

Poetic Machine

Computational Creativity for Automatic Poetry Generation in Bengali

Amitava Das

Computer Science and Engineering
University of North Texas
Denton, Texas, USA

Björn Gambäck

Computer and Information Science
Norwegian University of Science and Technology
Trondheim, Norway
and
SICS, Swedish ICT AB
Stockholm, Sweden



Collaborative Poetry Generation

- Fully automatic vs. in collaboration with the user
- Complete poem vs. one poetry line at the time

Collaborative Poetry Generation

- Fully automatic vs. in collaboration with the user
 - Complete poem vs. one poetry line at the time
1. The user enters a line of text
 2. The system generates a matching, rhyming line

Collaborative Poetry Generation

- Fully automatic vs. in collaboration with the user
 - Complete poem vs. one poetry line at the time
1. The user enters a line of text
 2. The system generates a matching, rhyming line
- Rhyme understanding
 - Parsing input to understand poetic structure
 - Rhyme generation
 - Output structure prediction
 - Candidate word generation

Poetry Evaluation

Criteria [Manurung 2004]:

- Meaningfulness
- Grammaticality
- "Poeticness"

Poetry Evaluation

Criteria [Manurung 2004]:

- Meaningfulness
- Grammaticality
- "Poeticness"

- In-depth / expert evaluation
- Random user evaluation

Bengali (Bangla)

- Spoken in Bangladesh and Eastern India
- 7th largest language in the World (2nd in India)
- Partially phonemic
 - pronunciation depends on part-of-speech and semantics

Bengali (Bangla)

- Spoken in Bangladesh and Eastern India
- 7th largest language in the World (2nd in India)
- Partially phonemic
 - pronunciation depends on part-of-speech and semantics
- Orthography derived from Sanskrit
- Characters = *akṣara*
 - 7 vowels
 - 4 semi-vowels
 - 30 consonants
- (Phonetic) Consonant group = *borgo*

Borgo-phonetic Groups

<i>Borgo</i>	Consonants				
k-borgo (ক)	ক(k)	খ(k ^h)	গ(g)	ঘ(g ^h)	ঙ(ŋ)
ʈʂ-borgo (চ)	চ(ʈʂ)	ছ(ʈʂ ^h)	জ(dʒ)	ঝ(dʒ ^h)	ঞ(n)
t-borgo (ট)	ট(t)	ঠ(t ^h)	ড(d)	ঠ(d ^h)	ণ(n)
ʈ-borgo (ত)	ত(ʈ)	থ(ʈ ^h)	দ(d̪)	ধ(d̪ ^h)	ন(n)
p-borgo (প)	প(p)	ফ(p ^h)	ব(b)	ভ(b ^h)	ম(m)
Internal (স্থঃস্তঅ) sound	য(dʒ)	য়(e)	র(r)	ল(l)	
Warm (ঝউ) sound	শ(j)	ষ(j)	স(s)	হ(h)	
Scolding (তাজনড়াত)	ড়(r)	ঢ়(r)			
Parasitic (ীয়শারপ)				ঃ(h)	ঁ(ŋ)

Borgo-phonetic Groups

less-stressed

<i>Borgo</i>	Consonants				
k-borgo (ক)	ক(k)	খ(k ^h)	গ(g)	ঘ(g ^h)	ঙ(ŋ)
ʈʂ-borgo (চ)	চ(ʈʂ)	ছ(ʈʂ ^h)	জ(dʒ)	ঝ(dʒ ^h)	ঞ(n)
t-borgo (ট)	ট(t)	ঠ(t ^h)	ড(d)	ঠ(d ^h)	ণ(n)
ʈ-borgo (ত)	ত(ʈ)	থ(ʈ ^h)	দ(d̪)	ধ(d̪ ^h)	ন(n)
p-borgo (প)	প(p)	ফ(p ^h)	ব(b)	ভ(b ^h)	ম(m)
Internal (স্থঃস্তঅ) sound	য(dʒ)	য়(e)	র(r)	ল(l)	
Warm (ঝউ) sound	শ(j)	ষ(j)	স(s)	হ(h)	
Scolding (তাজনড়াত)	ড়(r)	ঢ়(r)			
Parasitic (ীয়শারপ)				ঃ(h)	ঁ(ŋ)

