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Data Analytics Platform for the Optimization of Waste Management Procedures

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International Workshop on IoT Applications and Industry 4.0

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Data Analytics Platform for the Optimization of Waste Management Procedures

Introduction - Problem Definition

Smart waste management is a very important procedure in Industry 4.0

- Profitable asset for:
  - Waste producers
  - Waste management providers

- Connection with **IoT sensors** on industrial premises
- **Big data** availability
- Significant advances on **data analytics**

Enable the waste management companies:

- To smarten their domain
- To automate many of their solutions and processes

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Data Analytics Platform for the Optimization of Waste Management Procedures

Introduction- Our Contribution

The main goal is to contribute to smart waste management optimization by providing:

- Sensor-based bins and dedicated waste management operations that will forcefully replace obsolete methods
- Transparency of waste spend and access to historical data towards the evaluation and improvement of waste management through analytics
- Variety of analytic services to end users related to waste management activities in order to enhance the decision-making and optimize planning

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Data Analytics Platform for the Optimization of Waste Management Procedures

Overview

- Optimization tool for waste management companies
- State-of-the-art algorithms and methodologies for data analysis
- Advanced data visualization
- IoT devices connectivity and data analysis
- Secure data exchange based on authentication mechanisms

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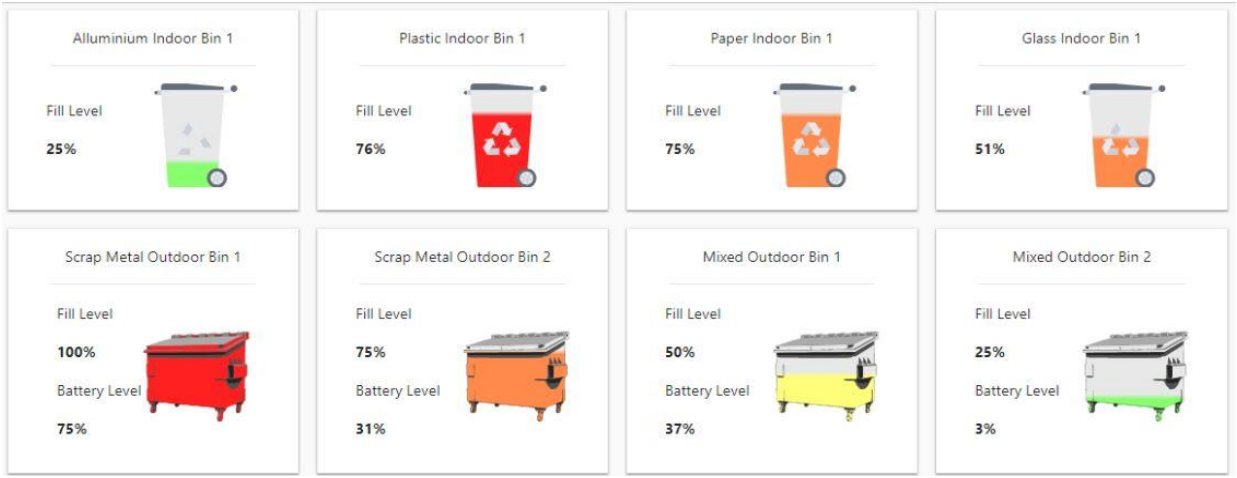
Data Analytics Platform for the Optimization of Waste Management Procedures

Services

- ✓ **Monitoring** of bins **fill level** based on **IoT sensors**
- ✓ **Analysis** of the bins **fill level trend**
- ✓ **Forecasting** about **the tonnage of wastes** that is going **to be transported** by a waste management company
- ✓ **Calculator** for **optimal pair** of **routes** and **tonnage** should be transported
- ✓ **Price forecasting** for **various** waste types/materials
- ✓ **Statistical analysis** and **visualization** for better data exploration

