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Algorithm Categories

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- Association rule learning
- Artificial neural networks
- Inductive logic programming
- Support vector machines
- Clustering
- Bayesian networks
- Reinforcement learning
- Representation learning
- Similarity and metric learning
- Sparse dictionary learning
- Genetic algorithms

Algorithms and Applications by Field/Industry

- Telecommunications
  - 5G
  - IoT
  - Autonomous vehicles
  - Smart cities
  - Engagement insights whose info is sold back to advertisers
- Marketing
  - Segmentation
  - Ranking/scoring
  - Market basket analysis > location and promotions of items
  - Cohort analysis and segmentation > targeted marketing
  - Customer churn prediction > churn prevention
  - Customer lifetime value forecasting > future business value and predicting growth
  - Targeted and personalized advertising
  - Companies
    - Appier
    - Voyager Labs
- Sales
  - Revenue forecasting and growth
- Security intelligence (security, fraud, and risk analysis)
- Customer relationship management
- AR and VR
- Gaming
  - Examples
    - AlphaGo (Monte-Carlo Tree Search)
    - DeepBlue
    - Watson Jeapordy
- Health care
- Insurance

- Retail
  - Recommendation engines
  - Virtual reality fitting systems
  - Shopping experience
- Autonomous transportation
  - Companies
    - Google
    - Apple
    - Uber
    - Lyft
    - Tesla
    - Waymo

Algorithms and Applications by Data Type

Ref [2]

- Sound/Audio
  - Voice detection/recognition
  - Voice search
  - Speaker identification
  - Sentiment analysis
  - Flaw detection (engine noise)
  - Fraud detection (latent audio artifacts)
  - Speech-to-Text
- Time Series/sequence
  - Log analysis/Risk detection
  - Enterprise resource planning
  - Predictive analysis using sensor data
  - Business and economic analysis
  - Recommendation engine
  - Examples and algorithms
    - Web log
      - RNN
    - Time series in general (has time stamp)
      - RNN
    - Sensors and measures over time
      - RNN
    - Arbitrarily long sequence that may take full input data
      - RNN
      - Markova model with large hidden state space
    - Fixed length sequence
      - CNN
      - Multilayer perceptron
- Text
  - Sentiment analysis
  - Augmented search, theme detection
  - Threat detection
  - Fraud detection
  - Named-entity recognition

- Image
  - Facial recognition and expression recognition
  - People identification
  - Image search
  - Machine vision
  - Photo clustering
  - Image recognition/classification
    - Is it a certain class or multiple classes (e.g., cat, car, ...)
  - Object recognition and detection
    - Detection is the location of the recognized object in the image (i.e., localization)
      - Output is bounding box (b_x, b_y, b_h, B_w), is object recognized in image, and class label(s)
      - Loss function calculation depends on whether the object is detected in the image
      - Sliding window detection (window size and stride)
        - Pass window as input to CNN
  - Landmark detection
    - X,Y point pairs representing individual landmarks in the image
    - Useful for emotion detection, filters, pose detection, ...
  - Algorithms
    - CNN
- Video
  - Motion detection
  - Real-time threat detection
  - Gesture recognition
- Unlabeled and/or unstructured data
  - Clustering
  - Anamoly detection (detecting anamolies)
  - Search (detecting similarities)
    - Compare docs, images, sounds, etc., and return similar items
- Labeled data
  - Predictive analytics
    - Regression and classification
      - Hardware failure
      - Health degredation, failure, and disease
      - Customer churn
      - Employee churn
- Columnar/tabular
  - Classic multilayer perceptrons + feature engineering

Algorithms and Applications by Task

- Prediction
  - Regression/classification
    - RNN
- Recommendation
- Generative
  - Novel output
    - RNN
- Reconstruction
  - Example: MINST
- Recognition and computer vision
  - Changing images in time (video)

        - LSTM (temporal aspect) with convolutions layers (capture structure/features)
- NLP, NLG, NLU
    - Machine translation
        - CNN
    - Sentiment analysis
        - CNN
    - Sentence classification
        - CNN
- Personal assistant
    - Voice to text then NLP to understand what the user wants to accomplish, then generating text, voice, action
- Anamoly detection
- Reinforcement learning
- Reality capture and reality computing

Regression (Supervised) - Univariate, Multivariate, ...