Borgo-phonetic Groups

<i>Borgo</i>	Consonants				
	less-stressed	less-stressed	high-stressed	high-stressed	
k-borgo (ক)	ক(k)	খ(k ^h)	গ(g)	ঘ(g ^h)	ঙ(ŋ)
ʈʂ-borgo (চ)	চ(ʈʂ)	ছ(ʈʂ ^h)	জ(dʒ)	ঝ(dʒ ^h)	ঞ(n)
t-borgo (ট)	ট(t)	ঠ(t ^h)	ড(d)	ঠ(d ^h)	ণ(n)
ʈ-borgo (ত)	ত(ʈ)	থ(ʈ ^h)	দ(d̪)	ধ(d̪ ^h)	ন(n)
p-borgo (প)	প(p)	ফ(p ^h)	ব(b)	ভ(b ^h)	ম(m)
Internal (স্থঃস্তঅ) sound	য(dʒ)	য়(e)	র(r)	ল(l)	
Warm (ঝউ) sound	শ(j)	ষ(j)	স(s)	হ(h)	
Scolding (তাজনড়াত)	ড়(r)	ঢ়(r)			
Parasitic (ীয়শারপ)				ঃ(h)	ঁ(ŋ)

Borgo-phonetic Groups

<i>Borgo</i>	Consonants				
	less-stressed	high-stressed	high-stressed	high-stressed	nasal
k-borgo (ক)	ক(k)	খ(k ^h)	গ(g)	ঘ(g ^h)	ঙ(ŋ)
ʈʂ-borgo (চ)	চ(ʈʂ)	ছ(ʈʂ ^h)	জ(dʒ)	ঝ(dʒ ^h)	ঞ(n)
t-borgo (ট)	ট(t)	ঠ(t ^h)	ড(d)	ঠ(d ^h)	ণ(n)
ʈ-borgo (ত)	ত(ʈ)	থ(ʈ ^h)	দ(d̪)	ধ(d̪ ^h)	ন(n)
p-borgo (প)	প(p)	ফ(p ^h)	ব(b)	ভ(b ^h)	ম(m)
Internal (স্থঃস্তঅ) sound	য(dʒ)	য়(e)	র(r)	ল(l)	
Warm (ঝউ) sound	শ(j)	ষ(j)	স(s)	হ(h)	
Scolding (তাজনড়াত)	ড়(r)	ঢ়(r)			
Parasitic (ীয়শারপ)				ঃ(h)	ঁ(ŋ)

Bengali Poetry

- Syllables
 - **Closed** = ends in vowel
 - **Open** = ends in consonant

Bengali Poetry

- Syllables
 - **Closed** = ends in vowel
 - **Open** = ends in consonant
- Metres
 - *Akṣara-ṛtta* – based on the number of **syllables**
 - *Mātrā-ṛtta* – based on the **vowel length**
 - *Svara-ṛtta* – based on the **vowel number**

Bengali Poetry

- Syllables
 - **Closed** = ends in vowel
 - **Open** = ends in consonant
- Metres
 - *Akṣara-ṛtta* – based on the number of **syllables**
 - *Mātrā-ṛtta* – based on the **vowel length**
 - *Svara-ṛtta* – based on the **vowel number**
- Rhymes / alliterations
 - *Adiprāsa* – **first** syllable rhymes
 - *Dviteeyakshara prāsa* – **second** syllable rhymes
 - *Antyaprāsa / anto-mil* – **last** syllable rhymes (tail-rhyme)

Bengali Poetry

- Syllables
 - **Closed** = ends in vowel
 - **Open** = ends in consonant
- Metres
 - *Akṣara-ṛtta* – based on the number of **syllables**
 - *Mātrā-ṛtta* – based on the **vowel length**
 - *Svara-ṛtta* – based on the **vowel number**
- Rhymes / alliterations
 - *Adiprāsa* – **first** syllable rhymes
 - *Dviteeyakshara prāsa* – **second** syllable rhymes
 - *Antyaprāsa / anto-mil* – **last** syllable rhymes (tail-rhyme)

