Novelty Assessment Report

Paper: GoR: A Unified and Extensible Generative Framework for Ordinal Regression

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Abstract

Ordinal Regression (OR), which predicts the target values with inherent order, underpins a wide spectrum of applications from computer vision to recommendation systems. The intrinsic ordinal structure and non-stationary inter-class boundaries make OR fundamentally more challenging than conventional classification or regression. Existing approaches, predominantly based on Continuous Space Discretization (CSD), struggle to model these ordinal relationships, but are hampered by boundary ambiguity. Alternative rank-based methods, while effective, rely on implicit order dependencies and suffer from the rigidity of fixed binning.

Inspired by the advances of generative language models, we propose **G**enerative **O**rdinal **R**egression (**GoR**), a novel generative paradigm that reframes OR as a sequential generation task. GoR autoregressively predicts ordinal segments until a dynamic ⟨EOS⟩, explicitly capturing ordinal dependencies while enabling adaptive resolution and interpretable step-wise refinement. To support this process, we theoretically establish a bias–variance decomposed error bound and propose the **Co**verage–**Di**stinctiveness Index (**CoDi**), a principled metric for vocabulary construction that balances quantization bias against statistical variance. The GoR framework is model-agnostic, ensuring broad compatibility with arbitrary task-specific architectures. Moreover, it can be seamlessly integrated with established optimization strategies for generative models at a negligible adaptation cost. Extensive experiments on **17** diverse ordinal regression benchmarks across **six** major domains demonstrate GoR's powerful generalization and consistent superiority over state-of-the-art OR methods.

Core Task Landscape

This paper addresses: **Predicting Ordinal Values with Inherent Order Relationships**

A total of **50 papers** were analyzed and organized into a taxonomy with **28 categories**.

Taxonomy Overview

The research landscape has been organized into the following main categories:

- **Ordinal Regression Methodologies and Theoretical Foundations**
- **Domain-Specific Applications of Ordinal Prediction**
- **Data Representation and Encoding for Ordinal Tasks**
- **Multivariate and Multi-Attribute Ordinal Modeling**
- **Ordinal Prediction with Auxiliary Information**

Complete Taxonomy Tree

- Predicting Ordinal Values with Inherent Order Relationships Survey Taxonomy
- Ordinal Regression Methodologies and Theoretical Foundations
  - Core Ordinal Regression Algorithms and Loss Functions
  - Generative and Autoregressive Ordinal Models ★ (3 papers)
    - [0] GoR: A Unified and Extensible Generative Framework for Ordinal Regression (Anon et al., 2026) View paper
    - [8] Parameterized Diffusion Optimization enabled Autoregressive Ordinal Regression for Diabetic Retinopathy Grading (Yu, 2025) View paper
    - [23] Ord2Seq: Regarding Ordinal Regression as Label Sequence Prediction (Jinhong Wang, 2023) View paper
  - Discriminative Models with Ordinal Constraints (3 papers)
    - [7] Ordinalclip: Learning rank prompts for language-guided ordinal regression (Li Wanhua, 2022) View paper
    - [10] Deep neural networks for rank-consistent ordinal regression based on conditional probabilities (Xintong Shi, 2023) View paper
    - [14] Meta Ordinal Regression Forest for Medical Image Classification With Ordinal Labels (Lei Yiming, 2022) View paper
  - Loss Function Design for Ordinal Tasks (2 papers)
    - [22] SLACE: A Monotone and Balance-Sensitive Loss Function for Ordinal Regression (Gal, 2025) View paper
    - [33] Soft labels for ordinal regression (Raul Diaz, 2019) View paper
  - Ranking-Based and Distance Metric Approaches (3 papers)
    - [4] Ordinal regression with explainable distance metric learning based on ordered sequences (Juan Luis SuÃ¡rez, 2021) View paper
    - [15] Structure-guided ranking loss for single image depth prediction (Ke Xian, 2020) View paper
    - [24] Robust Ordinal Regression: User Credit Grading with Triplet Loss-Based Sampling (Jing Zhang, 2021) View paper
  - Surveys and Comparative Studies of Ordinal Methods (2 papers)
  - [2] Ordinal regression methods: survey and experimental study (Pedro Antonio GutiÃ©rrez, 2015) View paper
  - [19] Old but Gold or New and Shiny? Comparing Tree Ensembles for Ordinal Prediction with a Classic Parametric Approach (P. Buczak, 2024) View paper
  - Uncertainty Quantification in Ordinal Prediction (1 papers)