- Simple and multiple linear regression
- Tree-based methods (e.g., decision tree or forest)
- Generalized linear models (GLM)
    - Poisson regression, aka log-linear model
- Generalized additive model (GAM)
- Regression with shrinkage (e.g., regularization)
- Stepwise regression
- Ordinary least squares
- Artificial Neural networks (ANN) and deep learning
- Ordinal regression
- Polynomial regression
- Nearest neighbor methods (e.g., k-NN or k-Nearest Neighbors)
- Gradient tree boosting
- Logistic regression
- Nonlinear regression

Example Applications

- Stock market predictions and algorithmic trading
    - Companies
        - Kavout
        - Sentient
        - Genotick
        - Numerai
        - QPLUM

Classification (Supervised) - Unary (one-class), Binary, and Multi-class

- Linear
    - Linear discriminant analysis (LDA), aka Fisher's linear discriminant
    - Logistic regression and multinomial logistic regression
    - Bayesian classifiers (as opposed to frequentist)
        - Naive Bayes
    - Perceptron methods
- Decision trees and random forests

- Naive bayes
- Hidden markov model
- Support vector machines (SVM)
  - Least squares support vector machines
- Artificial Neural networks (ANN) and deep learning
- Kernel estimation
  - Nearest neighbor methods (e.g., k-NN or k-Nearest Neighbors)
- One vs Rest and One vs One (binary transformation)
- Gradient tree boosting

Example Applications

- Many diseases or issues, including stroke, cancer, ...
  - Cancer detection using cell-free genomes
  - Cardiovascular events prediction (e.g., heart attack, stroke)
  - Companies
    - Google DeepMind
    - IBM's Watson (Watson for Oncology)
    - Others
      - Freenome
      - CureMetrix
- Spam for email
- Smart email categorization (Gmail)
  - Primary, social, and promotion inboxes, as well as labeling emails as important
- Credit decisions
  - Companies
    - Underwrite.ai

Regularization and Overfitting Prevention

- Least absolute shrinkage and selection operator (LASSO)
- Ridge regression
- Akaike information criterion (AIC)
- Bayesian information criterion (BIC)

Clustering (Unsupervised)

- Hierarchical clustering, aka connectivity-basedclustering and Hierarchical Cluster Analysis (HCA)
  - Single-linkage clustering
  - Complete linkage clustering
  - Unweighted Pair Group Method with Arithmetic Mean (UPGMA), aka average linkage clustering
- Centroid-based clustering
  - k-means
  - k-medoids
  - k-medians
  - K-means++
  - Fuzzy c-means
- Distribution-based clustering
  - Gaussian mixture models via expectation-maximization algorithm
- Density-based clustering
  - Density-based spatial clustering of applications with noise (DBSCAN)

    - Ordering points to identify the clustering structure (OPTICS)
    - Mean-shift
- Canapoy
- Association rule learning
    - Apriori
    - Eclat
- Topic modeling (text data)
- Fractal
- Guassian mixture models

Example Applications

Ensemble Methods (Supervised, Unsupervised)

- Bootstrap aggregating (bagging)
    - Random Forests and ExtraTrees
- Boosting
    - AdaBoost
    - Gradient boosting
    - Boost by majority
    - BrownBoost
    - xgboost
    - MadaBoost
    - LogitBoost
    - LPBoost
    - TotalBoost
- Pasting
- Bayesian model averaging (BMA)
- Weak learner theory
- Stacking (stacked generalization) and Blending
- Bayes optimal classifier
- Bayesian parameter averaging (BPA)
- Bayesian model combination (BMC)
- Bucket of models

Recommender Systems and Recommendations

- Collaborative filtering
- Content-based filtering
- Graph-based methods

Example Applications

- Netflix
    - Increase engagement, retention, and revenues
    - Examples
        - "Because you watched ..."
        - "Top picks for ..."
        - Recommendations by category
            - Trending Now
            - Neflix originals

        - TV Documentaries
- Amazon
    - Increase average order size and therefore sales (studies show between 5.9 to 30%)
    - Examples
        - "Customers who bought this item also bought"
        - "Customers who viewed this item also viewed"
        - "What other items do customers buy after viewing this item?"
        - "Recommendations for you in ..." (e.g., "Recommended for You in Kindle Books")
        - "New for you"
        - "Inspired by your shopping trends"
        - "Inspired by your Wish List"
- Robo-advisors and portfolio rebalancing
    - Weathfront
    - Betterment
- Spotify
    - Daily Mix
- Personalized news feeds, including Facebook

