TagItSmart!
Smart Tags driven service platform for enabling ecosystems of connected objects

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IS-COSMEU-Tag

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Introduction

Once the TagItSmart App has been developed, based on the preliminary research on the illicit trade issues in the perfumery sector, the following project task regarded the Experimentation of the App in a real Retail context.
The experimentation plan encompassed the following:

- User Acceptance Test: to test the specific functionality within the application and proof the consistency of both technical and functional requirements and developments;

- Design of Experiment: to test the readability of the tag in different situations (we tested both endogenous and exogenous factors).

Section 1 - User Acceptance Test

User Acceptance Test (UAT) must be executed by the “tester” which represent the prototype of the “final user”. Aim of the UAT is to validate every single functional requirement gather during the “Solution Design” phase and to test the conforming technical developments implemented during the “Realization” phase.

1.1 Requirements

To execute UAT properly, the following requirements must by achieved:

- Portable device (smartphone, tablet, etc.) with internet connector, camera and NFC reader;
- Internet connection;
- Google play web access;

1.2 Test scenario

The following table presents the list of scenarios within the UAT:

TEST	DESCRIPTION	ACTION	EXPECTED RESULT	TEST RESULT
1	Installation over Android devices	Installation	App properly installed	OK
4	Configuration - manual	Configuration	App configured	OK
5	Configuration - via socials	Configuration	App configured	OK
6	Configuration - geolocalization	Configuration	Geolocalization activated	OK
7	Execution - start menu	Execution	Correct start menu opening	OK
8	Execution - fragrance reading	Fragrance Reading	Correct fragrance reading menu opening	OK
9	Execution - fragrance reading - detection of a genuine fragrance corresponding to the physical one read in the UAT	Fragrance Reading	Fragrance detection working properly	OK
10	Execution - fragrance reading - detection of a genuine fragrance not corresponding to the physical one read in the UAT	Fragrance Reading	Fragrance detection working properly	OK
11	Execution - fragrance reading - detection of a genuine fragrance failed	Fragrance Reading	Fragrance detection working properly	OK
12	Execution - fragrance reading – detection of a decayed fragrance	Fragrance Reading	Fragrance detection working properly	OK
13	Execution - augmented reality genuine box reading	AR experience	Correct triggering of AR experience from perfume box	OK
14	Execution – augmented reality 3d model positioning	AR experience	Correct positioning of perfume 3d model on top of the box	OK
15	Execution – augmented reality non-genuine box reading	Fragrance Reading	AR not triggered	OK

Section 2 - Design of Experiment

Design of Experiment (DoE) is a statistics technique to improve industrial processes. DOE is a test or series of tests that enable us to compare two or more methods to determine which is better, or determine levels of controllable factors to optimize the yield of a process or minimize the variability of the output. In particular DOE help us to improve the processes by:

- Screening the factors to determine which are important to explain process variations and to try to understand how factors interact and drive the process (Characterization Experiments);

- finding the factor settings that produce optimal process performance (Optimization Experiments).

DoE was developed by R. A. Fisher in England, and dates back to the 1920s. Historically, experimental design was not widely used in industrial improvement studies since engineers had trouble working with the large number of variables and their interactions on many different levels of the industrial processes. Improvements in computer software lately allowed DoE to become an important tool for process improvement.
In the TagItSmart project, Design of Experiment is paramount to understand under which conditions the tag is correctly read by a handheld device with the app. Further tests on the Tag itself (eg. different stress tests to verify the Tag resilience to shocks, temperature changes, and other possible misuses of the tag or the product).
Obviously, we are interested – at this stage – in a characterization experiment.
Basic concepts for a well-concocted Design of Experiment are the following:

- ✓ **Factors** = process variables (under control of the experimenter) that affect the process output (response variable)
- ✓ **Factor levels** = values of the factor for which the tests are conducted
- ✓ **Response variable** = the experiment outcome being measured
- ✓ Each predetermined setting of the experimental conditions is a run – also known as **treatment** or treatment combination
- ✓ A given set of value of the factors (run) can be **replicated** one or more times.

2.1 Setting the factors

The in-store experiment was designed to encompass 6 factors, 4 of which can be controlled (during the experiment and during future utilization of Tag and App) by the brand or the user, and 2 of which are “exogenous”, but could impact on the response. The Response Variable taken into account is the correct reading of the Tag. Factors and levels are as follows:

- Endogenous factors:
  - Position of the tag. As defined in the Task 1.1, the Tag can be placed in 4 different positions
    - In the bottle;
    - Under the cache;
    - Inside the stopper;
    - Inside the (secondary) cardboard box.
  - Distance between the hand-held device and the tag:
    - Touching each other
    - 1cm distance
    - 2cm distance
    - 3cm distance

        - 5cm distance
- Exogenous factors:
    - Temperature of the tag. This factor has 3 levels:
        - Room temperature
        - Heated (with an hair-dryer for 30')
        - Cooled (30' in a refrigerator)
    - Presence of other tags nearby. This factor has 3 levels:
        - No other tags
        - A tag 2 centimetres apart, on the side
        - A tag right behind the tag to read (1 cm distance)

Replications: every treatment was to be repeated 10 times.

2.2 Selecting the right kind of experiment

Experiments with more than one factor to study can be divided into:

- 1 factor at a time Experiments: Designs in which the levels of the factors vary one at a time. These kind of design don't allow for the study of interactions between the factors and consequently important interactions may remain undetected
- Factorial Experiments: Design in which the factors are varied together in order to estimate the effects of each factor. We can have Full Factorial (when all combinations are tested) and Fractional Factorial.

Time for completing the experiments did not allow a full factorial experiment. A full factorial experiment, in fact, would result in 4x5x3x3 = 180 treatments, with very long setup times associated with changing the settings so many times. A need for "randomization" (i.e. not carrying out the experiments in a predefined sequence, eg. all the repetitions of one treatment in one go) would further increase the time required for experiments.

As a consequence, we opted for a reduced factorial design. With 4 factors on 3 levels each, it is possible to resort to the concept of Orthogonal Arrays developed by Taguchi in his Taguchi Robust Design approach. The set of experiments to carry out could be considered orthogonal if:

- every factor is tested on every possible level the same number of times;
- every factor is exposed to the average of all other factors.

Following Taguchi theory, we reduced the levels of the two endogenous factors to 3 (customarily, the "lower", a "middle" one and the "higher"). Regarding the position of the tag, the two intermediate levels (inside the cache and inside the stopper) were pretty similar. The choice of "low-middle-high" seemed like a no-brainer in the case of distance; thus, the 3 levels for the two endogenous factors were modified as follows:

- Position of the tag. As defined in the Task 1.1, the Tag can be placed in 4 different positions:
    - In the bottle;
    - Inside the stopper;
    - Inside the (secondary) cardboard box.
- Distance between the hand-held device and the tag:
    - Touching each other
    - 2cm distance
    - 5cm distance

The resulting table for the experiments encompasses the results, where factor 1 represented the position of the tag, factor 2 the distance, factor 3 the temperature and factor 4 the presence of other tags:

TREATMENT	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	TEST RESULT (AVERAGE)
1	Low	Low	Low	Low	Low
2	Low	Middle	Middle	Middle	Middle
3	Low	High	High	High	High
4	Middle	Low	Middle	High	Middle
5	Middle	Middle	High	Low	Middle
6	Middle	High	Low	Middle	Middle
7	High	Low	High	Middle	Middle
8	High	Middle	Low	High	Middle
9	High	High	Middle	Low	Middle