ICDAR 2019 CROHME + TFD: Competition on Recognition of Handwritten Mathematical Expressions and Typeset Formula Detection

Mahshad Mahdavi, Richard Zanibbi
Document and Pattern Recognition Lab
Rochester Institute of Technology
Rochester, NY, USA
mxm7832@rit.edu
rxzvcs@rit.edu

Harold Mouchère,
Christian Viard-Gaudin
LS2N - UMR CNRS 6004
University of Nantes
Nantes, France
harold.mouchere@ls2n.fr
christian.viard-gaudin@ls2n.fr

Utpal Garain
Computer Vision and Pattern Recognition Unit
Centre for Artif. Intel. and Mach. Leaning
Indian Statistical Institute
Kolkata, India
utpal@isical.ac.in

***Abstract*—We summarize the tasks, protocol, and outcome for the 6th Competition on Recognition of Handwritten Mathematical Expressions (CROHME), which includes a new formula detection in document images task (+ TFD). For CROHME + TFD 2019, participants chose between two tasks for recognizing handwritten formulas from 1) online stroke data, or 2) images generated from the handwritten strokes. To compare LaTeX strings and the labeled directed trees over strokes (label graphs) used in previous CROHMEs, we convert LaTeX and stroke-based label graphs to label graphs defined over symbols (symbol-level label graphs, or *symLG*). More than thirty (33) participants registered for the competition, with nineteen (19) teams submitting results. The strongest formula recognition results were produced by the USTC-iFLYTEK research team, for both stroke-based (81%) and image-based (77%) input. For the new typeset formula detection task, the Samsung R&D Institute Ukraine (Team 2) obtained a very strong F-score (93%). System performance has improved since the last CROHME - still, the competition results suggest that recognition of handwritten formulae remains a difficult structural pattern recognition task.**

***Index Terms*—mathematical expression recognition, handwriting recognition, formula detection, performance evaluation**

I. Introduction

During its history, the CROHME competition has advanced the state-of-the-art for handwritten math recognition systems, and produced a standard benchmark for online handwritten math recognition research. An IJDAR paper summarizing the outcomes and innovations in evaluating handwritten mathematical recognition during the first four years of the competition (2011-2014, 2016) is available [1], [2]. CROHME data has been used by research groups from around the world.

This sixth edition of CROHME was organized to continue encouraging activities in handwritten math recognition research, and to improve the available data, tools and benchmarks for research in this area. In CROHME 2019, there are three tasks: 1) online handwritten formula recognition (from strokes), 2) offline handwritten formula recognition (from images generated using strokes), and 3) typeset formula detection in document images.

To accommodate the growing number of encoder-decoder formula recognition systems producing LaTeX as output, in this edition we consider only symbolic formula structure, rather than in previous CROHMEs where systems were evaluated at the stroke level. For this purpose, we developed a new Symbolic Label Graph (symLG) representation that can be used with the existing evaluation tools for the competition (LgEval and CROHMELib).

Thirty-three (33) groups and individuals registered for the competition, and nineteen (19) groups submitted results. For the main task (online handwritten formula recognition), the highest recognition rate is 13% higher than in CROHME 2016 (67.65% vs. 80.73%). While encouraging, these rates suggest that recognizing handwritten math remains a difficult problem, likely due to the high number of symbol classses (101 for CROHME), and the complex two dimensional structure of math, which can include recursive and hierarchical structures.

In the following Sections we describe the competition tasks, dataset collection and encodings, evaluation metrics and tools, system descriptions, results, and then provide a brief conclusion.

II. Tasks

Task 1. Online Handwritten Formula Recognition. For the main task in CROHME, participants convert a list of handwritten strokes captured from a tablet or similar device to a Symbol Layout Tree (SLT) [3]. Participating systems are ranked based on the number of correctly recognized formulas (expression rate).

- **Task 1a (symbols)**: subtask where participants recognize isolated symbols, including 'junk' (invalid symbols). Ranked by symbol recognition rate.
- **Task 1b (parsing from provided symbols)**: subtask where participants parse formulas from provided symbols (stroke groups + labels). Ranked by expression rate.

Task 2. Offline Handwritten Formula Recognition. Strokes from the handwritten formulas in Task 1 are used