Bins Fill Level Monitoring based on IoT Sensors

- Use of **Ultrasonic** and **IR** sensors for fill level measurement
- Use of **LoRa** network in order to cover low power needs and get data from sensors
- **Measure** the **fill level** of both **indoor** and **outdoor** industrial bins containing scrap metal and recycling materials
- Provide distant **fill percentage monitoring** for efficient logistics, between industry and waste collection companies
- **Notification** mechanisms (email) for fill level over 80%



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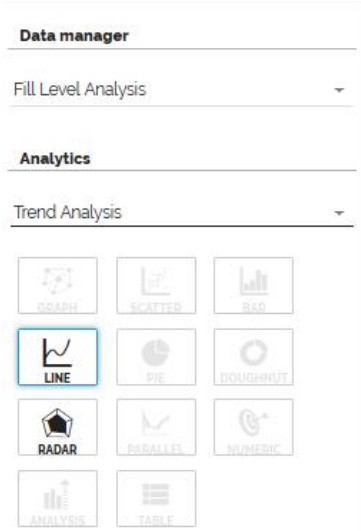
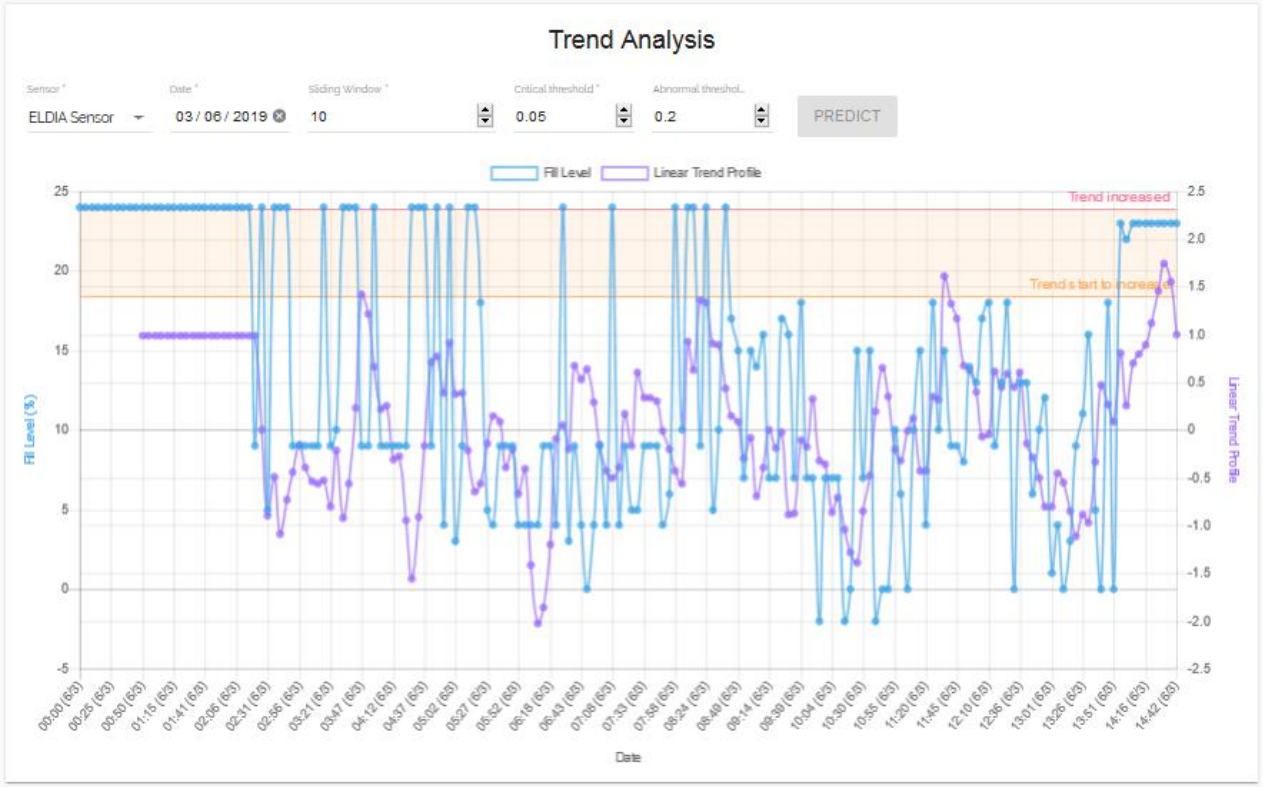
Fill Level Analysis
Trend Analysis

