



Variational Inference

Machine Learning: Jordan Boyd-Graber University of Colorado Boulder

LECTURE 21

Roadmap

- Big-picture questions
- VI for LDA
- More content questions
- Walkthrough of VI for LDA (HW)

Example

Three topics, same documents as last time

$$\beta = \begin{bmatrix} \text{cat} & \text{dog hamburger iron pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{bmatrix}$$
(1)

- Assume uniform γ : (2.0, 2.0, 2.0)
- Compute update for ϕ

$$\phi_{ni} \propto \beta_{iv} \exp \left(\Psi(\gamma_i) - \Psi\left(\sum_j \gamma_j\right) \right)$$
 (2)

• For a the first word (dog) in the document: dog cat cat pig

Example

Three topics, same documents as last time

$$\beta = \begin{bmatrix} \text{cat} & \text{dog hamburger iron pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{bmatrix}$$
(1)

- Assume uniform γ : (2.0, 2.0, 2.0)
- Compute update for ϕ

$$\phi_{ni} \propto \beta_{iv} \exp \left(\Psi(\gamma_i) - \Psi\left(\sum_j \gamma_j\right) \right)$$
 (2)

For a the first word (dog) in the document: dog cat cat pig

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \\ \end{array} \right] \left[\begin{array}{ccccc} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right]$$

•
$$\gamma = (2.000, 2.000, 2.000)$$

$$\beta = \left[\begin{array}{cccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right] \left. \begin{array}{c} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right.$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{cccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right] \left. \begin{array}{c} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right.$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right]^{\phi_{ni} \, \infty}_{\beta_{iv} \, \exp} \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right)$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(2) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right]^{\phi_{ni} \propto}_{\beta_{iv} \exp} \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right)$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(2) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- After normalization: {0.333, 0.333, 0.333}

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \\ \end{array} \right] \left[\begin{array}{ccccc} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right]$$

•
$$\gamma = (2.000, 2.000, 2.000)$$

$$\beta = \left[\begin{array}{cccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right] \left. \begin{array}{c} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right.$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{cccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right] \left. \begin{array}{c} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right.$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right]^{\phi_{ni} \, \infty}_{\beta_{iv} \, \exp} \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right)$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(2) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right]^{\phi_{ni} \propto}_{\beta_{iv} \exp} \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right)$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(2) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- After normalization: {0.333, 0.333, 0.333}

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \\ \end{array} \right] \left[\begin{array}{ccccc} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right]$$

•
$$\gamma = (2.000, 2.000, 2.000)$$

$$\beta = \left[\begin{array}{cccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right] \left. \begin{array}{c} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right.$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.260 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.072$

$$\beta = \left[\begin{array}{cccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right] \left. \begin{array}{c} \phi_{ni} \propto \\ \beta_{iv} \exp \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right) \end{array} \right.$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.260 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.072$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right]^{\phi_{ni} \, \infty}_{\beta_{iv} \, \exp} \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right)$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.260 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.072$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(2) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$

$$\beta = \left[\begin{array}{ccccc} \text{cat} & \text{dog} & \text{hamburger} & \text{iron} & \text{pig} \\ .26 & .185 & .185 & .185 & .185 \\ .185 & .185 & .26 & .185 & .185 \\ .185 & .185 & .185 & .26 & .185 \end{array} \right]^{\phi_{ni} \propto}_{\beta_{iv} \exp} \left(\Psi \left(\gamma_i \right) - \Psi \left(\sum_j \gamma_j \right) \right)$$

- $\gamma = (2.000, 2.000, 2.000)$
- $\phi(0) \propto 0.260 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.072$
- $\phi(1) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- $\phi(2) \propto 0.185 \times \exp(\Psi(2.000) \Psi(2.000 + 2.000 + 2.000)) = 0.051$
- After normalization: {0.413, 0.294, 0.294}

Update γ

- Document: dog cat cat pig
- Update equation

$$\gamma_i = \alpha_i + \sum_n \phi_{ni} \tag{3}$$

• Assume $\alpha = (.1, .1, .1)$

Update γ

- Document: dog cat cat pig
- Update equation

$$\gamma_i = \alpha_i + \sum_n \phi_{ni} \tag{3}$$

• Assume $\alpha = (.1, .1, .1)$

	ϕ_{0}	ϕ_{1}	ϕ_2	
dog	.333	.333	.333	
cat	.413	.294	.294	
pig	.333	.333	.333	
α	0.1	0.1	0.1	
sum	1.592	1.354	1.354	

Note: do not normalize!

