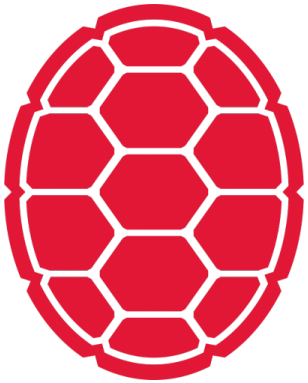


Introduction to Machine Learning

Machine Learning: Jordan Boyd-Graber
University of Maryland
FEATURE ENGINEERING

Content Questions

Announcements

- HW1 Turned in
- HW2 Due on Friday
- HW3 Due in two weeks (up now)

Administrivia Questions

Administrivia Questions

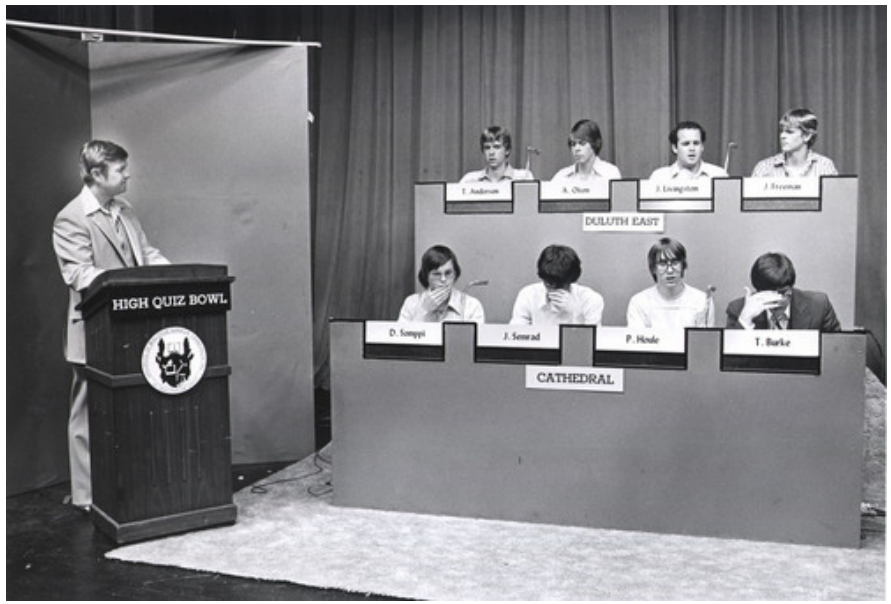
Administrivia Questions

Example of Feature Engineering

- Talk about problem domain: quiz bowl
- Brainstorm features
- Similar to HW3
- Need to get to airport . . .

Humans doing Incremental Classification

- Game called “quiz bowl”
- Two teams play each other
  - Moderator reads a question
  - When a team knows the answer, they signal (“buzz” in)
  - If right, they get points; otherwise, rest of the question is read to the other team
- Hundreds of teams in the US alone



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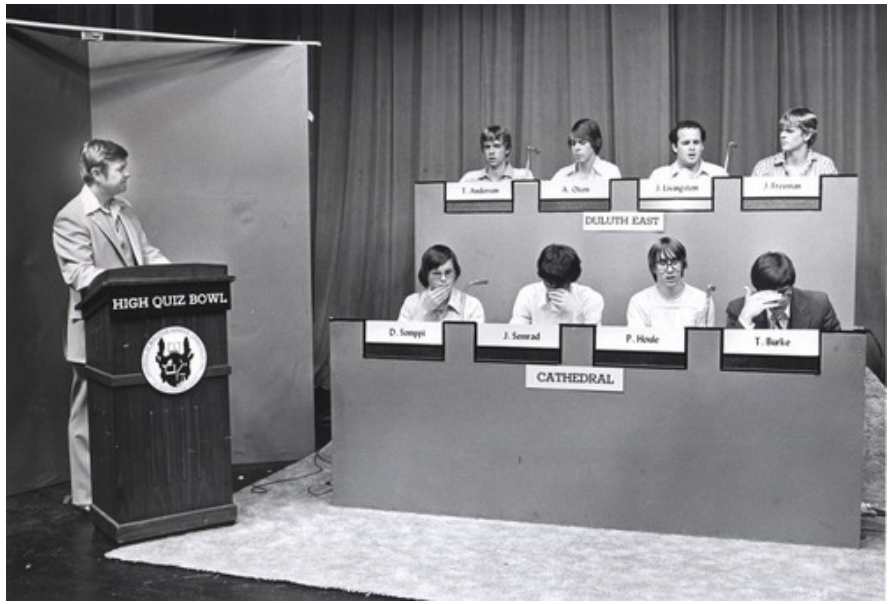
- Example . . .