- **Real-time analysis** of fill level **sensor data**
- **Trend Analysis** applied in order to create a **profile** for fill level trend
- **Slope Statistic Profile** method is applied on the time series of recordings (percentages) of a fill level sensor
- End user is able to select:
  - Sensor
  - Date
  - Sliding window for the analysis
  - Thresholds for the analysis
  - Type of visualization (line or radar)
- By using this analysis the waste management company is able to define which bin has the **most aggressive trend** in order to arrange a pick-up





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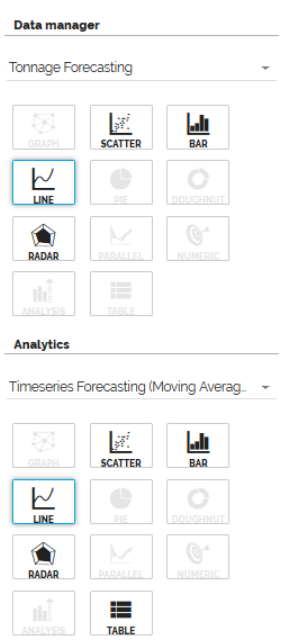
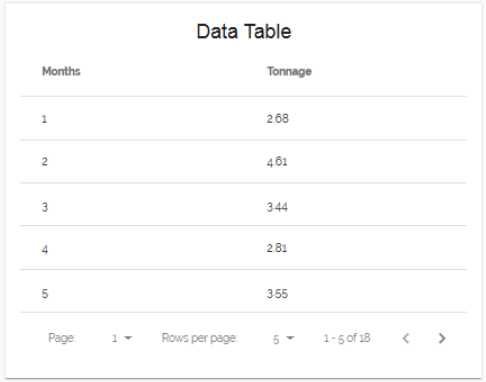
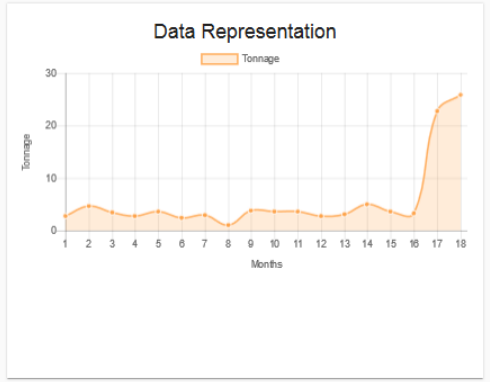
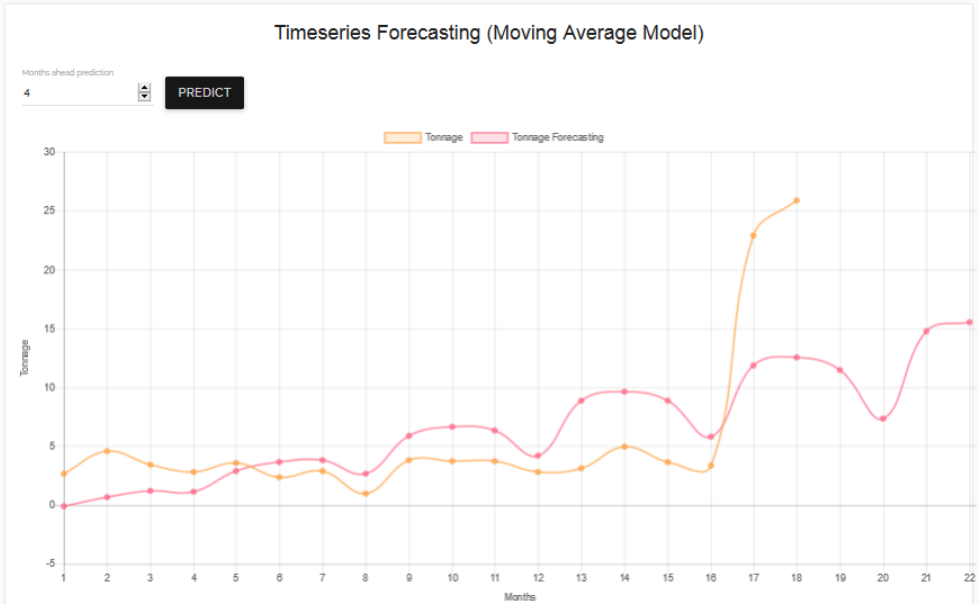
Tonnage Forecasting
Time series forecasting

