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CHAPTER OPENERS

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FIGURES

FIG. 1 Deduction: given the rule and the cause, deduce the effect; induction: given a cause and an effect, induce a rule; abduction: given a rule and an effect, abduce a cause. Elaboration by Irene Cazzaro based on <https://math.stackexchange.com/questions/619311/abductive-vs-inductive-reasoning>.

FIG. 2 Categories in which the terms related to a critique of source-based 3D digital models can be grouped. Visualisation by Irene Cazzaro.

FIG. 3 Connections between terms related to a critique of source-based 3D digital models from 1994 to 2019. Visualisation by Irene Cazzaro.

FIG. 4 Evolution in the definitions of terms related to the concept of „cultural heritage". Visualisation by Irene Cazzaro.

FIG. 5 Evolution in the definitions of the term "authenticity". Visualisation by Irene Cazzaro.

FIG. 6 Evolution in the definitions of the term "uncertainty". Visualisation by Irene Cazzaro.

FIG. 7 Connections between terms related to Digital Heritage Studies (red) and Digital Humanities (blue). Other words (green) have been added later to the list in order to complete and strengthen some connections. Visualisation by Irene Cazzaro.

FIG. 8 Workflow for reality- and source-based 3D digital models (visualisation by Irene Cazzaro based on Demetrescu 2018) composed of the following phases: collection on the field; collection of other available (archival) sources; organisation of the *dossier comparatif*; creation of the *eidotipi*; creation of the 3D model, which can continue to influence the previous steps.

FIG. 9 The five-star model according to Berners-Lee et al. (2006). <https://commons.wikimedia.org/wiki/File:5-star_deployment_scheme_for_Open_Data.png> (Wikimedia Commons, PD).

FIG. 10 An example of "uncertainty" evaluation based on fuzzy logic (Niccolucci and Hermon 2004). For each element in which the model is segmented, a calculation of fuzziness is performed by means of coefficients according to fuzziness diagrams such as the one shown here in the bottom right. For some elements, the creation of more variants may be necessary. Courtesy of the authors.

FIG. 11 An example of extended matrix in which, to the stratigraphic units found on site, some virtual stratigraphic units are added according to deductions and analogies. In the diagrams, they correspond to the cells with black background (Demetrescu 2018). Courtesy of the author.

FIG. 12 Digital tools to assess the reliability of a hypothetical digital 3D reconstruction, retrieved from <http://3dvisa.cch.kcl.ac.uk/project6.html> (screen capture 20.10.2024).

FIG. 13 Documentation related to five different parts of the Kloster Altenberg, the last edited model in ScieDoc: <http://dmz-39.architektur.tu-darmstadt.de/reconstruction/?ac=project&cm=view&project_id=24> (screen capture 16.10.2024). The "evaluation" field has been enlarged here for a better legibility.

FIG. 14 The approach that consists in visualising information through glyphs and icons especially derives from cartography (above), where it is particularly used to express quantity or flux (Bertin 1967). Below, we can see examples of glyphs specifically used to represent uncertainty (Pang, Wittenbrink, and Lodha 1996) regarding (from left to right): vector fields of winds and currents, line glyphs showing the gaps between two differently interpolated surfaces, line glyphs connecting particle positions along two streamlines calculated using different methods. Elaboration by Irene Cazzaro based on the above-mentioned publications.

FIG. 15 A simple monochromatic rendering can be an alternative to photorealism when textures are not available. This model represents the Traianeum in Pergamon, 200 AD (elaboration by Irene Cazzaro based on Lengyel and Toulouse 2016).

FIG. 16 "Diplomatic" visualisation method (Apollonio, Fallavollita, and Foschi 2021) according to which, rather than a photorealistic rendering or a neutral mono-material, the texture of the original drawing is used. Here on the top is a model of a square tomb developed starting from some drawings by Mauro Guidi (on the bottom) taken from Cesena Nuova, Atlante 41, Carta 48. Elaboration by Irene Cazzaro based on the above-mentioned paper, retrievable at <https://cris.unibo.it/handle/11585/847767> (open access from 11/01/2023).