Update γ

- Document: dog cat cat pig
- Update equation

$$\gamma_i = \alpha_i + \sum_n \phi_{ni} \tag{3}$$

• Assume $\alpha = (.1, .1, .1)$

	ϕ_{0}	ϕ_{1}	ϕ_{2}	
dog	.333	.333	.333	
cat	.413	.294	.294	x2
pig	.333	.333	.333	
α	0.1	0.1	0.1	
sum	1.592	1.354	1.354	

Note: do not normalize!

Update β

- \bullet Count up all of the ϕ across all documents
- For each topic, divide by total
- Corresponds to maximum likelihood of expected counts

Update β

- ullet Count up all of the ϕ across all documents
- For each topic, divide by total
- Corresponds to maximum likelihood of expected counts
- Unlike Gibbs sampling, no Dirichlet prior



Plan

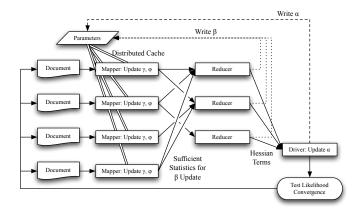
What research is going on in variational inference?

Automatic Inference

```
public void GaussianModel(double[] data)
{
  double mean = Factor.Random(new Gaussian(0, 100));
  double precision = Factor.Random(new Gamma(0, 1));
  for (int i = 0; i < data.Length; i++) {
    data[i] = Factor.Gaussian(mean, precision);
  }
  InferNet.Infer(mean);
  InferNet.Infer(precision);
}</pre>
```

Parallel LDA

Zhai et al, 2012



Online LDA

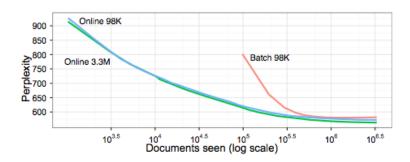
Hoffman and Blei, 2010

Algorithm 2 Online variational Bayes for LDA

```
Define \rho_t \triangleq (\tau_0 + t)^{-\kappa}
Initialize \lambda randomly.
for t = 0 to \infty do
    E step:
    Initialize \gamma_{tk} = 1. (The constant 1 is arbitrary.)
    repeat
        Set \phi_{twk} \propto \exp\{\mathbb{E}_{\sigma}[\log \theta_{tk}] + \mathbb{E}_{\sigma}[\log \beta_{kw}]\}
        Set \gamma_{tk} = \alpha + \sum_{m} \phi_{tmk} n_{tm}
    until \frac{1}{K} \sum_{k} |\text{change in} \gamma_{tk}| < 0.00001
    M step:
    Compute \bar{\lambda}_{kw} = \eta + Dn_{tw}\phi_{twk}
    Set \lambda = (1 - \rho_t)\lambda + \rho_t \tilde{\lambda}.
```

Online LDA

Hoffman and Blei, 2010



Online LDA

Hoffman and Blei, 2010

- 1: Initialize $\lambda^{(0)}$ randomly.
- 2: Set the step-size schedule ρ_t appropriately.
- 3: repeat
- 4: Sample a data point x_i uniformly from the data set.
- 5: Compute its local variational parameter,

