Measuring Meter: Modeling Poetic Rhythm as Coupled Oscillators and Sequence Models

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Abstract

Poetic meter is both formal constraint and embodied rhythm. We present a cross■disciplinary method that (1) infers stress patterns with a sequence model, (2) maps those patterns to a simple physical system of coupled oscillators, and (3) derives an interpretable “meter energy” that quantifies tension and release. On two annotated corpora (Shakespeare sonnets; a mixed modern set), our BiLSTM■CRF achieves 92% F1 for stress labeling; the oscillatory mapping correlates with expert scansion difficulty ($\rho \approx 0.61$). We show applications to meter classification, pedagogical visualization, and constraint■aware generation.

1. Introduction

Readers feel meter as expectation—beats you can march to—and deviation—surprises that make lines sing. Literary scholars annotate stress with scansion marks; physicists describe periodic motion with oscillators. This paper connects the two: we first infer a line’s stress pattern with a standard sequence model, then interpret the pattern through a physical analogy that reveals where tension accumulates and dissipates. The goal is not to reduce poetry to physics, but to borrow a language of explainable structure that students and machines can both use.

2. Related Work

Prosody modeling spans rule■based scansion, HMM/CRF tagging, and neural sequence models. Meanwhile, physics metaphors for art (e.g., harmonics in music) offer conceptual tools for pedagogy. Our contribution is to pair a competitive tagger with an explicit, low■parameter physical model that yields an interpretable score.

3. Data & Preprocessing

We compile two corpora: (i) Sonnets: 154 Shakespeare sonnets (~2k lines) with canonical iambic annotations; (ii) Modern: 1.2k lines from 20th/21st■century poets with crowd■sourced scansion cross■checked by two annotators ($\kappa=0.78$). Tokens are syllabified (heuristics + CMUdict), lowercased, and enriched with POS and lexical stress priors.

4. Method — 4.1 Stress Tagger

We train a BiLSTM■CRF to predict syllable■level stress ($y_t \in \{0,1\}$) given features (syllable, POS, word shape, lexicon prior, position in foot). The model slightly outperforms an HMM baseline and matches a transformer miniature on this scale while remaining fast and lightweight.

4. Method — 4.2 Oscillator Mapping

We model each foot as a damped harmonic oscillator with natural frequency tied to the expected metrical pattern (e.g., iamb: unstress→stress). Let ■_t be predicted stress; define displacement d_t = ■_t – y*_t, where y*_t is the ideal stress (0/1) for the target meter. Define per■line meter energy: E = Σ_t k d_t^2 + c(d_t – d_{t–1})^2 with spring constant k and coupling term c encouraging smooth transitions. Intuitively, E rises with substitutions (e.g., trochaic inversion), catalexis, or syncopation, and falls when the line settles into pattern.

4. Method — 4.3 Interpretability Layer

We align spikes in E with tokens to explain where and why tension appears (“spondee at black night”, “feminine ending”). A simple rule set labels common phenomena for teaching.

5. Experiments

Stress Labeling: BiLSTM■CRF reaches 92.1 F1 (Sonnets) and 88.3 F1 (Modern), beating HMM by +6–9 F1. Meter Classification (iambic vs trochaic vs free): logistic regression on summary features of E hits 91.5% accuracy. Pedagogy Study (pilot): 24 students used a prototype energy overlay in a scansion exercise; quiz scores improved by +14% vs. control, and confidence self■reports increased.

6. Applications

Teaching: Visualize meter energy atop text; click spikes to reveal labeled phenomena. Editing: Poets can tune line endings by observing how E responds to word choice. Generation: A small language model with a penalty for high E produces more metrical lines without rigid templates.

7. Discussion & Limitations

The oscillator analogy foregrounds periodicity but abstracts away semantics and prosodic nuance (intonation, speech rate). Our corpora are small and English■centric. Future work: multilingual meter, prosody■aware TTS evaluation, and human■in■the■loop authoring tools.

8. Conclusion

By combining a practical stress tagger with a physically interpretable energy score, we offer a common vocabulary for scholars, students, and models. Meter becomes something you can see and adjust, not just memorize.

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