RoboBEER:
A robot made with LEGO components that showed to be not a toy when analysing beer quality parameters based on foamability using computer vision algorithms.

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### Top producing countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Production (million hectoliters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>471.57</td>
</tr>
<tr>
<td>United States</td>
<td>223.51</td>
</tr>
<tr>
<td>Brazil</td>
<td>138.58</td>
</tr>
<tr>
<td>Germany</td>
<td>95.62</td>
</tr>
<tr>
<td>Russia</td>
<td>78.2</td>
</tr>
<tr>
<td>Mexico</td>
<td>74.5</td>
</tr>
<tr>
<td>Japan</td>
<td>53.8</td>
</tr>
<tr>
<td>Vietnam</td>
<td>46.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>44.05</td>
</tr>
<tr>
<td>Poland</td>
<td>39.8</td>
</tr>
</tbody>
</table>

Background

Beer consumption by country

- Czech Republic
- Germany
- Austria
- Poland
- Lithuania
- Estonia
- Romania
- Ireland
- Croatia
- Slovenia
- Spain
- Finland
- Latvia
- Belgium
- USA
- Slovakia
- Australia
- Bulgaria
- United Kingdom
- Hungary

Per capita consumption in liters

(Euromonitor 2017)
• Beer quality defined by:
  • Foamability
  • Foam stability
  • Foam texture (bubble size)
  • Colour
  • Alcohol content
  • Flavours and taste
  • Aromas
  • Mouthfeel

• Current methods to assess foam:
  • Time-consuming
  • Measure one or two parameters
  • Manual pouring

(Bamforth 2011, Cooper et al. 2002, Ferreira et al. 2005)
• Uniformity in measurement conditions
• Beer quality assessment:
  – Colour and foam-related parameters
  – Sealability
  – Prediction of intensity levels of sensory descriptors
  – Classification per type of fermentation
Approach used to solve the problem

- Robotic pourer prototype:
  - Lego® blocks
  - Lego® Servo motors
  - Open source sensors (temperature, alcohol and CO₂)
  - Arduino® boards
  - iPhone 5S

- Data processing:
  - Computer vision algorithms – Matlab®
  - Machine learning algorithms – Matlab Neural Network Toolbox™ 7
Use of Matlab

- Open source sensors:
  - CO$_2$, alcohol gas release, temperature
- Computer vision algorithms to assess:
  - Colour (RGB and CieLab)
  - Maximum volume of foam (MaxVol)
  - Total lifetime of foam (TLTF)
  - Lifetime of foam (LTF)
  - Foam Drainage (FDrain)
  - Bubble size distribution (small, medium and large)
Use of Matlab

Select line from top of the glass, after red cross appears select from top to bottom of glass

Foam analysis
Use of Matlab

https://www.youtube.com/watch?v=sN37Hkp cjhA
Use of Matlab

- Matlab® code to analyse results using principal component analysis (PCA) and cluster analysis
- Machine learning using Matlab Neural Network Toolbox™ 7 for pattern recognition and regression
Results – Temperature

SD = ±0.05 °C
Results – Alcohol

$y = 0.11x$
$R^2 = 0.83$

- **Bottom fermentation**
- **Top fermentation**
- **Spontaneous fermentation**
Results – CO₂
Results – PCA and Cluster
Results – ANN Pattern Recognition

Class / Targets:
1 = Top
2 = Bottom
3 = Spontaneous
Intensity of sensory descriptors:
- Bitterness
- Sweetness
- Sourness
- Aroma grains
- Aroma hops
- Aroma yeast
- Viscosity
- Astringency
- Carbonation mouthfeel
- Flavour hops
Conclusions

• Use of RoboBEER, computer vision and machine learning algorithms: cost effective and rapid tool to assess foamability
• Accessible tool for industry. Quality assurance of beer and packaging at the end of production line.
• ANN highly accurate model for beer classification using RoboBEER
• ANN regression high correlation for prediction of intensity levels of sensory descriptors