Poetry Corpus

- Downloaded from poetry sites on the net
- Mainly children poems by Sukumar Ray (+ Tagore)
- Written in *mātrā-vṛtta* metre with *anto-mil* rhyme

Poetry Corpus

- Downloaded from poetry sites on the net
- Mainly children poems by Sukumar Ray (+ Tagore)
- Written in *mātrā-vṛtta* metre with *anto-mil* rhyme

Units	Number
Sentences	3567
Words	9336
Unique Tokens	7245

Poetry Generation Model

- Inspired by Satyajit Ray's movie
'Kingdom of Diamonds' (1980)
- Entire conversation in rhythm

এরা যত বেশি পড়ে

ērā yata bēśi paṛē
(the more they read)

তত বেশি জানে

tata bēśi jānē
(the more they learn)

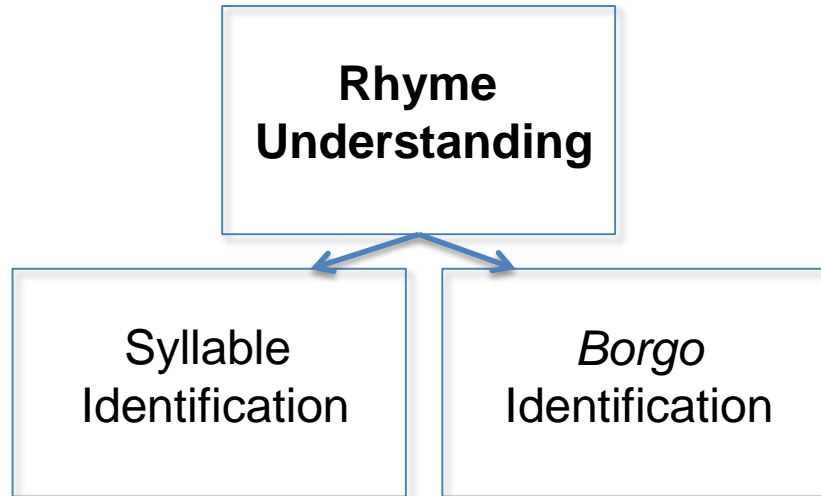
তত কম মানে

tata kama mānē
(the less they obey)