- [9] Aleatoric and Epistemic Uncertainty Measures for Ordinal Classification through Binary Reduction (Haas, 2025) View paper
- Parametric Statistical Models for Ordinal Data
- Proportional Odds and Probit Models (4 papers)
  - [5] Regression models for ordinal outcomes (Benjamin French, 2022) View paper
  - [25] Ordered probit Bayesian additive regression trees for ordinal data (Jaeyong Lee, 2024) View paper
  - [30] Regression with an ordered categorical response (Trevor Hastie, 1989) View paper
  - [31] Regression models for ordinal data (Valen E. Johnson, 1980) View paper
- Tutorials and Methodological Guidance (2 papers)
  - [16] Ordinal regression models made easy: A tutorial on parameter interpretation, data simulation and power analysis. (AltoÃ¨, 2024) View paper
  - [21] Ordinal regression models in psychological research: A tutorial (PC BÃ¼rkner, 2018) View paper
- Design Considerations for Ordinal Scales (2 papers)
  - [28] The number of response categories in ordered response models (M. Iannario, 2022) View paper
  - [37] Power properties of ordinal regression models for Likert type data (Ulf, 2022) View paper
- Tree-Based and Ensemble Methods for Ordinal Regression (3 papers)
- [20] Prediction of Turfgrass Quality Using Multispectral UAV Imagery and Ordinal Forests: Validation Using a Fuzzy Approach (Alexander Hernandez, 2024) View paper
- [34] OGBoost: A Python Package for Ordinal Gradient Boosting (Sharabiani, 2025) View paper
- [40] Random forest for ordinal responses: prediction and variable selection (Silke Janitza, 2016) View paper
- Counterfactual Inference and Causal Ordinal Modeling (1 papers)
- [17] Learning Counterfactual Outcomes Under Rank Preservation (Wu Peng, 2025) View paper

- Domain-Specific Applications of Ordinal Prediction
  - Medical and Healthcare Applications (4 papers)
  - [1] Symmetric perception and ordinal regression for detecting scoliosis natural image (Zhu Xiao-jia, 2025) View paper
  - [3] Forecasting mental states in schizophrenia using digital phenotyping data (Thierry Jean, 2025) View paper
  - [29] Functional Outcome Prediction in Acute Ischemic Stroke Using a Fused Imaging and Clinical Deep Learning Model (Yongkai Liu, 2023) View paper
  - [46] Deep transformation models for functional outcome prediction after acute ischemic stroke (Herzog, 2022) View paper
  - Social Sciences and Behavioral Data Analysis (2 papers)
  - [6] Analyzing ordinal data with metric models: What could possibly go wrong? (TM Liddell, 2018) View paper
  - [12] Improved Text Emotion Prediction Using Combined Valence and Arousal Ordinal Classification (Chalamandaris, 2024) View paper
  - Engineering and Infrastructure Assessment (2 papers)
  - [32] Bitemporal Attention Transformer for Building Change Detection and Building Damage Assessment (Wen Lu, 2024) View paper
  - [38] Prediction of bridge component ratings using ordinal logistic regression model (Pan Lu, 2019) View paper
  - Computer Vision and Image Analysis (1 papers)
  - [26] Language-Driven Ordinal Learning for Imbalanced Head Pose Estimation (Yaoxing Wang, 2024) View paper
  - Time-Series Ordinal Classification (1 papers)
  - [44] Convolutional- and Deep Learning-Based Techniques for Time Series Ordinal Classification (Rafael Ayllon-Gavilan, 2023) View paper
  - Transportation and Safety Applications (1 papers)
  - [50] Crash Injury Severity Prediction Using an Ordinal Classification Machine Learning Approach (Sheng-Shuo Zhu, 2021) View paper
  - Software Engineering and Quality Prediction (1 papers)
  - [47] A novel multiâ□□view ordinal classification approach for software bug prediction (Pelin Yildirim Taser, 2022) View paper
  - Environmental and Agricultural Prediction (3 papers)
  - [27] Privacyâ□□preserving peak time forecasting with Learning to Rank XGBoost and extensive feature engineering (Leo Semmelmann, 2023) View paper
  - [43] Using Bayesian threshold model and machine learning method to improve the accuracy of genomic prediction for ordered categorical traits in fish (Hailiang Song, 2023) View paper
  - [48] Wind speed prediction using ordinal classification: an analysis of extreme values (David Guijo-Rubio, 2025) View paper
  - Business and Decision Support Systems (2 papers)
  - [18] Smart system for forecasting financial outcomes and supporting strategic choices (Fengwei Lang, 2025) View paper
  - [35] Forecasting demand for new products: Combining subjective rankings with sales data (Marat Salikhov, 2021) View paper
  - Ranking and Selection Problems (1 papers)
  - [45] Learning from outcomes: Evidence-based rankings (C. Dwork, 2019) View paper
  - Epidemic and Public Health Forecasting (1 papers)
  - [42] Forecasting regionalCOVID-19 hospitalisation in England using ordinal machine learning method (Haowei Wang, 2025) View paper
  - Short-Term Prediction and Cognitive Modeling (1 papers)
  - [49] Short-term prediction through ordinal patterns (Neuman, 2021) View paper
- Data Representation and Encoding for Ordinal Tasks
  - Ordinal Encoding and Embedding Techniques (1 papers)
  - [11] Efficient Unicode Ordinal Values for Text Embedding with FastText and Word2Vec (Agnij Moitra, 2024) View paper
  - Conformal and Probabilistic Prediction for Ordinal Data (1 papers)
  - [41] Conformal prediction sets for ordinal classification (P Dey, 2023) View paper
- Multivariate and Multi-Attribute Ordinal Modeling
  - Multiple Ordinal Regression and Combined Modeling (1 papers)
  - [13] Multiple regression with multiple category nominal or ordinal measures (David Weisburd, 2021) View paper
  - Multi-Attribute Decision-Making with Ordinal Preferences (1 papers)
  - [39] Generalized Ordinal Priority Approach for Multi-Attribute Decision-Making under Incomplete Preference Information (Wang RenLong, 2024) View paper

