Forecasting Models

Statistics, Machine Learning & Deep Learning

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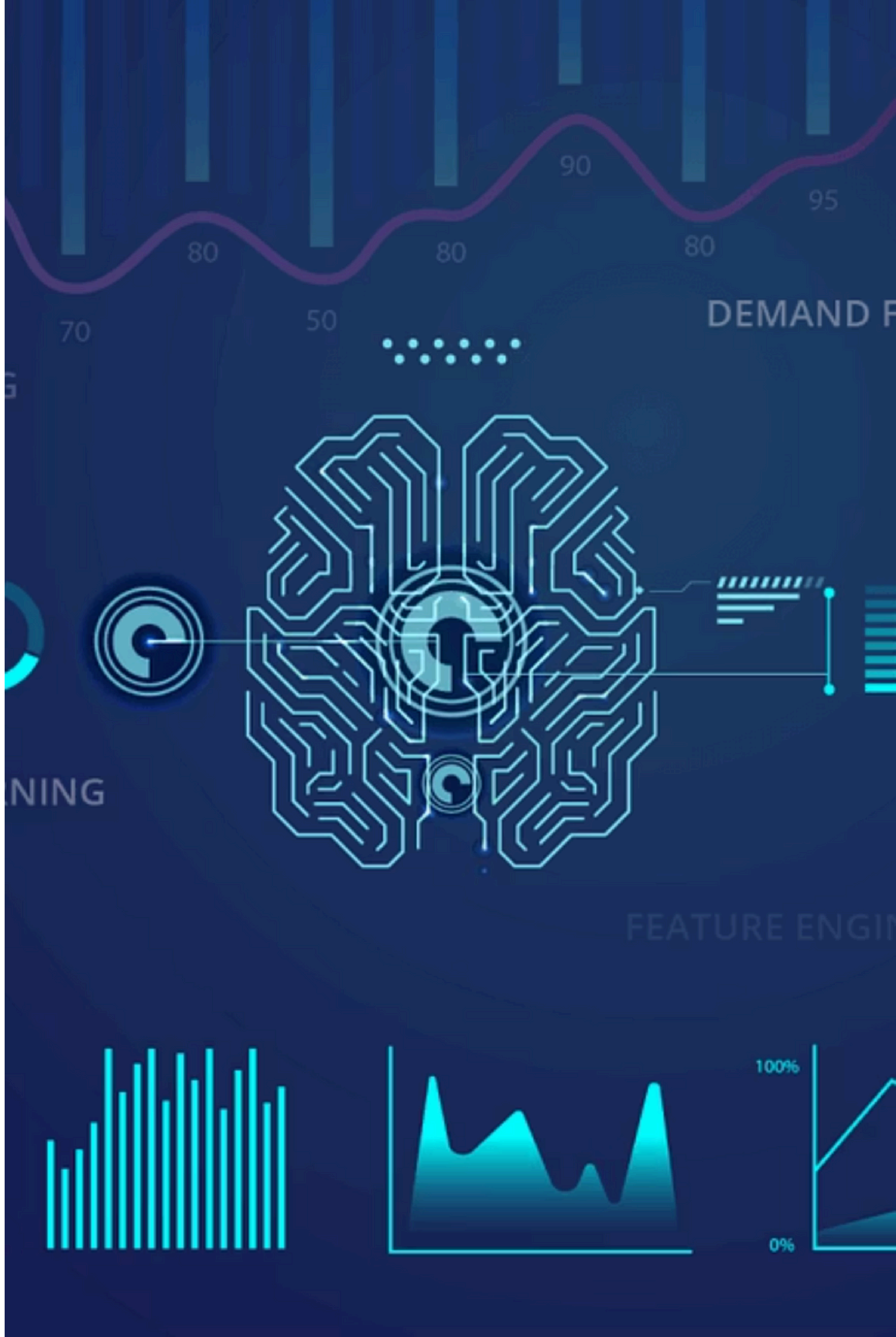
Overview

- Introduction to forecasting models
- Forecasting approaches
- Statistical Forecasting Models
- Machine Learning Forecasting Models
- Deep Learning Forecasting Models
- Comparison
- The use of each approache
- Challenges & Considerations
- Real-World Applications



What is Forecasting?