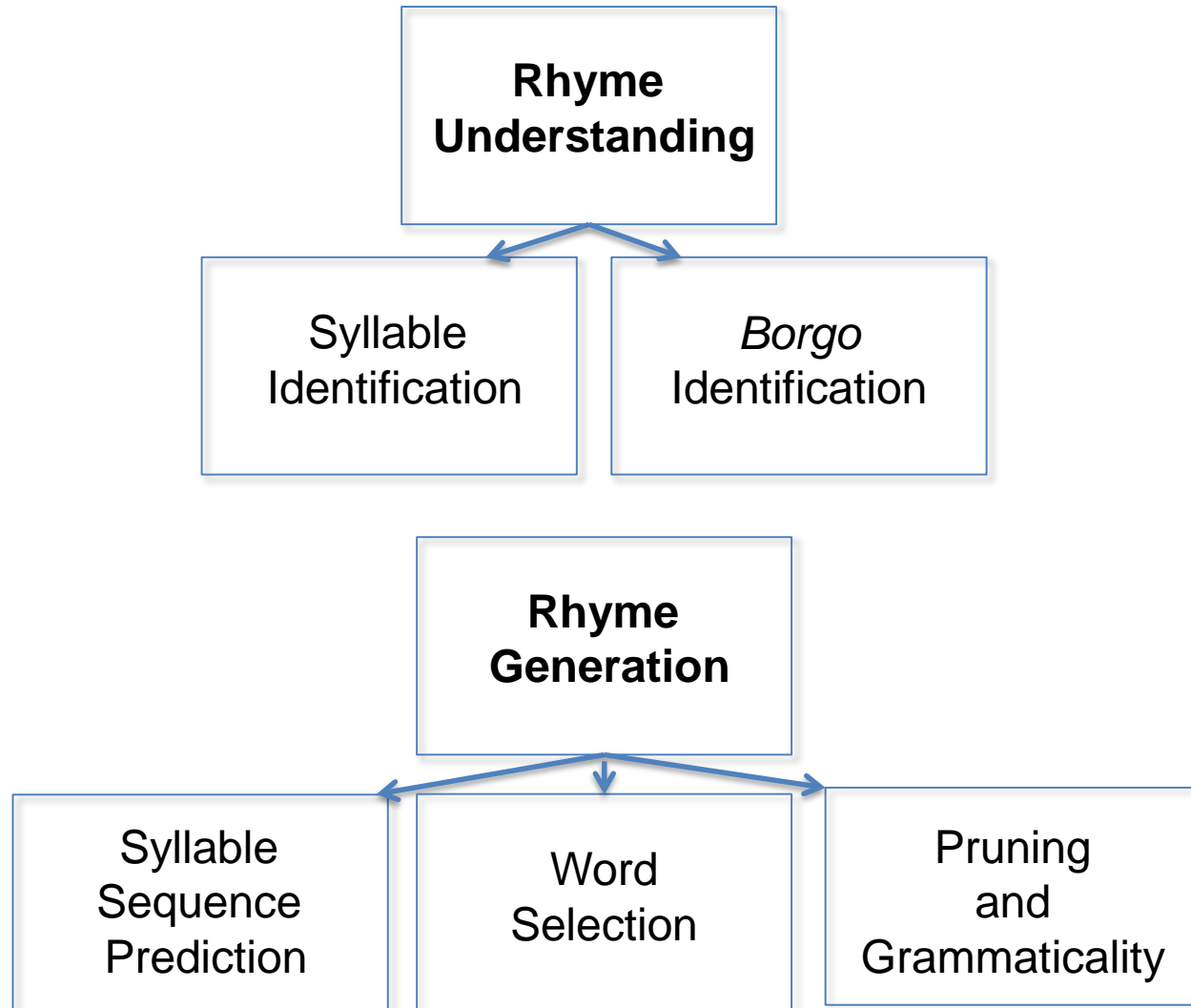
হীরক রাজার দেশে
Hirok Rajar Deshe



Poetry Generation Model



Poetry Generation Model



1. Rhyme Understanding

1a. Syllable Identification

Grapheme to phoneme converter [Basu et al. 2009]

- Words starting with vowel = marked 'v'
- Other words = marked with *borgo* group

1. Rhyme Understanding

1a. Syllable Identification

Grapheme to phoneme converter [Basu et al. 2009]

- Words starting with vowel = marked 'v'
- Other words = marked with *borgo* group

Input	আকাশের <i>akashar</i> <i>ākāśēra</i>	ময়দানে <i>mayadane</i> <i>mayādānē</i>	বাতাসের <i>bataser</i> <i>bātāsēra</i>	ভরে <i>vore</i> <i>bharē</i>
English	In the sky with the air			
Syllables	<i>ākā-śē-ra</i>	<i>mayā-dānē</i>	<i>bā-tā-sēra</i>	<i>bharē</i>
Syllable count	3	2	3	1
Open/Closed	o	c	o	c
<i>Borgo</i>	v	<i>p</i>	<i>p</i>	<i>p</i>

1. Rhyme Understanding

1b. *Borgo* Identification

- For open syllabic (consonant-ending) words:
Can use a word ending with a C from the same *borgo*

- Example: ঠ(t^h) and ট(t) are both in t-*borgo*

বুড়ো বুড়ো খাড়ি মেঘ ঢিপি হয়ে উঠে

buṛō buṛō dhāṛi mēgha ḍhipi haḳe uṭhē

(the very old inveterate cloud looks like a hill)