- **Forecasting** about the **tonnage** of wastes that is going **to be transported** by a waste management company
- **Time series forecasting** using **moving average** model
- **Visualization** of predictions
- End user is able to select:
  - **Number of months** for ahead prediction
  - **Type** of visualization (line, scatter, table, bar and radar)









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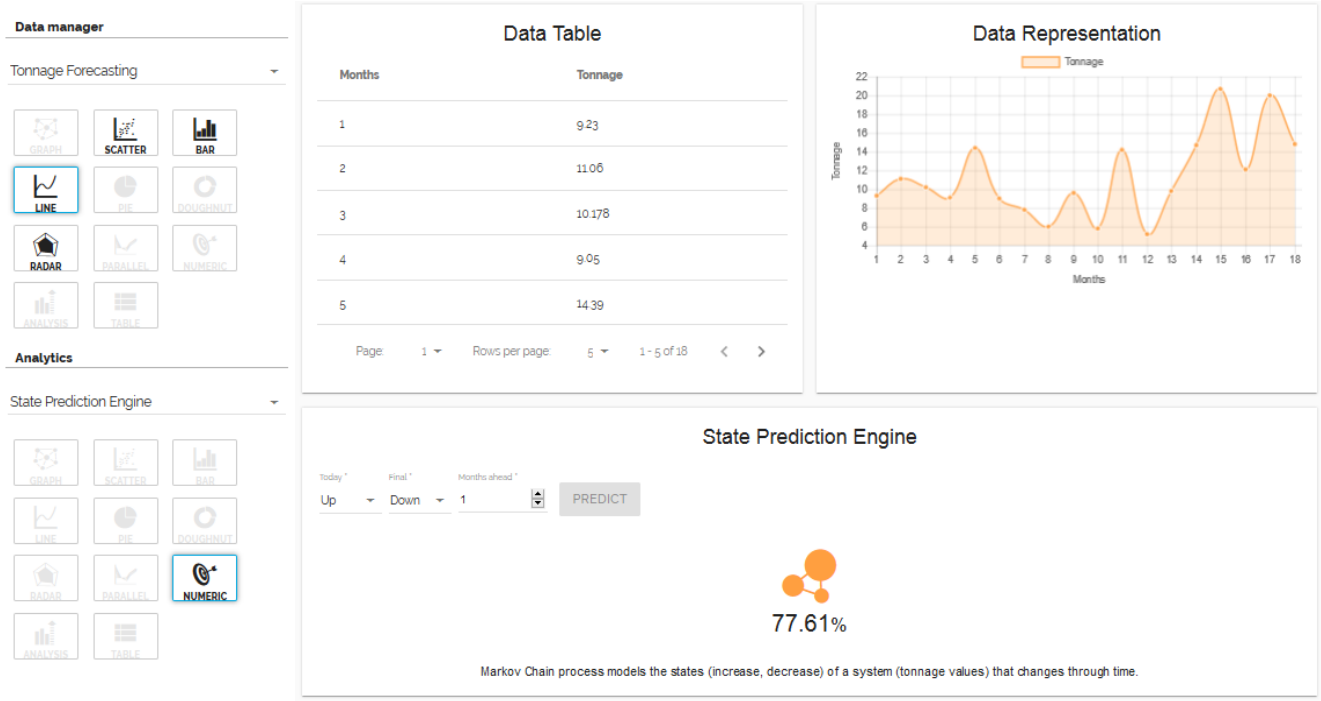
State Prediction Engine
Markov Chain Models