Neural Networks and Deep Learning

- Feed forward neural networks (FF or FFNN) and perceptrons (P)
- Radial basis function (RBF)
- Hopfield network (HN)
- Markov chains (MC or discrete time Markov Chain, DTMC)
- Boltzmann machines (BM)
- Restricted Boltzmann machines (RBM)
- Autoencoders (AE)
- Sparse autoencoders (SAE)
- Variational autoencoders (VAE)
- Denoising autoencoders (DAE)
- Deep belief networks (DBN)
- Convolutional neural networks (CNN or deep convolutional neural networks, DCNN)
- Deconvolutional networks (DN)
- Deep convolutional inverse graphics networks (DCIGN)
- Generative adversarial networks (GAN)Recurrent neural networks (RNN)Long / short term memory (LSTM)
    - CycleGAN
    - DiscoGAN
    - StarGAN
- Gated recurrent units (GRU)
- Neural Turing machines (NTM)
- Bidirectional recurrent neural networks, bidirectional long / short term memory networks and bidirectional gated recurrent units (BiRNN/BRNN, BiLSTM and BiGRU respectively)
- Deep residual networks (DRN)
- Echo state networks (ESN)
- Extreme learning machines (ELM)
- Liquid state machines (LSM)
- Support vector machines (SVM)
- Kohonen networks (KN, also self organising (feature) map, SOM, SOFM)

Example Applications[1]

- Feed forward neural network and Multilayer perceptron
  - Regression and classifications
- Restricted Boltzmann machine
  - Dimensionality reduction
  - Feature extraction/learning
  - Classification
  - Recommender systems
  - Topic modeling
  - Pretraining for weight initialization
- Autoencoders
  - Dimensionality reduction
  - Anomaly detection
  - Generative modeling
- Convolutional neural network
  - Image recognition
  - Video recognition
  - Automatic speech recognition (ASR)
  - Recommender systems
  - Natural language processing
- Recurrent neural network
  - Language modeling
  - Machine translation
  - Handwriting recognition
  - Speech recognition
  - Multilingual Language Processing
  - Natural language processing
- Self-organizing map
  - Dimensionality reduction
- Generative models
- Combinations
  - Image captioning (LSTM + CNN)

Recognition and Computer Vision

- Image
- Speech
- Video
- Text and optical character
- Pattern
- Audio
- Facial
- Handwriting

Example Applications

- Recognition
  - Shazam
  - Wine
    - Companies
      - Delectable
      - Vivino

    - Facebook photo recognition (highlights faces and suggests friends to tag)
    - Speech/Voice to text (faster to talk than to type acc'g to Stanford)
        - Companies
            - Google Cloud Speech API
    - Text to speech
        - Companies
            - Amazon Polly
    - Video
        - Companies
            - Clarifai
            - Google Cloud Video Intelligence
    - OCR
        - Mobile app check deposits and uploading receipts
        - Post office address recognition
    - Object recognition
        - Companies
            - Pinterest (then used to recommend other pins)
    - Image
        - Companies
            - Clarifai
            - Captricity
            - Google Cloud Vision API
            - Amazon Rekognition
- Computer vision
    - Manufacturing
        - Inspections
        - Quality control
        - Assembly line
    - Visual surveillance
        - Companies
            - BRS Labs AISight
    - Navigation, including autonomous vehicles
        - Land, water, and space
    - Medical image processing and diagnosis
    - Military
        - Detection of enemy solidiers and vehicles
        - Missle guidance
    - Drones
        - Inspection (pipelines), surveillance, exploration (buildings), and protection
        - Companies
            - Digital Signal
            - Shield.ai
    - Item recognition
        - Companies
            - Amazon Go

Anomaly Detection (Supervised, Unsupervised, Semi-supervised)

Algorithms

- Density-based techniques - K-nearest neighbor, Local outlier factor
- Subspace and correlation-based outlier detection for high-dimensional data

- One class support vector machines
- Replicator neural networks
- Cluster analysis-based outlier detection
- Deviations from association rules and frequent itemsets
- Fuzzy logic based outlier detection
- Ensemble techniques, using feature bagging, score normalization and different sources of diversity
- PCA (Principle component analysis)

Example Applications

- Per Wikipedia
  - Intrusion detection
  - Fraud detection
  - Fault detection
  - System health monitoring
  - Event detection in sensor networks
- Manufacturing
- Data security
  - Companies
    - Cylance
    - Darktrace
- Personal security (security screenings at airports, stadiums, concerts, and other venues)
- Law enforcement
- Application performance
- Credit card fraud detection

Text Processing, Analytics, and Mining

- Text processing
- Lexical Analysis
- Text Mining
  - Information retrieval
  - Text categorization
  - Text clustering
  - Concept/entity extraction
  - Production of granular taxonomies
  - Sentiment analysis
  - Document summarization
  - Entity relation modeling
  - Named entity recognition
  - Recognition of Pattern Identified Entities
  - Coreference
  - Syntactic parsing
  - Part-of-speech tagging
  - Quantitative text analysis

Natural Language Processing (NLP), Natural Language Generation (NLG), and Natural Language Understanding (NLU)

