PHONOTACTIC LANGUAGE RECOGNITION USING I-VECTORS AND PHONEME POSTERIOGRAM COUNTS

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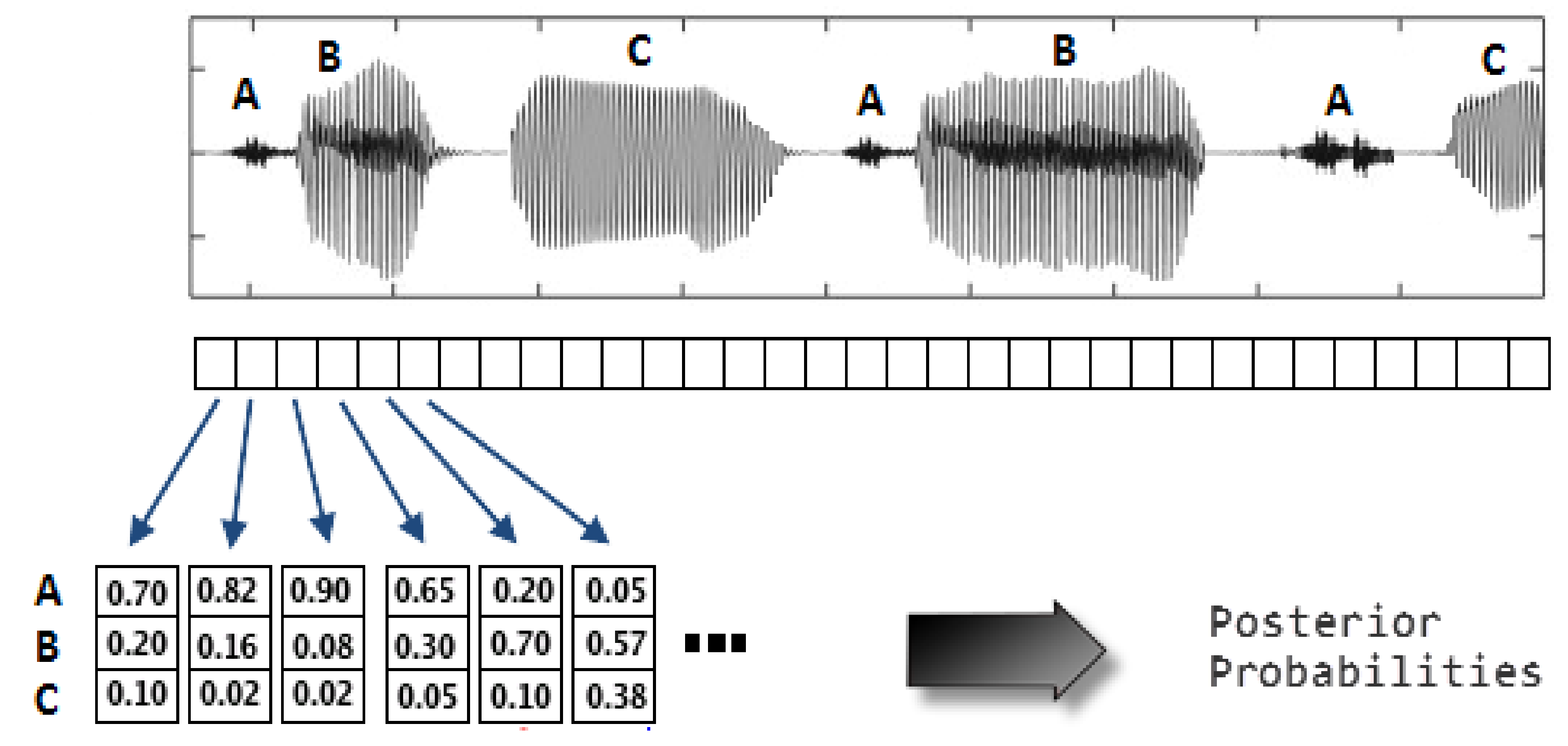
Content

- Introduction
- Steps to create Joint-Posteriogram n-gram counts
- Subspace Multinomial Models
  - i-vectors
- Results on LRE-2009
- Conclusions and Future work