- **Predict** the **probability** of **future increase** or **decrease** of the transferred tonnage based on **current state**
- **Markov chain** models used to determine the **probability** of moving from one state to another
- End user is able to select:
  - **Months ahead** period for the prediction
  - **Current** and **future state** of transferred tonnage (Up/Down)



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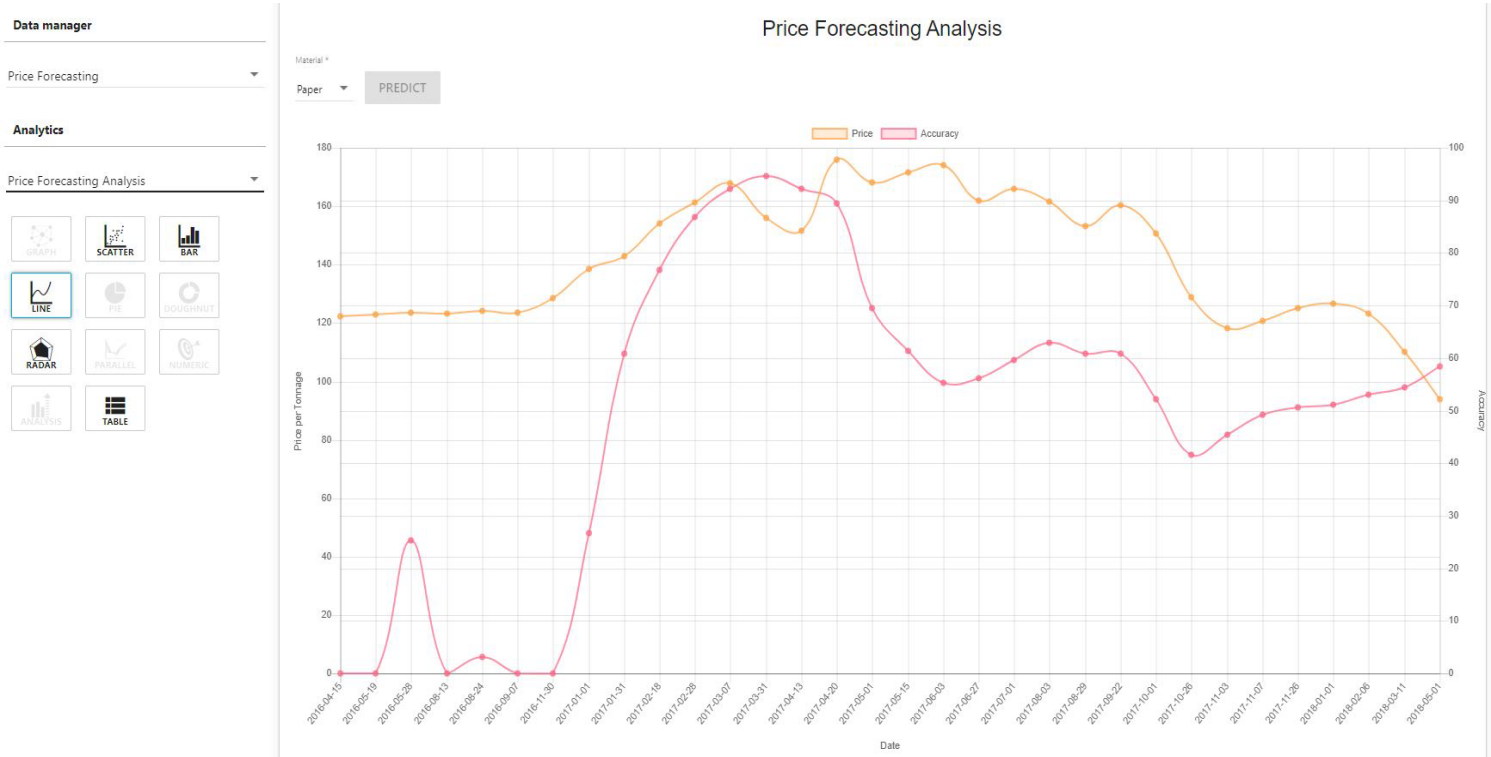
Price Forecasting
Deep Learning