শুয়ে বসে সভা করে সারাদিন জুটে।

śuḳe ba'sē sabhā karē sārādina juṭē

(they were meeting all day with the gathered friends)

2. Rhyme Generation

a. Syllabic Sequence Prediction

Support Vector Machines (WEKA; Hall et al. 2009)

- Corpus split into training and test sets
- Training set split into rhyming sentence pairs

2. Rhyme Generation

a. Syllabic Sequence Prediction

Support Vector Machines (WEKA; Hall et al. 2009)

- Corpus split into training and test sets
- Training set split into rhyming sentence pairs
- Features:
 - Syllable count sequence
 - Open/closed syllable pattern sequence
 - *Borgo* group marking sequence

2. Rhyme Generation

a. Syllabic Sequence Prediction

Support Vector Machines (WEKA; Hall et al. 2009)

- Corpus split into training and test sets
- Training set split into rhyming sentence pairs
- Features:
 - Syllable count sequence
 - Open/closed syllable pattern sequence
 - *Borgo* group marking sequence
- Three ML engines trained:
 1. Initial position
 2. Final position
 3. All intermediate positions

2. Rhyme Generation

b. Word Selection

- Word collection: poetry corpus + news corpus
- Syllable counts from grapheme to phoneme converter

2. Rhyme Generation

b. Word Selection

- Word collection: poetry corpus + news corpus
- Syllable counts from grapheme to phoneme converter
- Search space pruning:
 1. Syllable-wise similarity
 2. Open/closed syllable
 3. Semantic relevance
 4. *Borgo*-wise similarity
 5. Tail-rhyme (*anto-mil*) matching
 - Based on minimum edit distance for the final word

Semantic Relevance

- Essential for generating meaningful rhymes

Semantic Relevance

- Essential for generating meaningful rhymes
- Process:
 1. Stemming
 - Bengali shallow parser

Semantic Relevance

- Essential for generating meaningful rhymes
- Process:
 1. Stemming
 - Bengali shallow parser
 2. Translation by dictionary look-up
 - English-Bengali dictionary (Biśvās 2000)

Semantic Relevance

- Essential for generating meaningful rhymes
- Process:
 1. Stemming
 - Bengali shallow parser
 2. Translation by dictionary look-up
 - English-Bengali dictionary (Biśvās 2000)
 3. Concept matching
 - Only verbs and nouns
 - English ConceptNet (Havasi et al. 2007)

Semantic Relevance

- Essential for generating meaningful rhymes
- Process:
 1. Stemming
 - Bengali shallow parser
 2. Translation by dictionary look-up
 - English-Bengali dictionary (Biśvās 2000)
 3. Concept matching
 - Only verbs and nouns
 - English ConceptNet (Havasi et al. 2007)
 4. Relevance matching
 - Selected and given words co-occur in ConceptNet

Semantic Relevance, Example

- If the given line is:

আকাশের ময়দানে বাতাসের ভরে

ākāśēra maḃadānē bātāsēra bharē

the sky is filled with the air from the fields

- ConceptNet look-up will be for:
 - sky (আকাশ), field (ময়দান), air (বাতাস)

Semantic Relevance, Example

- If the given line is:

আকাশের ময়দানে বাতাসের ভরে

ākāśēra maḃadānē bātāsēra bharē

the sky is filled with the air from the fields

- ConceptNet look-up will be for:
 - sky (আকাশ), field (ময়দান), air (বাতাস)
- The extracted word list will contain ‘cloud’ (মেঘ)
- Originally used by Sukumar Ray in ‘Cloud Whims’:

ছোট বড় সাদা কালো কত মেঘ চরে।

chōṭa baṛa sādā kālō kata mēgha carē

many large and small, black and white clouds are grazing

Semantic Relevance, Example

- If the given line is:

আকাশের ময়দানে বাতাসের ভরে

ākāśēra maḃadānē bātāsēra bharē

the sky is filled with the air from the fields

- ConceptNet look-up will be for:

– sky (আকাশ), field (ময়দান), air (বাতাস)

