REACH

NEXT GENERATION DATA INCUBATOR

EXPLORE PHASE
TECHNICAL SPECIFICATIONS

11/05/2023

This project has received funding from the European Union's H2020 research and innovation programme under Grant Agreement no 951981

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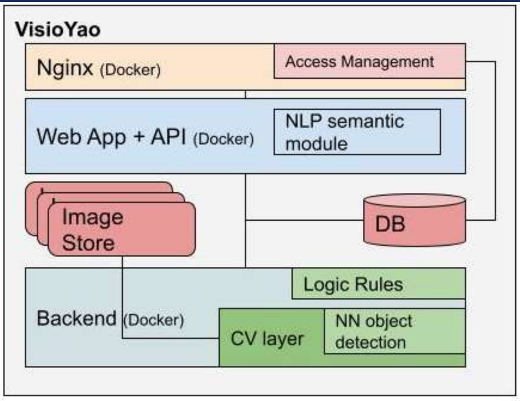
1 ANNEX I. Technical Specification Double-side Page

1. **TECHNICAL SCOPE:** The mock-up solution is suitable and correctly addresses the challenge/theme selected over the REACH dataset/s. The Big Data solution architecture proposed is adequate to tackle the data management issues associated to the solution in mind. "To what extent does the applications handle the data provided?"



VisioYao is a solution for automating part of the logistics process: it mimics the work of an operator analyzing the content of an order to understand if it is fully and correctly picked, using pictures of totes taken at different times during a picking process and comparing this information with the order, so as to detect in real time during the logistics process whether there are differences between the expected products and the real ones.
Apart from photographs and orders, which represent the core data for the use case, additional data (e.g. marketing data on product packaging (graphics/volume etc.), details of barcodes, etc.) if available and useful to improve the object recognition component can also be integrated into the solution.
The mock-up we present is a webapp exposing different user interfaces: 1) Login 2) Stats on the process 3) A core interface in which, having analysed the photo by means of our computer vision algorithms, differences (products present/missing) between the order and the images are shown, along with explaining how this information has been processed (logical rules above the computer vision component) and describing in words (semantic description) any anomalies found. This interface also allows the user to validate/reject the results and to insert further comments, which can be used to interactively refine the training component or to feed these details into the client's IT systems 4) A further interface shows the user the results of the computer vision algorithm processing alone, which is currently trained on a public dataset of drug packages.
The mock-up already contains the main components capable of handling the complexity of the project and allows us to test them. All components are dockerized. The service is provided via webapp. The interaction layer with the external environment is managed using Nginx, which acts as a reverse proxy and on which the access management and https components can be implemented. The persistence layer is managed by a PostgreSQL database, already present in the mock-up solution.
With a minimum of code updates, all components can be replicated and parallelised if necessary to allow the service to scale. The key algorithmic components are already present and tested in a pipeline similar to the one we aim to have in the final solution.
The system will expose a REST API with two step token based authentication, but it is possible to adapt the input/output data communication mode to the internal requirements of COFARES. API will make it possible to communicate in real time analysis results, alerts or send reports to external systems.

2. **SELECTION OF ALGORITHMS AND TOOLS:** The indicated Data Science approach, i.e. algorithms chosen, and Big Data architecture approach, i.e. tools chosen may successfully accomplish the required data governance, processing and analysis. A clear understanding of the used REACH dataset/s is demonstrated.

Data to be managed is mainly structured data (tables containing orders) and images (photographs of totes). It is possible to integrate further data (e.g. marketing data on product packaging (graphics/volume etc.), details of barcodes, etc.) in the training part of the solution.
With respect to this scenario and the expected volume of data we plan to use PostgreSQL as a database and use file system (possibly distributed) for the image component. As for the algorithmic pipeline, we adopt a combination of computer vision techniques, deep learning and logical algorithms.
For the computer vision stack, these are algorithms developed with the support of OpenCV. Normalisation and affine feature detector, classical homography, and similarity evaluation algorithms (e.g. SSIM) will be used. For the deep learning component, which will handle the classification phase, we use a YOLOv5-type network customised by Elif Lab's team, but possible alternatives will be evaluated in the course of the project. The inference component of the neural network will be managed using Pytorch for the server component and tensorflow-js for an interactive front-end component which we will use for tuning the algorithms during the development. The network is able to analyze an image in <200ms, making it feasible to operate in real time during the process.
A logic engine component acts on top of the object detection and categorisation ones and allows anomalies to be detected with respect to the products we expect to find in the totes. Rules will be developed using the CLIPS language, adopting Prolog in case of specific needs. One set of rules will be standard within VisioYao, another set will be defined together with the client based on