- **Deep Learning** algorithm to provide **prediction** for the **price** per ton at which specific commercial partners is likely to accept to buy/sell waste material
- Prediction model **based on historical price data – Recurrent Neural Network** (RNN) is used
- Initial network for regression is composed of four hidden **Long Short Term Memory** (LSTM) layers with 64, 32, 24 and 8 neurons respectively
- **Visualization** of **prediction values** and the coefficient of determination expressed as **accuracy rate** in the same diagram
- End user is able to select:
  - **Material** for price prediction
  - **Type** of visualization (line, scatter, table, bar and radar)



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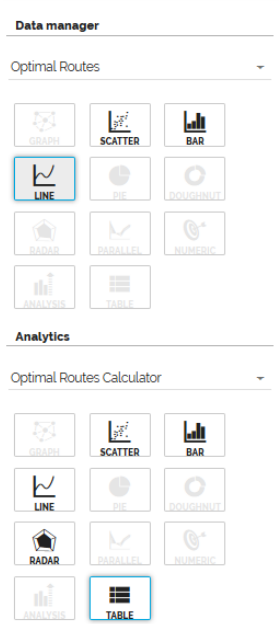
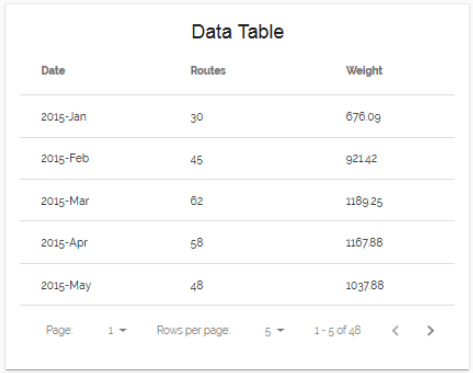
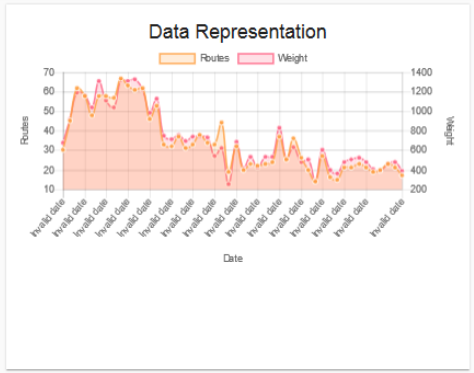
Optimal Routes Calculator
Genetic Algorithm

- Optimal Routes Calculator based on monthly data about **routes** and **transferred weight** of wastes per route
- Calculates **10 best** solutions/combinations for the **pair routes/weights** that can be transferred for a material
- End user is able to:
  - **Load** monthly **data** per material
  - **Select** type of **visualization** (table, scatter, bar, radar and line)







