Modeling Consumer Search for Making Online Advertising Decisions

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Outline

- Online Advertising
  - Background
  - Search Advertising
- Search Advertising
- Consumer Search
- Conclusions

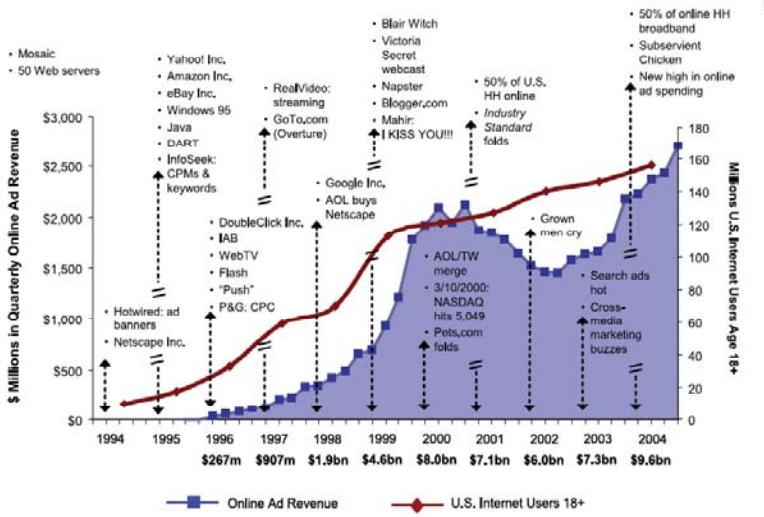
Online Advertising

Industry Background

The first banner ad in 1994

AT&T paid HotWired to display the above banner ad on October 25, 1994

A Brief History of Online Advertising



Source: The Decade in Advertising, DoubleClick (2005), Figure 2

Internet Advertising is Growing!

Medium	2003E Advertising Spending ($B)	Households (MM)	Ad Spending / Household ($)
Promotions	$97	99	$976
Newspapers	45	50	898
Classifieds	*15*	*55*	*289*
Direct Telephone	85	99	863
Direct Mail	48	99	483
Broadcast TV	43	99	429
Radio	20	60	328
Cable TV	16	70	226
Yellow Pages	14	99	146
Internet / Online	**7**	**60**	**120**
Total	$374	735	$4,469
Average	42	82	497

Online Advertising in 2008

US Online and Total Media Advertising Spending, 2006-2012 (billions and % of total media spending)

	Online	Total media	Online % of total media
2006	$16.9	$281.6	6.0%
2007	$21.1	$283.9	7.4%
2008	$25.9	$293.3	8.8%
2009	$30.0	$299.0	10.0%
2010	$35.0	$307.0	11.4%
2011	$41.0	$316.0	13.0%
2012	$51.0	$332.0	15.4%

Source: eMarketer, March 2008

093021 www.eMarketer.com

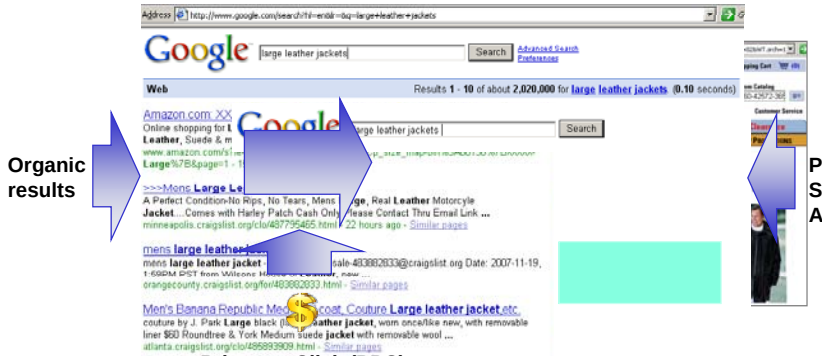
Source; eMarketer, March 2008

Dominant Players in Online Advertising

Google	YAHOO! SEARCH	MSN/Live
• The de facto leader: biggest advertising network. • Search ads product is called Google Adwords • Content ads product is Google Adsense	• The number 2 player. • Search ads product is Yahoo! Search Marketing (YSM) • Content ads product is Yahoo! Publisher Network (YPN)	• Up-and-coming player. • Search ads product is MSN AdCenter Search • Content ads product is MSN ContentAds

Search Advertising

Paid Search Advertising



How does Search Advertising Work?