$$\phi = \mathbb{E}_{\lambda^{(t-1)}}[\eta_g(x_i^{(N)}, z_i^{(N)})].$$

6: Compute intermediate global parameters as though x_i is replicated N times,

$$\hat{\lambda} = \mathbb{E}_{\phi}[\eta_g(x_i^{(N)}, z_i^{(N)})].$$

7: Update the current estimate of the global variational parameters,

$$\lambda^{(t)} = (1 - \rho_t)\lambda^{(t-1)} + \rho_t \hat{\lambda}.$$

8: until forever

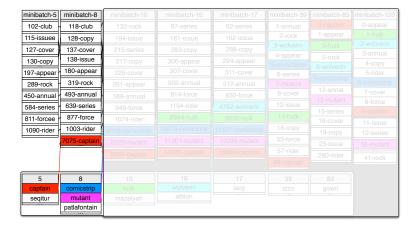
Machine Learning: Jordan Boyd-Graber

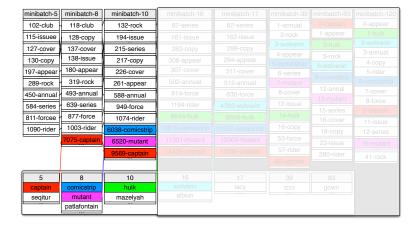
Best of Both Worlds

Algorithm 1 Algorithm for hybrid stochastic variational-Gibbs inference.

```
for t \in 1, ..., \infty do
   \rho_t \leftarrow \left(\frac{1}{t_0+t}\right)^{\kappa}
   sample minibatch \mathcal{B}
   for d \in \mathcal{B} do
        initialize z_d^0
        discard B burn-in sweeps
        for sample s \in 1, ..., S do
            for token i \in 1, ..., N_d do
                sample z_{di}^s \propto (\alpha + N_{dk})e^{\mathbb{E}_q[\log \beta_{kw}]}
            end for
        end for
   end for
   \lambda_{kw}^{t} \leftarrow (1 - \rho_t)\lambda_{kw}^{t-1} + \rho_t \left(\eta + \frac{D}{|\mathcal{B}|}\hat{N}_{kw}\right)
end for
```







minibatch-5	minibatch-8	minibatch-10	minibatch-16	minibatch-17	minibatch-39	minibatch-83	minibatch-120
102-club	118-club	132-rock	87-series	82-series			
115-issuee	128-copy	194-issue	161-issue	162-issue			
127-cover	137-cover	215-series	283-copy	288-сору			2-wolverin 3-annual
130-copy	138-issue	217-copy	306-appear	294-appear			4-copy
197-appear	180-appear	226-cover	307-cover	311-cover			5-rider
289-rock	319-rock	261-appear	502-annual	512-annual			6-comicstrip
450-annual	493-annual	588-annual	814-force	830-force			7-cover
584-series	639-series	949-force	1194-rider	4782-wolverin			8-force
811-forcee	877-force	1074-rider	8944-hulk	9659-hulk			9-captain
1090-rider	1003-rider	6038-comicstrip	10819-comicstrip	11527-comicstrip			11-issue
1000 11001	7075-captain	6520-mutant	11301-mutant	12009-mutant			12-series
	TOTO Supram		14335-captain	15040-captain			16-mutant
		9569-captain	14003 Capitaiii	13040 Captain			41-rock
			,				1
5	8	10	16	17			
captain	comicstrip	hulk	wolverin	lacy			
seqitur	mutant	mazelyah	albion				
	patlafontain						

minibatch-5	minibatch-8	minibatch-10	minibatch-16	minibatch-17	minibatch-39	minibatch-83	minibatch-120
102-club	118-club	132-rock	87-series	82-series	1-annual		
115-issuee	128-copy	194-issue	161-issue	162-issue	2-rock		
127-cover	137-cover	215-series	283-copy	288-copy	3-wolverin		
130-copy	138-issue	217-copy	306-appear	294-appear	4-appear 5-comicstrip		
197-appear	180-appear	226-cover	307-cover	311-cover	6-series		
289-rock	319-rock	261-appear	502-annual	512-annual	7-mutant		
450-annual	493-annual	588-annual	814-force	830-force	8-cover		
584-series	639-series	949-force	1194-rider	4782-wolverin	12-issue		
811-forcee	877-force	1074-rider	8944-hulk	9659-hulk	. 14-hulk		
1090-rider	1003-rider	6038-comicstrip	10819-comicstrip	11527-comicstrip	16-copy		
1030-11061	7075-captain		11301-mutant	12009-mutant	53-force		
	7075-captain	6520-mutant	14335-captain	15040-captain	57-rider		
		9569-captain	14335-Gaptain	15040-Captain	86-captain		
					oo captaiii		
5	8	10	16	17	39		
captain	comicstrip	hulk	wolverin	lacy	izzo		
seqitur	mutant	mazelyah	albion				
	patlafontain						

