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1.- Introduction:

The aim of this report is to enumerate the geometric objects of the mock-up to be identified during the analysis, explain their importance and describe how they are stored in the associated PIVOT structures. Regarding, the PIVOT objects that describe the electrical characteristics of the mock-ups are explained in document 3.1, “Modelling of all the objects of the PIVOT universal language via UML modelling”.

2.-Types of mock-ups:

Three sources are available for describing a mock-up: the paper designs, the AutoCAD files and the CATIA files. The structure of the first two ones is very similar because both sources provide information only in 2D, therefore, the same kind of objects is used for describing the geometry. As regards the CATIA files, they are a little different because their purpose is to contain mock-ups in 3D and, thus, the objects used for defining the geometry have some differences with those used in 2D.

3.- Typical elements used in 2D mock-ups:

Practically all the mock-ups contained in paper designs or AutoCAD files correspond to designs in 2D. The AutoCAD files already contain a description of basic elements (mainly, lines, circles and curves) and the conversion to equivalent PIVOT structures that contain the same information is almost immediate. In the case of the paper designs, the conversion process is more complex, because the design must be scanned and analyzed in order to recognize the different elements that appear in it. At the end, however, the PIVOT structures that will store the geometrical description of the mock-up will need to be able to define lines, circles, curves and, additionally, points. The reason for including the last ones is that they are very useful for positioning elements or defining connections between elements.

Apart from this, they contain numerous alphanumerical notes that complement the geometrical information with data about the attributes and characteristics of the objects they are attached to. These notes would need the correspondent PIVOT structures that store them. The conversion process of these elements is trivial when using AutoCAD files, because they are defined as individual elements. In the case of paper designs, the operation is quite more complex. As the design is a scanned image, the user must identify the notes and define them as text strings and then use a translator for extracting automatically their meaning.

4.- Typical elements used in 3D mock-ups:

The application that converts the mock-ups to PIVOT structures is not able of opening directly the CATIA files, because their format is encrypted, and we must export them to a standard format. It is the STL format which determines the geometrical elements to be stored in the PIVOT structures.

The STL files describe the shape of the components of the mock-up using facets, this is, polygons and, in most cases, triangles. For storing these polygons it is necessary to save their edges. Apart from this, we must also bear in mind the results of the analysis: The connections between the elements and the routing of the wires. The connections consist of points located in the intersections of

the elements, while the routings are given by polylines that go from one connection to another. To sum up, although the objects in the CATIA files contain splines and curved elements, these objects have been simplified for the graphical representation and may be described using only PIVOT structures that correspond to points and lines.

As regards the conversion process, the operation of exporting the CATIA files to STL files is performed by a macro executed in CATIA. This little program executes automatically the different functions that open the files associated to each element of the mock-up and generate the correspondent STL files. In these files, the geometrical description of the elements is already stored in facets. The conversion from these objects to the correspondent PIVOT structures is then trivial.

5.- Description of the PIVOT objects associated to the geometry of the mock-ups:

Next are explained the PIVOT structures that have been defined in order to give a complete description of the geometry for all the possible mock-ups that could be found. Most of them are common to mock-ups both in 2D and 3D, but some of them are needed only when describing mock-ups in 2D and others are only useful when working with designs in 3D and have no equivalent in 2D.

DESCRIPTION OF THE OBJECTS

Objects common to 2D and 3D:

Points and lines are the basic elements that constitute the mock-ups. They are used in both 2D and 3D designs in a very similar way. Therefore, their equivalents in PIVOT are almost the same. Next, there is a little description of each one of these objects and some examples of their use.

+Point:

It gives the position of a point in the plane or the space. The coordinates are two numbers in the first case and three in the second one. Apart from describing specific points, they may also be part of other structures such as PolyPoint or PolyLine.

+PolyPoint:

It contains a collection of two or more points.

+Line:

It describes a rectilinear segment. Its properties are the starting and ending points that give the position, length and orientation of the segment. This object may also be part of other structures such as the PolyLine.

+PolyLine:

It contains a collection of two or more line segments. Each segment may begin in the point where the previous one ends, being usual to use several Point objects for tracing the route, or be completely independent, being then better to use Line objects.

+Text:

Apart from points and lines, another element very common, especially in 2D mock-ups, is the text. This object contains a string of characters or numbers that normally refers to another geometric element of the mock-up.

+Arc:

The Arc was initially defined for describing the curved segments of 2D mock-ups. In order to not lose generality it was decided to extend the definition to both 2 and 3D.

The Arc object is currently defined as a quadratic Bezier curve, because it offers more generality than the arc of a circumference. We will use then three points for describing it. The first two points will correspond to the starting and ending points of the arc and the third one, the control point, will define the point in which the tangents to the curve in the starting and ending points of the arc intersect.

The initial purpose of this structure was to use it for describing curves in 2 and 3D. However, as there is not a structure defined specifically for describing circumferences in 3D, it may be used for defining this type of object, too. In this case, the circumference should be divided in three or more arcs and, then each one of them will be described by an arc.

Objects only for 2D:

CATIA files rarely contain information in 2D. Practically all 2D mock-ups correspond to paper designs and AutoCAD files. These files are mainly described using points, lines, circles and some text. The Circle object was added to the available structures in order to describe the circumferences in 2D. An equivalent of the circumference object has not been defined in 3D, because this element has not appeared in any of the mock-up examples studied and because, if it would be needed, it could be described using a combination of Arc objects. However, if a case in which this element is necessary is found, it will be added in future versions of PIVOT. Meanwhile, the Circle structure will be used for describing circumferences but only in 2D, the Sphere structure for describing spheres in 3D and, if the case appears, the circumferences in 3D would be described using a combination of Arc objects.

+Circle:

It describes a circumference in 2D. Its properties are the center, given in 2D coordinates, and the radius of the circle. Circumferences may be found combined with other lines in order to represent the symbol of certain electrical devices.

Objects only for 3D:

Generally, 3D mock-ups will correspond to designs in CATIA. The usual way of describing the parts of these mock-ups is using facets, i.e. polygons, because when exported to STL format each part of the mock-up is divided into a collection of triangles. These facets may be easily described using PolyLines. However, some other objects, such as spheres, cones and cylinders, have been considered for those cases in which the 3D mock-ups correspond to designs in AutoCAD or for those mock-ups which are contained in a format different from STL.

+Sphere:

It describes a sphere in the 3D space. Its properties are the center, described using 3D coordinates, and the radius of the sphere. It could be used for describing structural objects that could appear in the AutoCAD 3D mock-ups.

+Cone:

It describes a cone. Its properties are the bottom and top points of the revolution axis, given in 3D coordinates, and the radius in the inferior point of the cone. It is considered that the radius in the top point of the revolution axis is always zero and that the variation of the radius from the base to the top of the cone is linear. It could be used for describing structural objects that could appear in the AutoCAD 3D mock-ups.

+Cylinder:

It describes a cylinder. It is described using the top and bottom points of the revolution axis and the radius of the cylinder. It is considered that the value of the radius is constant. It could be used for describing structural objects that could appear in the AutoCAD 3D mock-ups.