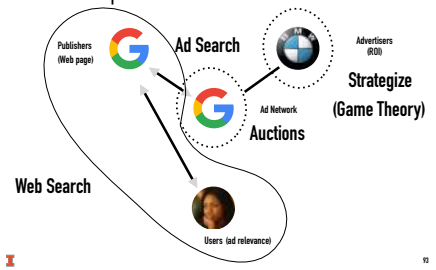
Per-request cost needs to be lower than the serving cost Low CTR make this a challenging problem

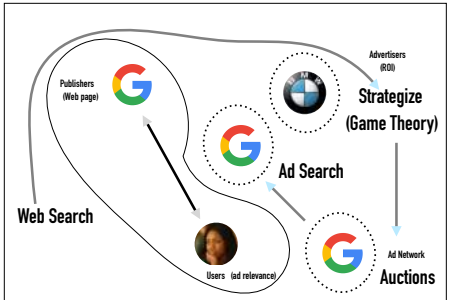
Search Engine perspective

Three problems

1. Ad retrieval (match to query/context) — Information Retrieval
2. Ordering the ads — Economics / AGT
3. Pricing on a click-through — Economics / AGT

Sponsored Search





Goal: Find the "best match" between a given user in a given context and a suitable advertisement.

Represent the user, the context, and the ads in an effective & efficient way

Define the mathematical optimization problem to capture the actual marketplace constraints and goals

Solve the optimization problem in an effective & efficient way

advertising is the fuel for the new internet economy

Advertising is a form of information.

Finding the "best ad" is often a type of information retrieval problem with multiple, possibly contradictory utility functions

Summary

The landscape of computational advertising is changing rapidly

Tremendous opportunity to innovate

market design and system infrastructure are also key

won't spend much time on this