- Ordinal Prediction with Auxiliary Information (1 papers)
  - [36] Predicting ordinal relations (Norman Cliff, 1994) View paper

Narrative

Core task: predicting ordinal values with inherent order relationships. The field organizes around several complementary perspectives. Ordinal Regression Methodologies and Theoretical Foundations encompasses core algorithms, loss functions, and generative or autoregressive formulations that respect rank structure, as seen in works like GoR Ordinal Regression[0] and Ord2Seq[23]. Domain-Specific Applications of Ordinal Prediction translate these methods into areas such as medical diagnosis (Forecasting Schizophrenia States[3], Diffusion Diabetic Retinopathy[8]) and infrastructure assessment. Data Representation and Encoding for Ordinal Tasks addresses how to embed or transform ordinal labels—ranging from soft-label schemes (Soft Labels Ordinal[33]) to vision-language approaches (OrdinalCLIP[7])—while Multivariate and Multi-Attribute Ordinal Modeling tackles settings with multiple interacting ordinal outcomes. Finally, Ordinal Prediction with Auxiliary Information explores leveraging side data or uncertainty estimates (Uncertainty Ordinal Classification[9]) to improve predictions.

Within the methodological core, a key tension emerges between threshold-based models rooted in classical cumulative-link ideas (Ordinal Regression Survey[2], Ordinal Data Regression[31]) and newer generative or sequence-based paradigms that treat ordinal prediction as a structured generation problem. GoR Ordinal Regression[0] sits squarely in the latter camp, proposing a generative autoregressive framework that contrasts with traditional threshold approaches and aligns closely with Ord2Seq[23], which also frames ordinal labels as sequences. Nearby works like Diffusion Diabetic Retinopathy[8] explore diffusion-based generative strategies for ordinal medical imaging, highlighting a broader shift toward probabilistic generation. Meanwhile, methods emphasizing explainability (Explainable Distance Ordinal[4]) or robust loss design (SLACE Monotone Loss[22]) offer alternative angles on enforcing ordinality. The original paper thus contributes to an active line of research reimagining ordinal regression through generative modeling, offering a fresh perspective on capturing rank dependencies beyond classical cumulative models.

Related Works in Same Category

The following **2 sibling papers** share the same taxonomy leaf node with the original paper:

1. Parameterized Diffusion Optimization enabled Autoregressive Ordinal Regression for Diabetic Retinopathy Grading

Authors: Yu, Qinkai, Zhou Wei, Qinkai Yu, Liu Han-tao, et al. (24 authors total) | **Year/Venue**: 2025 | **URL**: View paper

Abstract

As a long-term complication of diabetes, diabetic retinopathy (DR) progresses slowly, potentially taking years to threaten vision. An accurate and robust evaluation of its severity is vital to ensure prompt management and care. Ordinal regression leverages the underlying inherent order between categories to achieve superior performance beyond traditional classification. However, there exist challenges leading to lower DR classification performance: 1) The uneven distribution of DR severity level...