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Albert Einstein

Humans doing Incremental Classification

- This is **not** Jeopardy (Watson)
- There are buzzers, but players can only buzz at the end of a question
- Doesn't discriminate knowledge
- Quiz bowl questions are pyramidal

Feature Engineering

- Determining correct answer is a hard challenge (course project)
- Use same data to do classification
- Divided into specific categories
- Important to know which is which (e.g., might have different submodules to answer each category)

Top Features: Words

```
History          battles:efforts:pyramid:russia:byzantine:pre
Literature       poetic:jew:poet:poem:novel:poems:stories:lit
Social Science   holiday:ritual:zeus:psychological:economist:
Geography        built:nile:hill:square:fault:feature:mountai
Other            code:win:movies:strip:stanley:season:starrin
Biology          selection:enzyme:humans:chromosome:membrane:
Fine Arts        painter:canvas:composers:foreground:commissi
Physics          physical:vector:scattering:classical:quark:p
Chemistry        paradox:doubly:obtained:concentrations:molar
Mathematics      denoted:curve:algebraic:differential:polygon
Earth Science    areas:hot:discontinuity:earth:region:period:
Science          momentum:largest:contrasted:radiation:limit:
Astronomy        found:beyond:object:astronomer:constellation
```

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```
History          battles:efforts:pyramid:russia:byzantine:pre
Literature       poetic:jew:poet:poem:novel:poems:stories:lit
Social Science   holiday:ritual:zeus:psychological:economist:
Geography        built:nile:hill:square:fault:feature:mountai
Other            code:win:movies:strip:stanley:season:starrin
Biology          selection:enzyme:humans:chromosome:membrane:
Fine Arts        painter:canvas:composers:foreground:commissi
Physics          physical:vector:scattering:classical:quark:p
Chemistry        paradox:doubly:obtained:concentrations:molar
Mathematics      denoted:curve:algebraic:differential:polygon
Earth Science    areas:hot:discontinuity:earth:region:period:
Science          momentum:largest:contrasted:radiation:limit:
Astronomy        found:beyond:object:astronomer:constellation
```

Accuracy: 0.765

Top Features: Bigrams Only

```
History          who served:vice presidential:the election:ch
Literature       his novels:this literary:his plays:poem abou
Social Science   this economic:this anthropologist:of social:
Geography        this state:lake s:the nile:the oldest:was bu
Other            in 2005:this show:an oscar:comic strip:yr am
Biology          amino acid:syndrome and:the enzyme:the brain
Fine Arts        this composer:painter of:opera about:its com
Physics          formula for:a quantum:x rays:of matter:of pa
Chemistry        chemist who:is present:this chemist:tend to:
Mathematics      sub n:data structure:algorithm for:mathemati
Earth Science    its name:mohs hardness:above it:characterize
Science          this process:this number:reaction this:store
Astronomy        the solar:the universe:moon of:the milky:mil
```

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```
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Social Science   this economic:this anthropologist:of social:
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Other            in 2005:this show:an oscar:comic strip:yr am
Biology          amino acid:syndrome and:the enzyme:the brain
Fine Arts        this composer:painter of:opera about:its com
Physics          formula for:a quantum:x rays:of matter:of pa
Chemistry        chemist who:is present:this chemist:tend to:
Mathematics      sub n:data structure:algorithm for:mathemati
Earth Science    its name:mohs hardness:above it:characterize
Science          this process:this number:reaction this:store
Astronomy        the solar:the universe:moon of:the milky:mil
```

Accuracy: 0.800

Top Features: Trigrams Only

History	the battle of:name this leader:ftp what was:
Literature	identify this author:this short story:of the
Social Science	this deity s:name this economic:this thinker
Geography	name this largest:this state contains:this i
Other	on the album:name this film:this comic strip
Biology	disease of the:name this phylum:the producti
Fine Arts	of this painting:this composer of:of this op
Physics	**is** governed by:the standard model:name this
Chemistry	this doubly eponymous:the presence of:of org
Mathematics	name these mathematical:product of two:name
Earth Science	of the paleozoic:d double prime:of this mine
Science	**is** broken down:this compound s:the photoelec
Astronomy	a black hole:**in** the sky:of the universe:brig

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History          the battle of:name this leader:ftp what was:
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Chemistry        this doubly eponymous:the presence of:of org
Mathematics      name these mathematical:product of two:name
Earth Science    of the paleozoic:d double prime:of this mine
Science          is broken down:this compound s:the photoelec
Astronomy        a black hole:in the sky:of the universe:brig
```

Accuracy: 0.756

Top Features: Unigrams and Bigrams

History	khan:emperor:successor:occurred:minister:byz
Literature	play:poet:playwright:stories:author who:lite
Social Science	bull:economist:holiday:anthropologist:psycho
Geography	african:was built:bridge:red:sea:city s:this
Other	band:player:season:film:starring:team:oscar:
Biology	cellular:membrane:protein:cell:syndrome:chro
Fine Arts	composition:movement:painting:piano:painted:
Physics	matter:voltage:quark:physical:wavelength:phy
Chemistry	chemical:reacts:spectroscopy:ion:gases:molar
Mathematics	euler:matrix:curve:prime:mathematical:method
Earth Science	zone:forms:period:hot:mantle:boundary:discon
Science	largest:this protein:this number:an electron
Astronomy	found:object:galaxies:mass:distance:atmosphe

Top Features: Unigrams and Bigrams