- Syntax

    - Lemmatization
    - Morphological segmentation
    - Part-of-speech tagging
    - Parsing
    - Sentence breaking (also known as sentence boundary disambiguation)
    - Stemming
    - Word segmentation
    - Terminology extraction
- Semantics
    - Lexical semantics
    - Machine translation
    - Named entity recognition (NER)
    - Natural language generation
    - Natural language understanding
    - Optical character recognition (OCR)
    - Question answering
    - Recognizing Textual entailment
    - Relationship extraction
    - Sentiment analysis
    - Topic segmentation and recognition
    - Word sense disambiguation
- Discourse
    - Automatic summarization
    - Coreference resolution
    - Discourse analysis
- Speech
    - Speech recognition
    - Speech segmentation
    - Text-to-speech

Example Applications

- Smart personal assistants
    - Companies
        - Alexa
        - Google Assistant
        - Siri
    - Uses
        - Internet searches and answer questions
        - Set reminders
        - Integrate with your calendar
            - Make appointments
        - Receive sports, news, and finance updates
        - Create to-do lists
        - Order items online
        - Use services (e.g., order an Uber)
        - Play music
        - Play games
        - Smart home integration
- NLG - computer generated reports and news

    - Summarizing documents
    - Story telling
    - Sports recaps
    - Companies
      - Narrative Science
- NLP and language translation
    - Voicemail transcripts
    - eDiscovery
    - Companies
      - Google Natural Language API
      - Google Cloud Translation API
      - Textio for writing optimal job descriptions
- NLU and Chatbots
    - Shopping
    - Errands
    - Day to day tasks
    - Companies
      - x.ai (personal assistant)
      - MindMeld
      - Google Inbox Smart Reply
      - Amazon Lex, includes Automatic speech recognition (ASR)
- Smart instant messaging
    - Companies
      - Google Allo smart messaging app (https://allo.google.com/)

Reinforcement Learning

- Q-learning
- Markov decision process (MDP)
- Finite MDPs
- Monte Carlo methods
- Criterion of optimality
- Brute force
- Value function estimation
- Direct policy search
- Temporal difference methods
- Generalized policy iteration
- Stochastic optimization
- Gradient ascent
- Simulation-based optimization
- Learning Automata[edit]
- Example
    - Multi-armed bandit problem

Example Applications

Model selection, validation, and resampling methods

- Cross-validation
- Hyperparameter optimization

- Bootstrap
- Mallow's Cp
- Akaike information criterion (AIC)
- Bayesian information criterion (BIC)
- Minimum description length (MDL)

Model tuning: bias variance tradeoff and model complexity

- Validation curve
- Learning curve
- Residual sum of squares
- Goodness-of-fit metrics
- Grid search

Feature extraction, feature selection, and feature engineering

- Wrapper methods
- Sensitivity analysis
- PCA
- Random forests
  - Mean decrease impurity
  - Mean decrease accuracy
- Text-based
  - Stemming
  - Tokenizing
  - Synonym substitutions
- Least absolute shrinkage and selection operator (LASSO)
- Subset selection

Dimensionality Reduction

- Principle component analysis (PCA)
- Kernel PCA
- Locally-Linear Embedding (LLE)
- t-distributed Stochastic Neighbor Embedding (t-SNE)
- Factor analysis
- K-means clustering
- Canopy clustering
- Feature hashing
- Wrapper methods
- Sensitivity analysis
- Self organizing maps
- Text data
  - Term frequency (TF)
  - Inverse document frequency (IDF)
- Latent Dirichlet Allocation (LDA)

Virtual and Augmented Reality

- Coming soon...

Information Retrieval

- Discounted cumulative gain (DCG)
- Discounted cumulative gain (nDCG)
- Term frequency–inverse document frequency (TF-IDF)

Logical Reasoning

- Expert systems
- Logical reasoning

Optimization and Search

- Stochastic search
- Stochastic optimization (SO) methods
- Genetic algorithms
- Simulated annealing
- Gradient search
- Linear programming
- Integrer programming
- Non-linear programming
- Active learning
- Ensemble learning
- Minimum
- Maximum
- Optimal value or optimal combination
- Metaheuristic methods
- Randomized search methods
- Tree search
- Monte Carlo tree search (MCTS)
- Evolutionary computation

Mathematical/quantitative Finance and Risk Management

- Risk management
- Mathematical/quantitative Finance
- Linear Regression
- Monte Carlo methods
- Empirical risk minimization