minibatch-5	minibatch-8	minibatch-10	minibatch-16	minibatch-17	minibatch-39	minibatch-83	
102-club	118-club	132-rock	87-series	82-series	1-annual	0-captain	
115-issuee	128-copy	194-issue	161-issue	162-issue	2-rock	1-appear	
127-cover	137-cover	215-series	283-copy	288-copy	3-wolverin	3-hulk	
130-copy	138-issue	217-copy	306-appear	294-appear	4-appear 5-comicstrip	5-rock	
197-appear	180-appear	226-cover	307-cover	311-cover	6-series	6-wolverin	
289-rock	319-rock	261-appear	502-annual	512-annual	7-mutant	9-comicstrip	
450-annual	493-annual	588-annual	814-force	830-force	8-cover	12-annal	
584-series	639-series	949-force	1194-rider	4782-wolverin	12-issue	13-mutant	
811-forcee	877-force	1074-rider	8944-hulk	9659-hulk	14-hulk	15-series 16-cover	
1090-rider	1003-rider	6038-comicstrip	10819-comicstrip	11527-comicstrip	16-copy	19-copy	
	7075-captain	6520-mutant	11301-mutant	12009-mutant	53-force	23-issue	
		9569-captain	14335-captain	15040-captain	57-rider	280-rider	
		- COCO Capitani			86-captain	200-11061	
5	8	10	16	17	39	83	
captain	comicstrip	hulk	wolverin	lacy	izzo	gown	
	mutant	mazelyah	albion	lacy	1220	gown	
seqitur	patlafontain	mazeiyari					
	panaiontain						

minibatch-5	minibatch-8	minibatch-10	minibatch-16	minibatch-17	minibatch-39	minibatch-83	minibatch-120
102-club	118-club	132-rock	87-series	82-series	1-annual	0-captain	0-appear
115-issuee	128-copy	194-issue	161-issue	- 162-issue	2-rock	1-appear	1-hulk
127-cover	137-cover	215-series	283-copy	288-copy	3-wolverin	3-hulk	2-wolverin 3-annual
130-copy	138-issue	217-copy	306-appear	294-appear	4-appear 5-comicstrip	5-rock	4-copy
197-appear	180-appear	226-cover	307-cover	311-cover	6-series	6-wolverin	5-rider
289-rock	319-rock	261-appear	502-annual	512-annual	7-mutant	9-comicstrip	6-comicstrip
450-annual	493-annual	588-annual	814-force	830-force	8-cover	12-annal	7-cover
584-series	639-series	949-force	1194-rider	4782-wolverin	12-issue	13-mutant	8-force
811-forcee	877-force	1074-rider	8944-hulk	9659-hulk	14-hulk	15-series 16-cover	9-captain
1090-rider	1003-rider	6038-comicstrip	10819-comicstrip	11527-comicstrip	16-copy		11-issue
1000 11001	7075-captain	6520-mutant	11301-mutant	12009-mutant	53-force	19-copy	12-series
	TOTO CAPICATI		14335-captain	15040-captain	57-rider	23-issue	16-mutant
		9569-captain	14000 captain	13040 Capitain	86-captain	280-rider	41-rock
					oo captaiii		
5	8	10	16	17	39	83	
captain	comicstrip	hulk	wolverin	lacy	izzo	gown	
seqitur	mutant	mazelyah	albion				
	patlafontain						

minibatch-5	minibatch-8	minibatch-10	minibatch-16	minibatch-17	minibatch-39	minibatch-83	minibatch-120
102-club	118-club	132-rock	87-series	82-series	1-annual	0-captain	0-appear
115-issuee	128-copy	194-issue	161-issue	162-issue	2-rock	1-appear	1-hulk
127-cover	137-cover	215-series	283-copy	288-copy	3-wolverin	3-hulk	2-wolverin
130-copy	138-issue	217-copy	306-appear	294-appear	4-appear	5-rock	3-annual 4-copy
197-appear	180-appear	226-cover	307-cover	311-cover	5-comicstrip 6-series	6-wolverin	5-rider
289-rock	319-rock	261-appear	502-annual	512-annual	7-mutant	9-comicstrip	6-comicstrip
450-annual	493-annual	588-annual	814-force	830-force	8-cover	12-annal	7-cover
584-series	639-series	949-force	1194-rider	4782-wolverin	12-issue	13-mutant	8-force
	877-force		8944-hulk	9659-hulk	14-hulk	15-series	9-captain
811-forcee	1003-rider	1074-rider	10819-comicstrip	11527-comicstrip	16-copy	16-cover	11-issue
1090-rider		6038-comicstrip			53-force	19-copy	12-series
	7075-captain	6520-mutant	11301-mutant	12009-mutant	57-rider	23-issue	16-mutant
		9569-captain	14335-captain	15040-captain		280-rider	41-rock
					86-captain		
5	8	10	16	17	39	83]
captain	comicstrip	hulk	wolverin	lacy	izzo	gown	l
seqitur	mutant	mazelyah	albion				l
	patlafontain						l