```
History          khan:emperor:successor:occurred:minister:byz
Literature       play:poet:playwright:stories:author who:lite
Social Science   bull:economist:holiday:anthropologist:psycho
Geography        african:was built:bridge:red:sea:city s:this
Other            band:player:season:film:starring:team:oscar:
Biology          cellular:membrane:protein:cell:syndrome:chro
Fine Arts        composition:movement:painting:piano:painted:
Physics          matter:voltage:quark:physical:wavelength:phy
Chemistry        chemical:reacts:spectroscopy:ion:gases:molar
Mathematics      euler:matrix:curve:prime:mathematical:method
Earth Science    zone:forms:period:hot:mantle:boundary:discon
Science          largest:this protein:this number:an electron
Astronomy        found:object:galaxies:mass:distance:atmosphe
```

Accuracy: 0.803

Top Features: Unigrams, Bigrams, Trigrams

```
History          emperor:organized:occurred:russia:legislatic
Literature       play:poet:writer:playwright:literature:poems
Social Science   hindu:anthropologist:holiday:demand:economis
Geography        this river:of this river:was built:red:this
Other            team:player:film:code:movie:season:yr:oscar:
Biology          humans:syndrome:protein:cellular:gene:membra
Fine Arts        10 pointsname this:pointsname this:pointsnam
Physics          wavelength:materials:decay:material:voltage:
Chemistry        hydrogen:molecules:this equation:spectroscop
Mathematics      named after:problem:space:data:algebraic:met
Earth Science    zone:hot:boundary:areas:period:material:regi
Science          radiation:machine:momentum:this group:atom:s
Astronomy        supernova:telescope:mass:astronomical:radiat
```

Top Features: Unigrams, Bigrams, Trigrams

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History          emperor:organized:occurred:russia:legislatic
Literature       play:poet:writer:playwright:literature:poems
Social Science   hindu:anthropologist:holiday:demand:economis
Geography        this river:of this river:was built:red:this
Other            team:player:film:code:movie:season:yr:oscar:
Biology          humans:syndrome:protein:cellular:gene:membra
Fine Arts        10 pointsname this:pointsname this:pointsnam
Physics          wavelength:materials:decay:material:voltage:
Chemistry        hydrogen:molecules:this equation:spectroscop
Mathematics      named after:problem:space:data:algebraic:met
Earth Science    zone:hot:boundary:areas:period:material:regi
Science          radiation:machine:momentum:this group:atom:s
Astronomy        supernova:telescope:mass:astronomical:radiat
```

Accuracy: 0.809

Top Features: Character *n*-grams

```
History          khan: case: post: colo: new :orth : died:ses
Literature       epic:novel: " : play :play : play: poem :poe
Social Science   rivers: rivers: idea: son : myth:deity: deit
Geography        red : pass :ers. :nation : is : lies: lies :
Other            nger :(rl: : (rl:: (rl: : game: you : use :
Biology          rine : dna : cell:plant: grow:ase, :some :ge
Fine Arts        solo:piece: opera : st. : opera:opera : chor
Physics          law :zero :less : time : due : can :ying :ti
Chemistry        mole: chemis: chemist: sulf:sion :nium : che
Mathematics      proof: be :proof: any : has : are : four: se
Earth Science    laye: form:rock : rock : or : know: known:la
Science          is\n : law :ine. : atom: 10 : are : this: n
Astronomy        lion :cloud: earth: eart: radi: its : mass:
```

Top Features: Character *n*-grams

History	khan: case: post: colo: new :orth : died:ses
Literature	epic:novel: " : play :play : play: poem :poe
Social Science	rivers: rivers: idea: son : myth:deity: deit
Geography	red : pass :ers. :nation : is : lies: lies :
Other	nger :(rl: : (rl:: (rl: : game: you : use :
Biology	rine : dna : cell:plant: grow:ase, :some :ge
Fine Arts	solo:piece: opera : st. : opera:opera : chor
Physics	law :zero :less : time : due : can :ying :ti
Chemistry	mole: chemis: chemist: sulf:sion :nium : che
Mathematics	proof: be :proof: any : has : are : four: se
Earth Science	laye: form:rock : rock : or : know: known:la
Science	is\n : law :ine. : atom: 10 : are : this: n
Astronomy	lion :cloud: earth: eart: radi: its : mass:

Accuracy: 0.808

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- How questions are written (quotas per packet)
- Syntax (paying attention to words after "this")
- Authors of questions

HW3

- Detecting spoilers
- Kaggle competition (individual level)
- Given code already works (don't change output format)
- Can only change features