- The extracted word list will contain ‘cloud’ (মেঘ)

- Originally used by Sukumar Ray in ‘Cloud Whims’:

ছোট বড় সাদা কালো কত মেঘ চরে।

chōṭa baṛa sādā kālō kata mēgha carē

many large and small, black and white clouds are grazing

“gibberish /... /not what i would call good poetry”

2. Rhyme Generation

c. Pruning and Grammaticality

1. Bi-gram matching

- Same word collection (poetry + news)
- Weights for all bi-grams (frequency / total number of unique)

2. Rhyme Generation

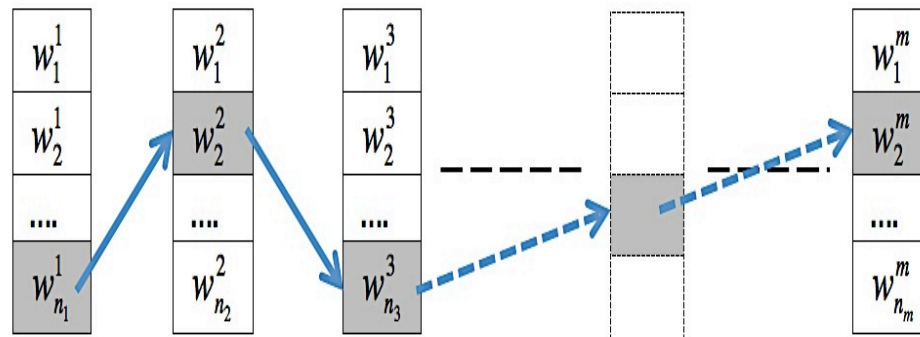
c. Pruning and Grammaticality

1. Bi-gram matching

- Same word collection (poetry + news)
- Weights for all bi-grams (frequency / total number of unique)

2. Aggregation

- Best combination = maximizing the weighted path



Evaluation: Criteria (scales 1-3)

- Poeticness
 - 3 = Rhythmic
 - 2 = Partially rhythmic
 - 1 = Not rhythmic
- Grammaticality
 - 3 = Grammically correct
 - 2 = Partially grammically correct
 - 1 = Not correct
- Meaningfulness
 - 3 = Meaningful
 - 2 = Partially meaningful
 - 1 = Not meaningful

Evaluation: Evaluators

- In-depth / three experts
 - 100 input sentences each

Evaluation: Evaluators

- In-depth / three experts
 - 100 input sentences each
 - 1. Literature student
 - Simple poem lines (from Satyendranath Dutta's work)

Evaluation: Evaluators

- In-depth / three experts
 - 100 input sentences each
 1. Literature student
 - Simple poem lines (from Satyendranath Dutta's work)
 2. Journalist
 - News line input (short, 'poetic-like' sentences)

Evaluation: Evaluators

- In-depth / three experts
 - 100 input sentences each
 1. Literature student
 - Simple poem lines (from Satyendranath Dutta's work)
 2. Journalist
 - News line input (short, 'poetic-like' sentences)
 3. Technology student
 - Modern Bengali songs (short & simple sentences)

Evaluation: Evaluators

- In-depth / three experts
 - 100 input sentences each
 1. Literature student
 - Simple poem lines (from Satyendranath Dutta's work)
 2. Journalist
 - News line input (short, 'poetic-like' sentences)
 3. Technology student
 - Modern Bengali songs (short & simple sentences)
- Ten random users
 - 5 of them: restricted input (≤ 5 words)
 - 5 of them: unlimited input length (∞)

Reasonable Output

- Poetry (Satyendranath Dutta: 'Song of the Palanquin' / 'Palkir Gan')

Reasonable Output

- Poetry (Satyendranath Dutta: ‘Song of the Palanquin’ / ‘Palkir Gan’)
 - পালকী চলে U: **Pālakī calē** *Palanquin moves!*
 - দুলাকি চালে S: **Dulaki cālē** *Trot pace*