Introduction

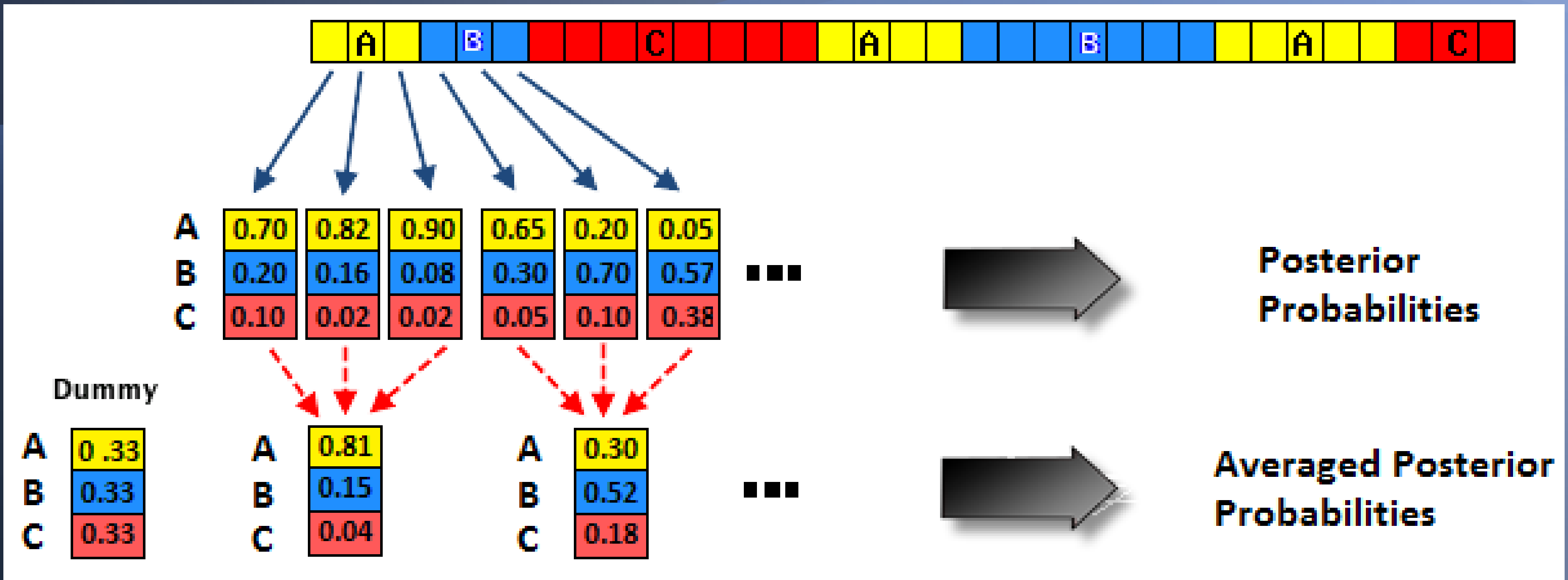
- Current main approaches to LID
  - Acoustic-based: i-vectors, JFA, SVMs, or GMMs
  - Phonotactic
- Phonotactic systems:
  - PRLM, PPRLM: LMs created using different phonetic ASR
  - Lattice-based soft-counts: Created from phone lattices
    - Zero counts (i.e. data sparseness)
    - Limited by the number of phonemes and n-gram order
    - Dimensionality reduction: PCA or n-gram selection
  - Using i-vectors through Subspace Multinomial Models (SMMs)
    - We propose a new feature vector that performs better than soft-counts

