Implementation of a Portal Dedicated to Higgs Bosons for Experts and the General Public

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Introduction

- The implementation of a web portal dedicated to Higgs boson research is presented.
- A database is created with more than 1000 relevant articles using CERN Document Server API and web scraping methods.
- The database is automatically updated when new results on the Higgs boson become available.
- Using natural language processing, the articles are categorised according to properties of the Higgs boson and other criteria.
- The process of designing and implementing the Higgs Boson Portal (HBP) is described in detail.
- The components of the HBP are deployed to CERN Web Services using the OpenShift cloud platform.
- The web portal is operational and freely accessible on http://cern.ch/higgs.

Higgs Boson Research

- 1989 – 2000: CERN – Large Electron-Positron Collider
  - ALEPH
  - DELPHI
  - L3
  - OPAL
- 1987 – 2011: Fermilab – Tevatron Collider
  - CDF
  - D0
- 2010 – present: CERN – Large Hadron Collider
  - ATLAS
  - CMS

Research Resources

- 1000+ scientific publications (experimental results)
- Various types of experiments
- Various publishing methods
- New results each week/day
- Large number of articles – important to create a categorisation system

Goals

- Easy access to publications
- Collection and categorization
- Visualisation of development precisions
- Bringing the research closer to the public

Collecting data

Which data?

- Publications – title, abstract, tables, graphs.
- Measured values – masses, production modes, decay modes. . .

How?

- Fermilab (old websites) – web scraping
- CERN – CERN Document Server API
- Measured values – extract from text

Categorisation

- Goal of the publication
  - Experimental measurement
  - Search for “new physics”
- Observed events
  - Higgs boson production
  - Higgs boson decay
- Other properties
  - Number of collisions (luminosity)
  - Collision energy
  - Experiment
  - Current stage (preliminary, submitted, published)

Natural Language Processing

Vocabulary varies by the type of experiment

- Standard Model vs “new physics”
- Naive Bayes classifier
- Relies on the frequency of certain words
- No need to specify the words beforehand
- Training examples
- Tokenization, stopwords, lemmatization
- Python, scikit-learn, nltk

Numeric values and keywords detection

- Plain searching – ineffective
- Named Entity Recognition
- English corpus
- AI learns to recognize written text patterns
- Further algorithmic processing

NLP example of article title:

Search for charged Higgs bosons produced via vector boson fusion and decaying into a pair of W and Z bosons using proton-proton collisions at $\sqrt{s}$ = 13TeV.

Application

- Categorisation model
- Manual training
- Training and testing set ∼100 articles
- Standard F1-score

Categorization results

- True Positives: TP
- False Positives: FP
- False Negatives: FN

Precision = TP/(TP+FP)

Recall = TP/(TP+FN)

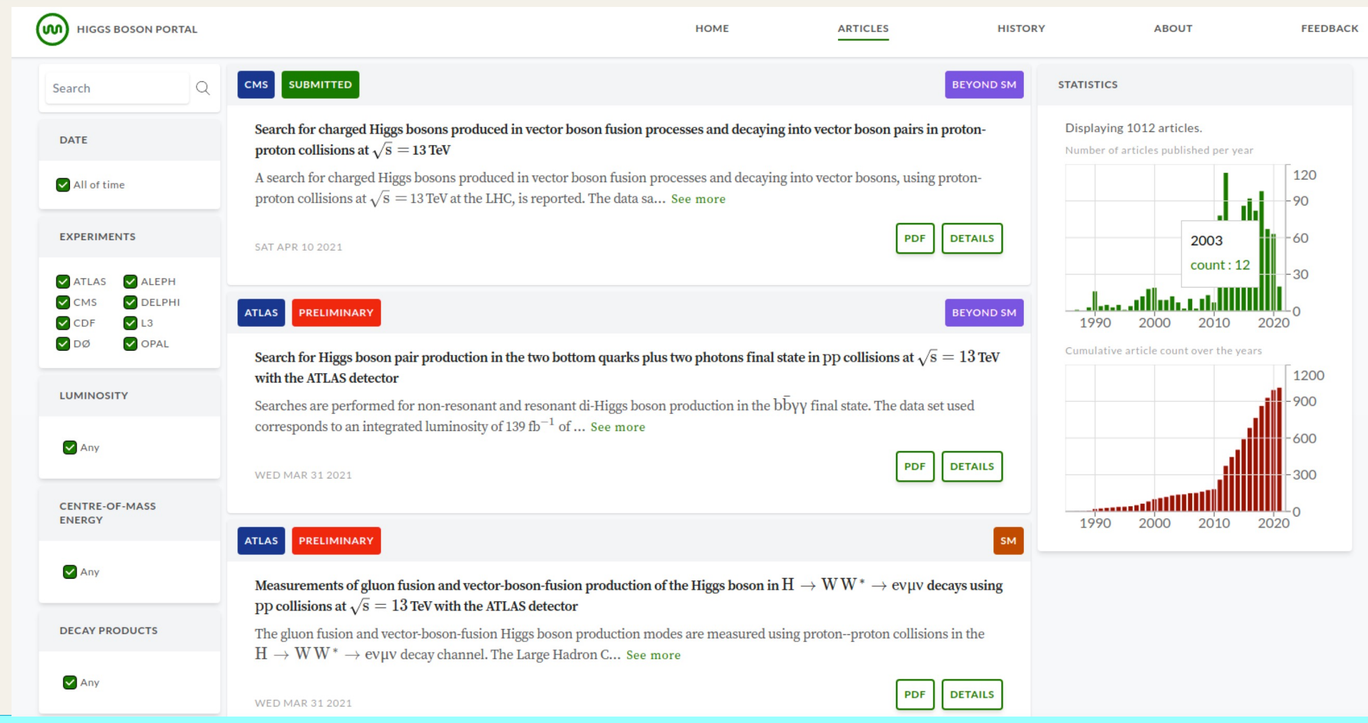
F1 score = 2 P*R/(P+R)

Category	Precision (%)	Recall (%)	F_1-score (%)
Luminosity	96	88	92
Energy	100	85	92
Production mode	87	85	86
Decay mode	81	79	80

Web Application

- User Interface and administration
- Administrator can adjust NLP categorization
- Categorised publications stored in a database – MongoDB
- Daily updates – Python cron jobs
- API – Flask
- UI and administration – React.js, Tailwind.css

User Interface



References/Acknowledgements

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- 18th International Masterclasses 2022, https://physicsmasterclasses.org

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