Reasonable Output

- Poetry (Satyendranath Dutta: 'Song of the Palanquin' / 'Palkir Gan')
 - পালকী চলে U: **Pālakī calē** *Palanquin moves!*
 - দুলাকি চালে S: **Dulaki cālē** *Trot pace*
 - স্তব্ধ গাঁয়ে U: **Stabdha gām̐yē** *Stunned village*
 - রুদ্ধ দ্বারে S: **Rud'dha dbārē** *Cloggy doors*

Reasonable Output

- Poetry (Satyendranath Dutta: ‘Song of the Palanquin’ / ‘Palkir Gan’)
 - পালকী চলে U: **Pālakī calē** *Palanquin moves!*
 - দুলাকি চালে S: **Dulaki cālē** *Trot pace*
 - স্তব্ধ গাঁয়ে U: **Stabdha gām̐yē** *Stunned village*
 - রুদ্ধ দ্বারে S: **Rud'dha dbārē** *Cloggy doors*
- News (Bartanam newspaper: <http://bartamanpatrika.com>)
 - কে হবেন প্রধানমন্ত্রী ? U: **Kē habēna pradhānamantrī?**
Who will be the prime minister?
 - গদি নেওয়ার ষড়যন্ত্রী S: **Gadi nē'ōyāra ṣarayantrī**
Conspirator for the throne

Reasonable Output

- **Poetry** (Satyendranath Dutta: ‘Song of the Palanquin’ / ‘Palkir Gan’)
 - পালকী চলে U: **Pālakī calē** *Palanquin moves!*
 - দুলাকি চালে S: **Dulaki cālē** *Trot pace*
 - স্তব্ধ গাঁয়ে U: **Stabdha gām̐yē** *Stunned village*
 - রুদ্ধ দ্বারে S: **Rud'dha dbārē** *Cloggy doors*
- **News** (Bartanam newspaper: <http://bartamanpatrika.com>)
 - কে হবেন প্রধানমন্ত্রী ? U: **Kē habēna pradhānamantrī?**
Who will be the prime minister?
 - গদি নেওয়ার ষড়যন্ত্রী S: **Gadi nē'ōyāra ṣarayantrī**
Conspirator for the throne
- **Lyrics** (modern Bengali songs)
 - গভীরে যাও U: **Gabhīrē yā'ō** *Dive into the depth of your heart*
 - শুধরে নাও S: **Śudharē nā'ō** *Rectify yourself*

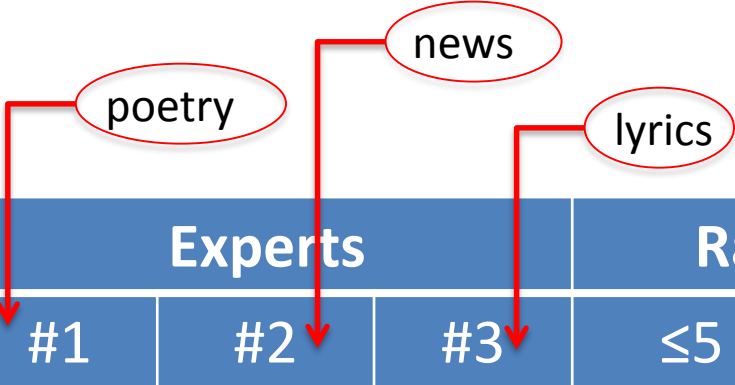
Reasonable Output

- Poetry (Satyendranath Dutta: ‘Song of the Palanquin’ / ‘Palkir Gan’)
 - পালকী চলে U: **Pālakī calē** *Palanquin moves!*
 - দুলাকি চালে S: **Dulaki cālē** *Trot pace*
 - স্তব্ধ গাঁয়ে U: **Stabdha gām̐yē** *Stunned village*
 - রুদ্ধ দ্বারে S: **Rud'dha dbārē** *Cloggy doors*
- News (Bartanam newspaper: <http://bartamanpatrika.com>)
 - কে হবেন প্রধানমন্ত্রী ? U: **Kē habēna pradhānamantrī?**
Who will be the prime minister?
 - গদি নেওয়ার ষড়যন্ত্রী S: **Gadi nē'ōyāra ṣarayantrī**
Conspirator for the throne
- LYRICS (modern Bengali songs)
 - গভীরে যাও U: **Gabhīrē yā'ō** *Dive into the depth of your heart*
 - শুধরে নাও S: **Śudharē nā'ō** *Rectify yourself*