Relationship Analysis

Both papers belong to the generative and autoregressive ordinal models category, employing sequential generation approaches to predict ordinal values. They overlap in using autoregressive mechanisms to capture ordinal dependencies: GoR generates ordinal segments via token sequences with dynamic termination for general ordinal regression tasks, while AOR-DR decomposes diabetic retinopathy grading into sequential binary classification steps using diffusion-based conditional probability modeling. The key difference is that GoR proposes a unified, model-agnostic framework with vocabulary construction (CoDi) for diverse domains, whereas AOR-DR focuses specifically on medical image grading with diffusion optimization to handle long-tailed distributions and class boundary ambiguity in DR datasets.

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2. Ord2Seq: Regarding Ordinal Regression as Label Sequence Prediction

Authors: Jinhong Wang, Yi Cheng, Jintai Chen, Tingting Chen, Danny Chen, et al. (7 authors total) | **Year/Venue**: 2023 | **URL**: View paper

Abstract

Ordinal regression refers to classifying object instances into ordinal categories. It has been widely studied in many scenarios, such as medical disease grading and movie rating. Known methods focused only on learning inter-class ordinal relationships, but still incur limitations in distinguishing adjacent categories thus far. In this paper, we propose a simple sequence prediction framework for ordinal regression called Ord2Seq, which, for the first time, transforms each ordinal category label i...

Relationship Analysis

Both papers belong to the generative and autoregressive ordinal models category, employing sequence generation approaches to ordinal regression. They overlap in transforming ordinal regression into sequential prediction tasks that capture ordinal dependencies through autoregressive mechanisms. However, GoR uses a vocabulary-based token generation framework with dynamic EOS termination and adaptive resolution for continuous ordinal values, while Ord2Seq transforms ordinal categories into fixed binary label sequences, decomposing the task into recursive binary classification steps primarily for discrete ordinal categories.

Contributions Analysis

Overall novelty summary. The paper proposes Generative Ordinal Regression (GoR), which reframes ordinal regression as an autoregressive sequence generation task, predicting ordinal segments until a dynamic end-of-sequence token. This work resides in the 'Generative and Autoregressive Ordinal Models' leaf, which contains only three papers total including the original. The leaf sits within a broader taxonomy of 50 papers across ordinal regression methodologies, indicating this generative paradigm represents a relatively sparse but emerging research direction compared to more established threshold-based or discriminative approaches.

The taxonomy reveals that GoR's immediate neighbors include Ord2Seq, which also treats ordinal labels as sequences, and diffusion-based generative methods for medical imaging. The broader parent branch encompasses discriminative models with ordinal constraints, loss function design, and ranking-based approaches—each containing two to three papers. Adjacent branches cover parametric statistical models (proportional odds, probit) with eight papers and tree-based methods with three papers, suggesting the field remains anchored in classical threshold models while generative formulations represent a newer, less crowded frontier.

Among nine candidates examined through limited semantic search, none clearly refute the three main contributions. The GoR framework itself was compared against three candidates with no overlapping prior work identified. The Coverage–Distinctiveness Index (CoDi) for vocabulary construction examined four candidates without finding refutation. The theoretical MSE error bound analysis reviewed two candidates, again with no clear precedent. This suggests the specific combination of autoregressive generation, adaptive resolution, and principled vocabulary metrics may be novel within the examined scope, though the search scale remains modest.

The analysis reflects a constrained literature search rather than exhaustive coverage, examining fewer than ten semantically similar papers. While the generative autoregressive approach appears distinctive within this limited sample and the sparse taxonomy leaf, the field's broader structure shows active development in adjacent discriminative and loss-based methods. The work's novelty appears strongest in its specific generative formulation and vocabulary construction metric, though comprehensive assessment would require examining additional candidates beyond the top-K semantic matches.

This paper presents **3 main contributions**, each analyzed against relevant prior work:

Contribution 1: Generative Ordinal Regression (GoR) framework

Description: The authors introduce GoR, a framework that reformulates ordinal regression as an autoregressive sequence generation task. The model predicts ordinal value segments as tokens until generating a dynamic end-of-sequence token, explicitly capturing ordinal dependencies while enabling adaptive resolution and interpretable step-wise refinement.

This contribution was assessed against **3 related papers** from the literature. Papers with potential prior art are analyzed in detail with textual evidence; others receive brief assessments.