- Advertisers (directly or through a SEM firm) buy a set of keywords (the keywords typed in by users of a search engine) by allocating a total budget & a max.bid for each keyword. *e.g. Apple buying "Jay Leno" keyword from Google using AdWords.*
- When a user types/searches for "Jay Leno" in Google, an automatic auction will take place: the highest bidder will have its ad shown in the result page.

AdWords Pricing

- Google assigns a quality score based on keywords selected by advertiser.
  - Quality score depends on keyword's CTR, relevance of ad text, historical keyword performance, and other relevancy factors
  - Higher quality score = lower minimum bid and costs.
- The higher the rank number, the higher the position of the ad.
  - Calculated in part by multiplying keyword's max. CPC times its Quality Score.
  - Every time your ad is
- Advertising price is determined by Auction Market.
- If your maximum bid is less than the minimum rate needed to trigger an ad, you either need to raise your bid or refine your key words.
  - You can set a maximum bid that Google will never exceed.
  - You can set a daily budget. Google will adjust ad frequency based on this budget.

Sample AdWords Console from Google

Summary

Jan 1, 2007 to Jan 22, 2007 ▸Change range

Ad Networks	Status	Current Bid Max CPC	Clicks	Impr.	CTR	Avg. CPC	Cost	Avg. Pos
Google + search network	Enabled	Default $0.33 [edit]	0	97	0.00%	-	-	18.9
Content network	Disabled		0	0	-	-	-	-
Total			0	97	0.00%	-	-	-

Keywords

+ Add keywords: Quick add | Keyword tool Edit Keywords | Search this list

Edit Keyword Settings | Delete 1 - 15 of 15 keywords.

Keyword	Status	Current Bid Max CPC	Clicks ▾	Impr.	CTR	Avg. CPC	Cost	Avg. Pos
Total	Enabled	Default $0.33 [edit]	0	97	0.00%	-	-	18.9
"contextual advertising"	Active	$0.33	0	42	0.00%	-	-	31.3
"CPA advertising"	Active	$0.33	0	32	0.00%	-	-	11.3
"cost-per-action advertising"	Active	$0.33	0	9	0.00%	-	-	12.0

More on Search Advertising

- In practice, Google also adds its own algorithm to ensure that the ad is most relevant to the keyword, and to determine the order/position of the ads (who goes first, second, etc). How?
  - CPM (Cost per Milieu) = cost per thousand impression/click
  - Clickthrough Rate (CTR)
  - Other factors
- Terms to know: Searches/Queries, Clicks, CTR, Cost-per-Click, Conversion Rate, PPC (Pay-per-Click)...

Google's Adsense allows ads to be placed almost anywhere

Monday, September [illegible], 2006

Platform War at the Digital Music Space

When I was working on the Microsoft-sponsored project with **CMU School of Design** last Spring, our instructor **Shelley Evenson** brought in a guest speaker to talk about his design consulting assignments. His most recent task was to advise Samsung on how to create a product as successful as the Apple iPod. He made a point about their MP3 players being loaded with too much features, but the other thing he really nailed was that Apple is successful in not only creating a product *per se*, but also an entire **platform** - or ecosystem, if you will - in which that product lives. So it's not just iPod the MP3 player, it is also iTunes the application on the desktop and the online music store. In other words, the iPod is "vertically integrated".

By now all the major players aspiring to catch up have bought this idea. Microsoft Zune is going to be vertically integrated the same way, **bloggers say**. Others, perhaps sensing that Microsoft is not going to let Zune get songs from sources other than their own, began making counter-moves. RealNetworks Rhapsody & SanDisk Sansa **linked up** just today, Samsung and MusicNet **did too** earlier. Meanwhile, **Nokia bought Loudcyc** to inject music into mobile phones. **Napster** has fallen behind and publicly stated it is now actively seeking for a partner.