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the experience of the operators already working in the logistics process.

3. **TECHNICAL SCALABILITY AND FLEXIBILITY OF THE SOLUTION:** The solution can truly cope with humongous and increasing datasets, potentially from diverse data providers, and is flexible it to adapt to other related domains.

The proposed solution integrates different components, although guaranteeing the adequate speed to work in real time in the identified use case. The deep learning component, which is usually the most challenging to manage due to both the computational cost and the training, will be used only to enrich the raw image information (e.g. tagging images, but not producing the final output of the pipeline). In this way, the scope of the component is circumscribed, more predictable and faster in training and retraining. More classical computer vision techniques will also be used: these are lightweight and specific to handle features that cannot be handled effectively with machine learning. The component that will guarantee the elasticity of the process is the part of the logical rules that will manage the enriched data and leverage client's knowledge. This combination makes it possible to create an effective but elastic, verifiable and steerable process. During the deployment we will also introduce ways to manage the user feedback to improve both the deep learning and logical components. The relational and structured component of the dataset will be managed with the PostgreSQL database, which has proven capacities to scale on very high volumes of data. The input of further data in the training part of the solution is already planned as a possibility. Based on the customer's process, we also expect the possibility of integrating the solution into a broader analysis context and thus being able to manage information such as, on the internal side, anomalies in the management of machines (linking the lack of product to any downtime), on the external side any useful information coming from agents (e.g. transport bills) or from the end customer (pharmacies) to completely trace the path of the products. The solution is already designed to work on several domains. In addition to the logistics domain, our developments at the moment concern, with similar logic to that described here, asset management and visual inspection activities, in particular in the energy field.

4. **DATA GOVERNANCE AND LEGAL COMPLIANCE:** Data sharing challenges, data governance and legal compliance, must be observed. The proposed solution is compliant with the current data legislations concerning security and privacy (e.g. GDPR).

The data we will handle does not contain personal information. However, all data will be managed with the highest level of security. Encryption techniques will be used for all sensitive data (e.g. if they may represent a trade secret) at the database level. The interaction component between VisioYao and the client's system will be through secure channels and authentication techniques and tokens, such as JWT (JSON Web Token), will be used to manage and track interactions. We expect to sign a comprehensive legal agreement with the data provider. The solution is designed for on-premises operation, but the same security technologies will be applied in the event of a request for an external cloud-based installation. Images will be stored in encrypted filesystems and in case there is no specific need for data retention, automatic deletion of data when no longer required will be defined. All components will be securely dockerized and constantly updated to the latest operating system and library versions.

5. **QUALITY ASSURANCE AND RISK MANAGEMENT:** Feasible and credible quality process followed for the final product generation. The potential risks in all the phases of the project (design of the solution, development, testing, deployment…) are identified and convincing mitigation plans put in place.

Training dataset: we have not yet visibility on the quality of the provided dataset. From the challenge description, we expect to have a sufficient amount of images and metadata (checked with COFARES, this risk is unlikely). In case an integration is needed, we will autonomously generate a synthetic dataset through Webots simulation software. This risk could also be partially manageable through our logic component, that can make up for incomplete information by incorporating a priori rules, improving and stabilizing the performance of the classification output. Quality of images: As stated in the challenge description, COFARES welcomes suggestions on how to improve the physical environment and the devices used, so we expect to be able to solve any problem related to the setting together with the data provider. Corner cases: VisioYao will be able to identify corner cases, marking them in order to allow to analyse these occurrences and create ad hoc strategies for their management.

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