Deep Learning methods for biotic and abiotic stresses detection in fruits and vegetables: state of the art and perspectives

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Abstract

• Deep Learning (DL), a type of Machine Learning, has gained significant interest in many fields, including agriculture.
• ResNet50 and VGG16 were the most used architectures from the 132 reviewed articles.
• Data scarcity, imbalance, and homogeneity of some image backgrounds, which negatively influence the robustness of the developed models were discussed.

Introduction

• Fruits and vegetables contain dietary fiber and vitamins, which help lower the risk of cardiovascular disease and obesity (Slavin, 2012).
• However, many biotic and abiotic factors cause losses in their productivity.
• Deep Learning (DL) is used for early disease identification.
• We performed a bibliometric analysis and a systematic literature review focusing on the two types of stresses for effective monitoring to enhance crop performance.

Methodology

Paper selection

Research Questions (RQ)

We state below our research questions:

1. What is the motivation for using the DL or AI method?
2. What species was concerned?
3. What type of stress was involved?
4. What are the types and sources of data used?
5. What are the countries of the self-made data?
6. What models were used?
7. What are the evaluation metrics?
8. What are the performances achieved?
9. What are the gaps and perspectives?

Tools used for the literature synthesis and analysis

• VOSviewer for keywords co-occurrence network (Eck, 2022)
• Pandas, Matplotlib, and Numpy libraries of Spyder Notebook in Anaconda environment and package ‘ggplot2’ of R software.

Main Results

General statistics

• 132 articles published between 2003 and 2022
• Journal articles (64%)
• Conference proceedings (36%)

Figure 1: PRISMA flow diagram of the selection process

Bibliometric analysis

Figure 2: Keywords co-occurrence

Figure 3: Countries wise distribution of self-data collected

Table 1: Top five most studied species of fruits and vegetables

<table>
<thead>
<tr>
<th>Species Scientific name</th>
<th>Occurrence</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>13</td>
<td>9.63</td>
</tr>
<tr>
<td>Tomato</td>
<td>135</td>
<td>10.38</td>
</tr>
<tr>
<td>Grape</td>
<td>143</td>
<td>11.58</td>
</tr>
<tr>
<td>Lemon</td>
<td>16</td>
<td>1.28</td>
</tr>
<tr>
<td>Peach</td>
<td>189</td>
<td>15.71</td>
</tr>
</tbody>
</table>

Figure 4: DL models

Figure 5: Performance of best models

RQ6: What models were used?

Top 5 most used models

• VGG16: 40.36%
• ResNet18: 36.07%
• VGG19: 13.54%
• GoogleNet: 5.51%
• AlexNet: 3.51%

RQ7: What are the evaluation metrics?

Top 3 most used metrics

• Accuracy: 40%
• Precision: 15.56%
• Recall: 10.16%

RQ8: What are the performances achieved?

Gaps

• Small database
• Unbalanced class
• Heterogeneous background
• Non-robustness of models
• Self-collected data are mostly from developed countries
• No study on climate change stress prediction on fruits and vegetables using DL or AI

Perspectives

• Collection of data on real field situations over the world
• Improvement of the robustness of the models
• Study of the prediction of stress due to climate change on fruits and vegetables using AI and DL

Conclusions

Despite being widely used for diseases and stress classification, DL models present many challenges for users and scientists. For better productivity of fruits and vegetables, automatic methods based on AI and DL for early identification of stress need to be improved.

References