Example Applications

Ranking

- Ranking

Example Applications

Time-series

- Time series

- Rolling means
- Autocorrelation
- Frequency vs time domains and transfers (e.g., spectral analysis)
- Trend and residual component decomposition
- ARIMA modeling for forecasting and detecting trends

Example Applications

Survival

- Survival analysis

Example Applications

Forecasting (Wikipedia)

- Last period demand
- Simple and weighted N-Period moving averages
- Simple exponential smoothing
- Poisson process model based forecasting and multiplicative seasonal indexes
- Average approach
- Naïve approach
- Drift method
- Seasonal naïve approach
- Time series methods
  - Moving average
  - Weighted moving average
  - Kalman filtering
  - Exponential smoothing
  - Autoregressive moving average (ARMA)
  - Autoregressive integrated moving average (ARIMA)
  - Extrapolation
  - Linear prediction
  - Trend estimation
  - Growth curve (statistics)
- Causal / econometric forecasting methods
  - Regression analysis
    - Parametric (linear or non-linear)
    - Non-parametric techniques
  - Autoregressive moving average with exogenous inputs (ARMAX)
- Judgmental methods
  - Composite forecasts
  - Cooke's method
  - Delphi method
  - Forecast by analogy
  - Scenario building
  - Statistical surveys
  - Technology forecasting
- Artificial intelligence methods
  - Artificial neural networks

    - Group method of data handling
    - Support vector machines
- Other
    - Simulation
    - Prediction market
    - Probabilistic forecasting and Ensemble forecasting
- Considerations
    - Seasonality and cyclic behaviour

Example Applications

Simulation

- Discrete event simulation
- Markov models
- Agent-based simulations
- Monte carlo simulations
- Systems dynamics
- Activity-based simulation
- ODES and PDES
- Fuzzy logic

Example Applications

Segmentation

- Behavioral
- Demographic
- Geographic

Example Applications

Experimentation and Experimental Design

- Design of Experiments (DOE)
- A/B testing

Example Applications

Embedded

- Deep learning

Example Applications

- Robotic cognition

Hypothesis Testing

- T-test - Compare two groups
- ANOVA - Compare multiple groups

Hybrid Solutions and Applications

Example Applications

- Google search
- Autonymous vehicles (Business insider)
  - Reduce accidents and related injuries and death
  - Improved traffic (via ridesharing and smart traffic lights) and fuel efficiency
  - Reduced carbon emissions
  - Faster commutes and travel time
  - Get your time back in the vehicle to do what you want
  - Efficient ride-sharing
  - Companies
    - Zoox
    - Nauto
    - nuTonomy
- Home monitoring, control, and security
  - Companies
    - Flare
- Voice-controled robotics
- Photo-realistic pictures generation from text or sketches
  - NYU article
- Music generation
  - Companies
    - Jukedeck
- Movie and script generation
- Automatically generated software code
  - Companies
    - DeepCoder (Microsoft and Cambridge)
- Authentication without passwords (using mobile phone that knows it's you)
  - Companies
    - TypingDNA
- Customer support
  - Companies
    - DigitalGenius
- Optimized directions and routes
- Plagiarism Checkers
- Robo-readers and graders
- Virtual reality
- Gaming
- Zillow's "zestimate" feature, which estimates the price of homes
- Medical/Health
  - Companies
    - BenevolentAI
- Sales
  - Companies
    - InsideSales.com
- Crime
  - Who, Type, and location
  - Based on previous crime and social media activity
  - Companies
    - BRS Labs AISight
- Suicide risk

    - Based on a lot of different risk factors
    - Companies
        - Facebook
        - Instagram
        - Cogito
- Agriculture - predicting crop yields
    - Companies
        - Descartes Lab
        - Stanford's Sustainability and Artificial Intelligence Lab
- Uber's ETA

Other Algorithms

- Massive-scale graph
- Geospatial temporal predictive analytics
- Hyperfast analytics
- Embedded deep learning
- Cognitive machine learning and IoT
- Natural language processing, generation, and understanding
- Structured database generation
- Game theory
- Control theory
- Operations research
- Information theory
- Simulation-based optimization
- Multi-agent systems
- Swarm intelligence
- Genetic algorithms

Polls and Popularity

- Top Algorithms and Methods Used by Data Scientists

References

1. Wikipedia
2. DL4J Deep Learning Use Cases
3. Wikipedia Outline of Machine Learning
4. Wikipedia Machine Learning Portal
5. Wikipedia Outline of Artificial Intelligence
6. Wikipedia Artificial Intelligence Portal
7. Wikipedia List of Emerging Technologies
8. Wikipedia Outline of Statistics
9. Wikipedia Statistics Portal
10. Wikipedia Outline of Mathemetics
11. Wikipedia Mathemetics Portal