Definition: Forecasting is the process of predicting future values based on historical data.
Importance: It’s used in Sales & demand prediction,Healthcare planning,Supply chain & logistics and Finance & stock markets

What are the main forecast approaches ?

- **Statistical models:** Based on math rules — assumes trends, seasonality, and linear patterns.
- **Machine Learning Models :** Learns patterns from data — uses features beyond just past values.
- **Deep Learning Models:** Neural networks learn complex, long-term patterns in sequences.

Statistical models

- **Definition:** It’s a model based on mathematical formulas that model trends, seasonality, and past patterns.

- **Strengths:**
  .Interpretable
  .Fast and simple
  .Good for small datasets

Statistical models

- **Limitations:**

  .Can't handle complex patterns

  .Limited use of external features

- **Popular Models:**

  .ARIMA (AutoRegressive Integrated Moving Average)

  .SARIMA (Seasonal ARIMA)

  .Exponential Smoothing (ETS, Holt-Winters)

  .Linear Regression

Machine Learning Forecasting Models

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- **Definition:** It’s an algorithm that learn patterns from data (not predefined formulas).

- **Strengths:**

.Can handle many features (weather, holidays, etc.)

.Works with nonlinear patterns

.More accurate than statistical models in many cases

Machine Learning Forecasting Models

- **Limitations:**

  .Needs more data

  .Can be harder to interpret

- **Popular Models:**

  .Random Forest Regression

  .XGBoost (Extreme Gradient Boosting)

  .SVR (Support Vector Regression)

  .k-Nearest Neighbors (k-NN) for Time Series

  .Decision Tree

Deep Learning Forecasting Models

- **Definition:** Uses neural networks to capture complex, long-term dependencies in time series.

- **Strengths:**
  .Best for complex, high-dimensional data
  .Learns temporal patterns directly
  .Highly scalable

Deep Learning Forecasting Models

- **Limitations:**

  .Needs large datasets

  .Requires GPUs and long training time

  .Harder to explain (black box)

- **Popular Models:**

  .LSTM (Long Short-Term Memory)

  .GRU (Gated Recurrent Unit)

  .Transformer (like in GPT, BERT)

  .Temporal Convolutional Networks (TCN)

Comparison

Feature	statistical	ml	dl
Handles small data	yes	Meduim	needs big data
Supports many features	no	yes	yes
Learns from sequences	limited	manual	strong
Interpretability	high	Meduim	low
Handles Non-linearity	no	yes	yes

When to Use each Model?

The choice between statistical, machine learning (ML), and deep learning forecasting models depends on the problem's complexity, data availability, and interpretability requirements. Statistical models (e.g., ARIMA, ETS) are ideal for small datasets with clear trends and seasonality, where interpretability is crucial—such as in economics or financial forecasting.

When to Use each Model?

Machine learning models (e.g., XGBoost, SVR) work well when dealing with multiple features and moderate-sized datasets, offering flexibility for scenarios like sales forecasting with promotional inputs.

When to Use each Model?

Deep learning models (e.g., LSTMs, Transformers) excel in handling large-scale, complex data with intricate patterns, making them suitable for applications like high-frequency stock predictions or weather modeling, though they require significant computational resources.

When to Use each Model?

The best approach often involves testing different models and selecting the one that balances accuracy, efficiency, and explainability for the specific use case.

Challenges & Considerations

Statistical Models: Struggle with abrupt changes

Machine Learning: Needs good feature engineering

Deep Learning: Requires large data, expensive to train

Real-World Applications

Domain	Statistical	ML	DL
Retail sales	ARIMA	XGBoost	LSTM
Weather	Holt-Winters	Random Forest	Transformer
Energy usage	SARIMA	SVR	GRU
Finance	ARIMA	LightGBM	Temporal CNN