The platform war is somewhat reminiscent of the Windows vs. Apple OS of the past - only this time, Apple has the upper hand. Whether consumers will embrace more than one major digital music platform remains to be seen.

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Privacy Information

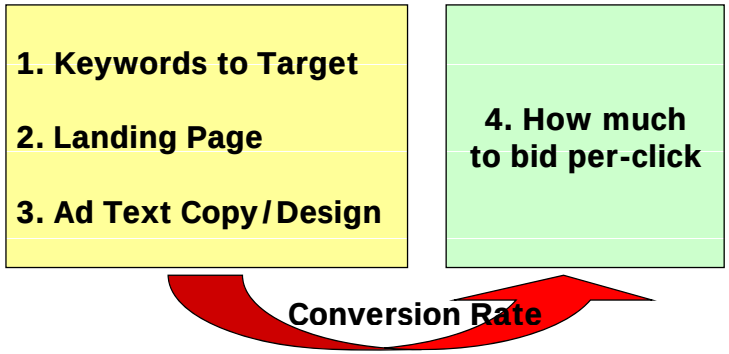
Contextual Ads

- Google: Since we let advertisers put ads on our search results pages, why not create a solution for advertiser to put ads on other websites? Result = AdSense. Advertisers subscribed to AdWords have the option to sign up for AdSense.
- Adsense is not keyword-based. AdSense must "sense" the context of a specific website in order to determine what ads to show. How?
  - Text content, images meta-data, URL, etc. etc.
- In AdSense, I get paid a commission everytime visitors to my site clicks on the Google ads on my website.
  - Arbitrage opportunity: clickfraud problem – I can click on the ads on my website and get paid for it.
  - Some solutions: CPA (Cost-per-Action) model

Purchase Conversion Prediction

Keywords to Target

Advertising Decisions



Simple, Naïve Approach

- Enumerate keywords and experiment
  - Google can suggest keywords
  - Check organic keywords
  - Look at competitors search terms
  - Use a search engine optimizer
- Problems:
  - Many keywords have sparse responses, (ex., one click for "Embroidered Harley Jacket with Diamonds")
  - May miss good keywords ("Lether jacket") or reject marginal ones too soon (0 out of 10 clicks for one week)
  - Experimentation is Expensive

Generating Keywords

- Exploit the long-tails in keyword search
  - "massage" costs $5 per click
  - "lomilomi massage" costs $.20 per click
  - "traditional hawaiian massage" costs $.05 per click
- Some automated approaches:
  - Google's Adword Tool looks for past queries that contain the search terms
  - Proximity based methods: query search engine for seed keyword and then append it with words near it. (Cannot generate keywords that do not contain original term.)
  - WordTracker: use meta-tag spidering
  - TermsNet: exploit semantic relationships
  - Wordy: Look for relevant keywords that might be cheaper

Expert Approach

- Classify keywords by type and use historical data to estimate conversion models
- Example:
  - "coats" → Generic search
  - "large leather jackets" → Size, Type
  - "Gap leather coat" → Brand, Type
  - "Black Izod Lambskin Leather" → Color, Brand, Type
  - "WilsonsLeather.com" → Web address
- Important attributes: Brand, Size, Color, Price, ... Looking for attributes that connote specificity

Modeling our Expert Approach

- Text Classification Model for Search Strings:

  C: "search string" for site s and visit $i \rightarrow \mathbf{x}_{si}$

- Hierarchical Logistic Regression to Predict Purchase Conversion:

$$\text{logit}\{\Pr(convert_{si})\} = \boldsymbol{\beta}_s' \mathbf{x}_{si}$$

$$\boldsymbol{\beta}_s = Z_s \boldsymbol{\theta} + \mathbf{u}_s$$

Allows us to score arbitrary keywords and predict conversion, Hierarchical nature allows us to borrow information across sites

Expert Approach Example

- Suppose a consumer searches for:

  "large Wilsons leather jacket"
- We can identify the following components and they relative contributions to the odds ratio:

  "large" -> Size +10% on log odds

  "Wilsons" -> Brand +50% on log odds

  "leather jacket" -> Base Conversion of 1%
- Predicted overall conversion rate: 2%

Expert Approach Summary

- Advantages:
  - Robust to many sites within a category
  - Much better forecasts for infrequent words
  - Could be used to predict new sites that are similar
- Disadvantages:
  - Requires expert to create categories
  - Which can be slow and costly
  - Careful attention to how words are categorized

Machine Learning Approach

- Define a language model for search queries. Alternative generate a sample of search results for each string, and use this sample of results to define term-document approach, and use vector-space representation of search.

$$\text{"search string"} \rightarrow \{\mathbf{r}_{si1}, \mathbf{r}_{si2}, \ldots, \mathbf{r}_{siM}\}$$

$$V: \{\mathbf{r}_{si1}, \mathbf{r}_{si2}, \ldots, \mathbf{r}_{siM}\} \rightarrow \boldsymbol{\gamma}_{si}$$

- Many choices for our dimension reduction function V, principal component, clustering, LSI, ... We can use the search string representation in this new space in our logistic regression model.

Problem: Statistical properties of the sampling process

Machine Learning Example

- Extract words frequently associated with "large Wilsons leather jacket" using a search engine (top 100 matches)
  - Vocabulary: "leather", "jacket", "wilsons", "outerwear", "distressed", "black", "handbags", "men", "women", "apparel", "medium", "price", ...
  - Words are weighted by frequency
- Compare this phrase with others for similarity. For example "large leather jacket"
  - Vocabulary for "large leather jacket": "leather", "jacket", "clothing", "style", "fashion", "coats", "Men", "women", "classy", "comfortable", "prices", "discounted", "parkas", "luggage", ...
- Find that "large Wilsons leather jacket" is more similar to "Wilsons leather jacket" than "big red leather jacket"

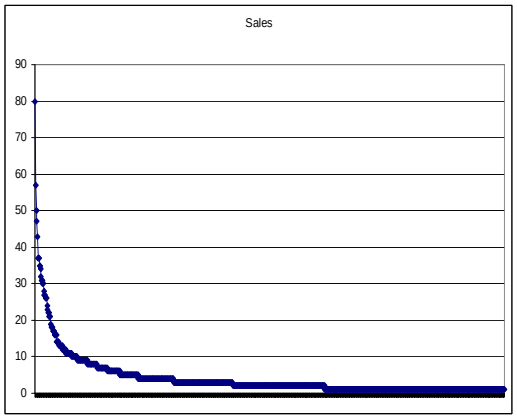
Machine Learning Approach Summary

- Advantages:
  - Automated and does not require human expert to categorize
  - Can be replicated over large number of sites
  - Yields similar accuracy to expert approach
- Disadvantages:
  - Training is computational intensive and more complex
  - Statistical properties of query expansions not well understood
  - Does not take advantage of natural language structure

Empirical Application

Keyword Conversion

- ~15,000 purchases
- ~3,000 keywords
- ~5 purchases per keyword, but highly skewed as well
- 2,175 (71%) keywords don't generate any sales
- The top 10 keywords attract 10,292 (72%) sales



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Predictions

Expert

Actual \ Predicted	No Conversion	Conversion	
No Conversion	27430	10693	93%
Conversion	539	2298	7%
	68%	32%	40960

Overall Accuracy **73%**

ML Approach

Actual \ Predicted	No Conversion	Conversion	
No Conversion	26348	11775	93%
Conversion	505	2332	7%
	66%	34%	40960

Overall Accuracy **70%**

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Conclusions

Online Advertising

- Search advertising has arisen as a dominate form of online advertising
- Presented an approach for predicting purchase conversion before any keyword bid is made by using experience with past keyword bids
- Next steps:
  - Need to generalize to all facets of search engine marketing (landing pages, advertising text)
  - Relate to previous searches, understand general to specific searching