Optimal Routes Calculator

Top 10 Simulated Solutions
Material: Brown paper

#	Routes	Weights (tons)
1	30	761
2	36	922
3	30	760
4	20	507
5	15	383
6	43	1091
7	23	588
8	33	842
9	25	618
10	33	837

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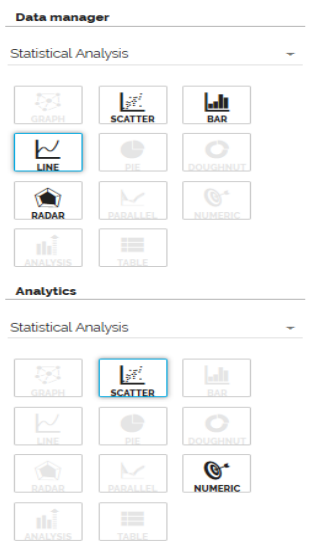
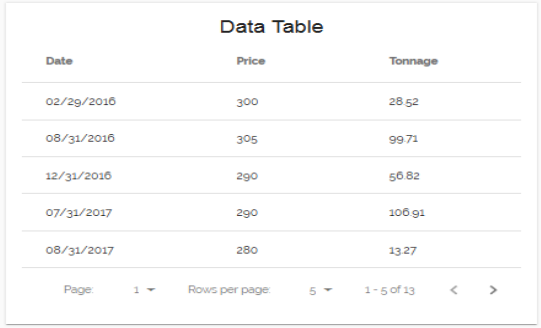
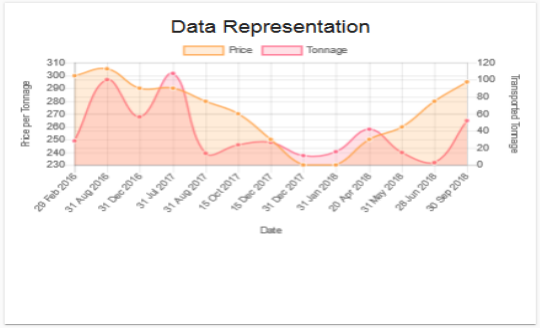
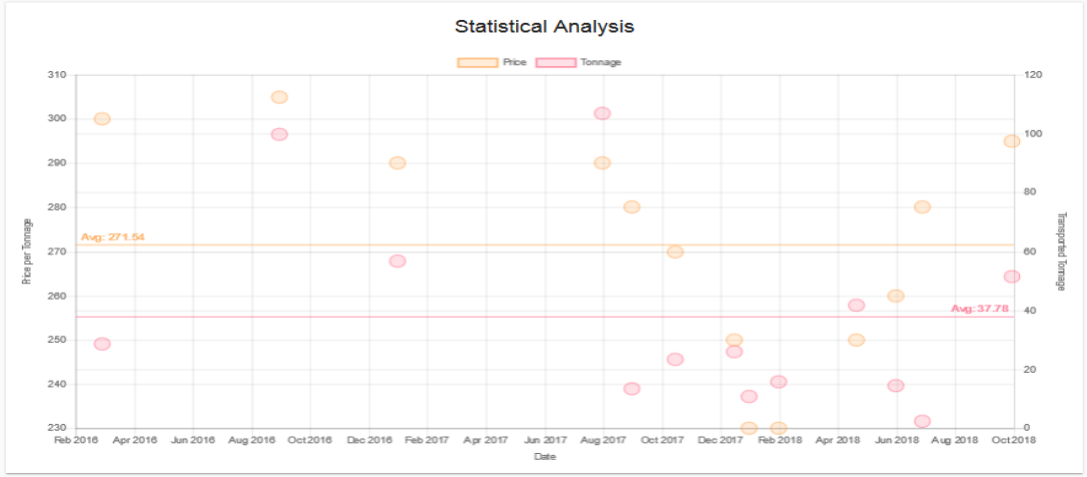
Statistical Analysis

- **Statistical analysis** of the end user's data
  - Price averages, tonnage averages etc.
- **Visualization** of **statistical analysis** output









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Conclusions

Proposed solution

- IoT data analytics platform for waste management optimization
- To-the-point Data analytics solutions
  - Waste bins fill level monitoring/analysis
  - Forecasting of transported tonnage
  - Price forecasting of waste materials
  - Optimal transportation KPIS (routes/tonnages)

Gains to waste management companies

- Supervised control of waste level
- Access to historical data
- Planning and optimization potential
- Financial and environmental benefits

Thank you

COMPOSITION has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement No 723145