1. Compute Posterior Probabilities



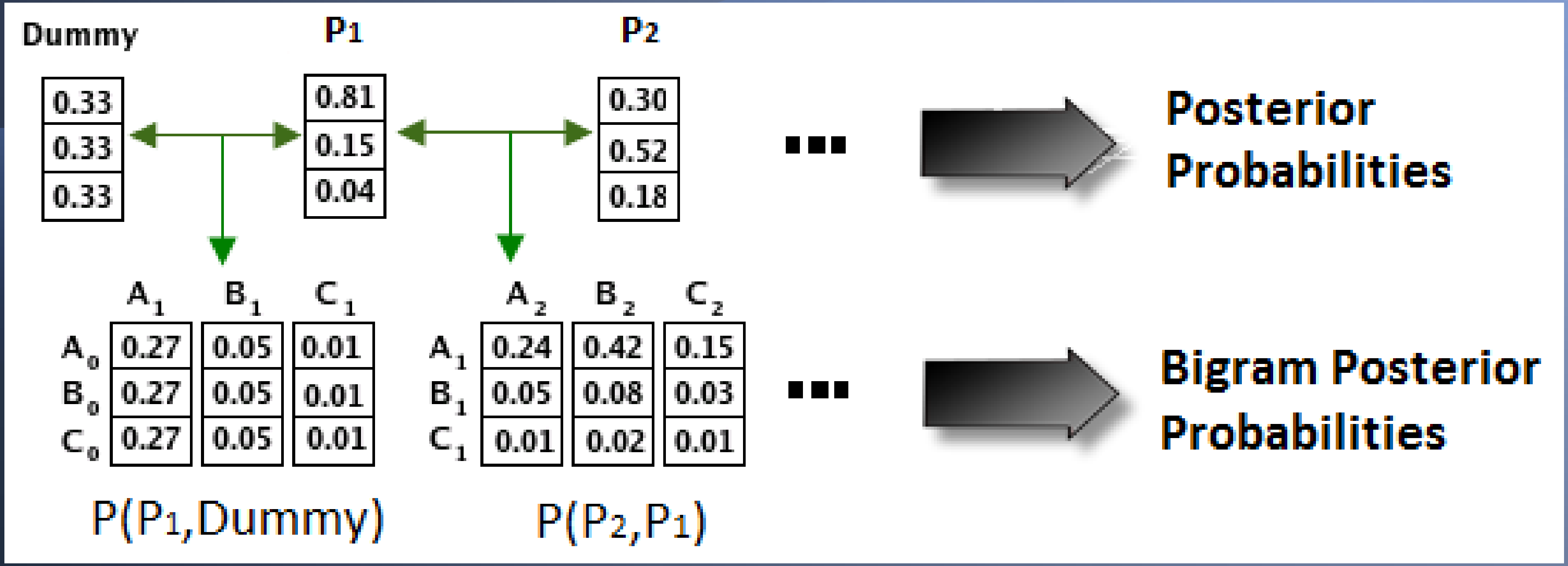
- In the example, we consider only three phonemes and bigrams. In our experiments, they were 33 and we used trigrams.

2. Compute Posterior Probs



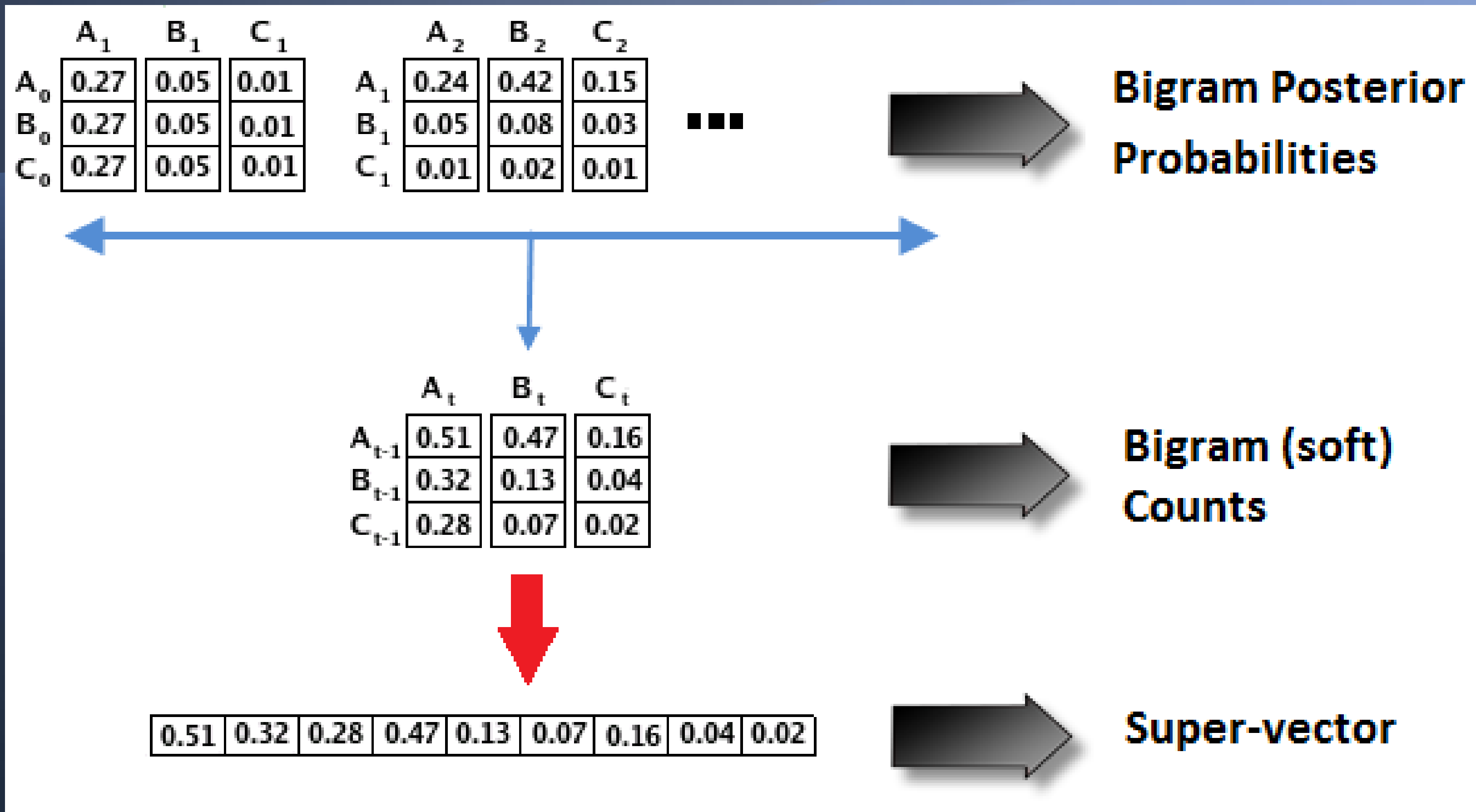
- Find the phoneme boundaries using Viterbi algorithm
  - Can be seen as incorporation of a-priori information
- Average the posterior probs over the phone boundaries
  - Smoothes the posterior probs and avoids the high-correlation of within-phoneme posteriors