Evaluation: Results

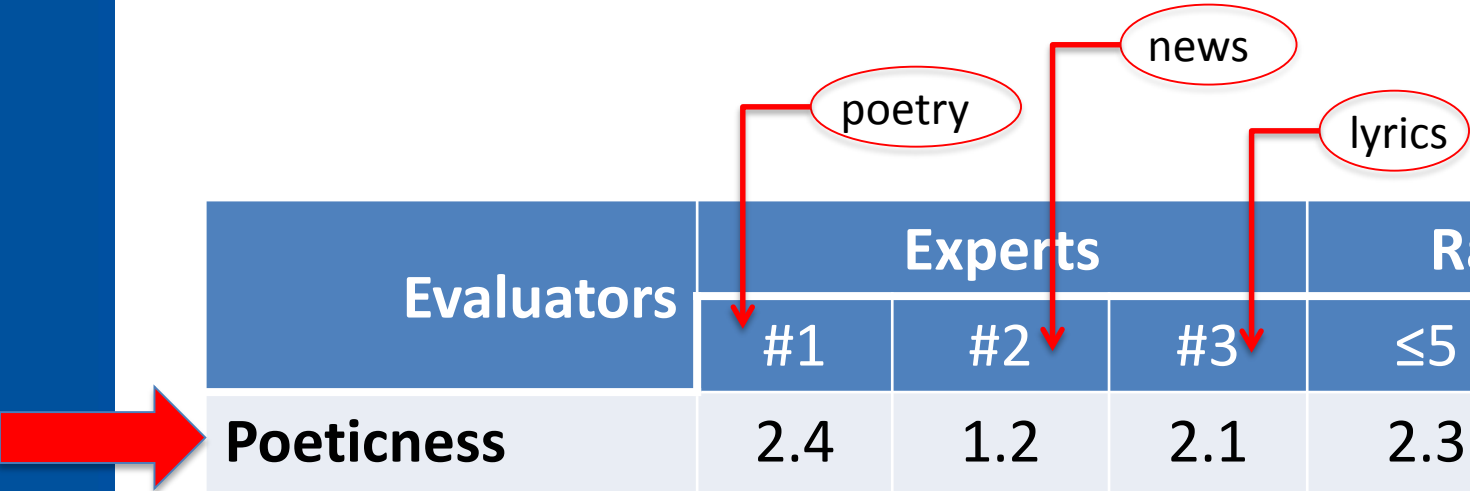
Evaluators	Experts			Random	
	#1	#2	#3	≤ 5	∞
Poeticness	2.4	1.2	2.1	2.3	1.9
Grammaticality	1.7	1.0	1.4	1.8	0.6
Meaningfulness	1.5	0.9	1.1	1.6	0.8

Evaluation: Results



Evaluators	Experts			Random	
	#1	#2	#3	≤5	∞
Poeticness	2.4	1.2	2.1	2.3	1.9
Grammaticality	1.7	1.0	1.4	1.8	0.6
Meaningfulness	1.5	0.9	1.1	1.6	0.8

Evaluation: Results



Evaluators	Experts			Random	
	#1	#2	#3	≤5	∞
Poeticness	2.4	1.2	2.1	2.3	1.9
Grammaticality	1.7	1.0	1.4	1.8	0.6
Meaningfulness	1.5	0.9	1.1	1.6	0.8

Summary

- Interactive rhyme generation
- One matching line
- Rules and metres of Bengali poesi

Summary

- Interactive rhyme generation
- One matching line
- Rules and metres of Bengali poesi

Strategy:

- Bengali syllabification engine
- SVM-based structure prediction
- Word candidates by semantic relevance (ConceptNet)
- Word selection by bi-gram pruning