1. Distribution-based discretisation and ordinal classification applied to wave height prediction

URL: View paper

Brief Assessment

Distribution Based Discretisation[59] focuses on wave height prediction using discretization and ordinal classification methods. The candidate's brief mentions of 'autoregressive structure' and 'ordinal regression models' lack sufficient detail to demonstrate prior work on reformulating ordinal regression as an autoregressive sequence generation task with dynamic end-of-sequence tokens and adaptive resolution.

2. Dynamic Spatio-Temporal Sequential Ordinal Models: Application to Invasive Weeds

URL: View paper

Brief Assessment

Spatio Temporal Ordinal[58] addresses spatio-temporal ordinal data using sequential ordinal models for vegetation ecology, not autoregressive sequence generation for general ordinal regression with adaptive resolution.

3. Scalable Autoregressive Monocular Depth Estimation

URL: View paper

Brief Assessment

Autoregressive Monocular Depth[57] focuses on monocular depth estimation using autoregressive prediction with spatial (low-to-high resolution) and ordinal (coarse-to-fine granularity) objectives. The original paper proposes a general framework for ordinal regression across diverse domains (age estimation, aesthetic assessment, recommendation systems), not depth estimation specifically.

Contribution 2: Coverage–Distinctiveness Index (CoDi) for vocabulary construction

Description: The authors develop CoDi, a metric that guides vocabulary design by balancing coverage (minimizing quantization bias) and distinctiveness (reducing statistical variance). This metric is grounded in a theoretical bias-variance decomposition that establishes a closed-form MSE error bound for the generative ordinal regression task.

This contribution was assessed against **4 related papers** from the literature. Papers with potential prior art are analyzed in detail with textual evidence; others receive brief assessments.

1. Learning a fine vocabulary

URL: View paper

Brief Assessment

Learning Fine Vocabulary[54] focuses on clustering-based spatial embedding for quantization in a different context. The candidate does not address vocabulary construction metrics balancing coverage and distinctiveness for ordinal regression tasks.

2. Building descriptive and discriminative visual codebook for large-scale image applications

URL: View paper

Brief Assessment

Visual Codebook Building[56] focuses on visual vocabulary construction for image retrieval using clustering-based methods and spatial coding. It does not present a bias-variance decomposition framework or a metric balancing quantization bias and statistical variance for vocabulary design in ordinal regression contexts.

3. Learning vocabularies over a fine quantization

URL: View paper

Brief Assessment

Fine Quantization Vocabularies[53] focuses on visual descriptor quantization for image retrieval, not ordinal regression vocabulary design. The candidate's vocabulary construction addresses quantization errors in feature space, while the original paper's CoDi metric balances coverage and distinctiveness for ordinal value segmentation in generative regression tasks.

4. Vocabulary hierarchy optimization for effective and transferable retrieval

URL: View paper

Brief Assessment

Vocabulary Hierarchy Optimization[55] addresses hierarchical quantization errors in visual vocabularies for image retrieval, not ordinal regression. The candidate's density-based metric learning corrects quantization bias in visual word generation, while CoDi balances coverage and distinctiveness for ordinal value segmentation in a generative framework—fundamentally different problem domains and theoretical foundations.

Contribution 3: Theoretical analysis of rank-based methods and MSE error bound

Description: The authors provide a theoretical characterization of the limitations of rank-based continuous space discretization methods through conditional independence analysis. They also derive an MSE error bound via bias-variance decomposition that quantifies the trade-off between token selection, sequence length, and prediction accuracy.

This contribution was assessed against **2 related papers** from the literature. Papers with potential prior art are analyzed in detail with textual evidence; others receive brief assessments.

1. Rank-1 Matrix Approximation-Based Channel Estimation for Intelligent Reflecting Surface-Aided Multi-User MISO Communications

URL: View paper

Brief Assessment

Rank Matrix Channel Estimation[52] focuses on IRS channel estimation using rank-1 matrix approximations for wireless communications, not on rank-based continuous space discretization methods for ordinal regression. The MSE bound derived in the candidate addresses channel estimation error, not the bias-variance trade-off in token selection for generative ordinal regression.

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2. A multi-breakpoints approach for symbolic discretization of time series

URL: View paper

Brief Assessment

Multi Breakpoints Discretization[51] focuses on symbolic discretization of time series data using multiple breakpoints, not on rank-based continuous space discretization methods or MSE error bounds for ordinal regression. The candidate addresses a different problem domain (time series discretization) with different objectives than the original paper's theoretical analysis of ordinal regression methods.

Appendix: Text Similarity Detection

No high-similarity text segments were detected across any compared papers.

References

- [0] GoR: A Unified and Extensible Generative Framework for Ordinal Regression View paper
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