3. Create N-gram Posterior Probs



- Outer product with the posteriogram of the previous phones
- Assume that the frames of the averaged posteriogram are statistically independent,
  - Therefore we have joint probabilities for sequences of phonemes

4. N-gram Counts via N-gram Posterior Probs



- Sum up all matrices to obtain n-gram soft counts
- Obtain feature super-vector for creating next the phonotactic i-vectors using SMMs

Subspace Multinomial Models

- Allows extraction of low-dimensional vectors of coordinates in total variability subspace (i.e. i-vectors)
- The log-likelihood of data *D* for a multinomial model with *C* discrete events is determined by

$$\log p(D) = \sum_{n=1}^{N} \sum_{c=1}^{C} \gamma_{nc} \log \varphi_{nc}$$

- Where γ_{nc} is the count for n-gram event *c* at utterance *n*, and φ_{nc} is the probability of a multinomial distribution defined by the subspace model

i-vectors from SMM

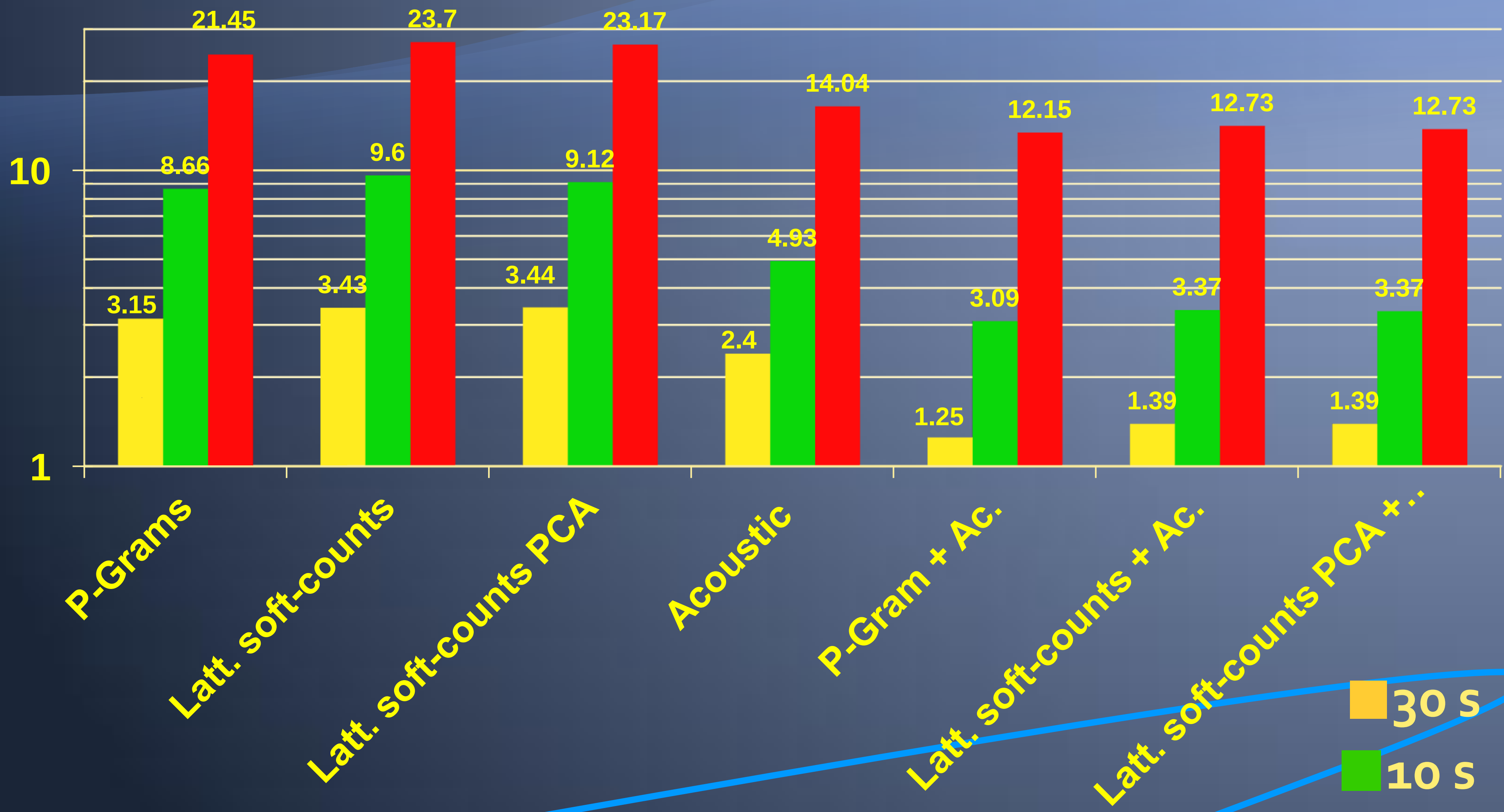
$$\varphi_{nc} = \frac{\exp\left(m_c + t_c w_n\right)}{\sum_i^C \exp\left(m_i + t_i w_n\right)}$$

- Where t_c is the c-th row of subspace matrix T (Extractor), and w_n is the i-vector
- An i-vector for a single utterance is estimated numerically by maximizing the likelihood (ML)
- Matrix T is trained numerically using ML by iteratively optimizing T and re-estimating the i-vectors for all training utterances
- Then we use these i-vectors as feature input for training a discriminative LID classifier
  - Multiclass logistic regression

Experimental Setup

- NIST LRE 2009 database
  - 50K segments for training (~119h), 38K segments for dev (~153h) and 31K sentences for test (~125h)
  - 23 languages, test on 3, 10, and 30 s conditions
  - Results given using C_{avg} metric
- Acoustic i-vector system
  - 7 MFCC + 49 SDCs, CMN/CVN, 2048 Gaussians -> i-vectors of 400 dimensions
- Comparisons with:
  - Lattice-based soft-counts with i-vectors (size 600)
  - Lattice-based soft-counts with PCA (reduction to 1000 dimensions)
- Fusion: Multiclass logistic regression
  - Acoustic and Phonotactic

Results on NIST LRE 2009



- Vertical-axes in logarithm

Conclusions and Future Work

- Advantages of the new features
  - Avoid data sparseness (i.e. robustness)
  - Results outperforms a similar system based on lattice soft-counts with i-vectors
    - 8,16% relative on 30 s condition
  - Fusion with acoustic i-vectors are also better
    - 10% relative on 30 s condition

- Future Work: Apply discriminative n-gram selection techniques to reduce the vector size
  - Avoids low frequency n-gram counts
  - Allows using high n-gram orders

…Thanks for your attention…

Comments or Questions?