FIG. 17 Variations in the line type to visualise uncertainty (Strothotte, Masuch, and Isenberg 1999). Courtesy of the authors.

FIG. 18 Use of wireframe to visualise the most uncertain parts (Kensek, Dodd, and Cipolla 2004). Courtesy of the authors.

FIG. 19 Use of scanlines to obtain textures with different levels of detail (Potter et al. 2007). Courtesy of the authors.

FIG. 20 Transparency variations: the more transparent, the more uncertain (Stefani 2010). Pilot project of the French national digitisation programme "3D monuments"led by the UMR 694 MAP laboratory: <http://www.gamsau.map.cnrs.fr/3D-monuments/projets/projet_sgdesert_presen-presen.php>. Courtesy of the author.

FIG. 21 Superimposition of a schematic render to the photorealistic one, with variations on transparency (Strothotte et al. 1999). Courtesy of the authors.

FIG. 22 Use of a cartoon effect to visualise uncertainty (Freudenberg et al. 2001). Courtesy of the authors.

FIG. 23 Variations in the level of detail (Heeb and Christen 2019). CC BY 4.0.

FIG. 24 Creation of sketches (Heeb and Christen 2019). CC BY 4.0.

FIG. 25 Colour-coded uncertainty levels (Kozan 2004). Courtesy of the author.

FIG. 26 RGB Colour mapping (Georgiou and Hermon 2011). Courtesy of the authors.

FIG. 27 The ten uncertainty levels in the project “Byzantium 1200”, 2011. Courtesy of the authors.

FIG. 28 Source-based colour scale applied to a drawing by Palladio (Apollonio, Gaiani, and Sun 2013). Courtesy of the authors.

FIG. 29 The five-level uncertainty scale for The Swedish Pompeii project (elaboration by Irene Cazzaro based on Dell’Unto et al. 2013).

FIG. 30 Probability map (Perlinska 2014). Courtesy of the author.

FIG. 31 Ten-level uncertainty scale (Resco and Figueiredo 2014). Courtesy of the authors.

FIG. 32 Comparison between a spectral and a non-spectral scale (Ortiz-Cordero, León Pastor, and Hidalgo Fernández 2018). Courtesy of the authors.

FIG. 33 Green-to-red qualitative uncertainty scale (Landes et al. 2019). Courtesy of the authors.

FIG. 34 Two different scales to visualise uncertainty (Grellert et al. 2019). Courtesy of the authors.

FIG. 35 Uncertainty scale allowing different granularity, here in the 7+1 variant, applied to the Villa Pisani in Bagnolo by Andrea Palladio (Apollonio, Fallavollita, and Foschi 2021). <https://cris.unibo.it/handle/11585/847767> (open access from 11/01/2023).

FIG. 36 Reconstruction of an archaeological site and superimposition of an uncertainty scale by Pablo Aparicio Resco. It is possible to switch between the two images by means of a slider. The uncertainty scale has been updated with respect to the 2014 one: instead of purple (a misleading colour), grey has been chosen. <https://parpatrimonioytecnologia.wordpress.com/2022/06/06/hacia-una-nueva-version-de-la-escala-de-evidencia-historico-arqueologica/> (screen capture 31.10.2024).

FIG. 37 Use of different points of view to highlight different features of the model (Heeb and Christen 2019). CC BY 4.0.

FIG. 38 Selection of variants of Egyptian columns through an interface that allows the combination of a base, eight shafts and four capitals (Kensek 2007). Courtesy of the author.

FIG. 39 Variants of the same tower according to different documentation (Heeb and Christen 2019). CC BY 4.0.

FIG. 40 Three examples among the many spectrograms used in scientific disciplines. On the left: the RF (radio frequency) spectrum of a battery charger over time; top right: spectrogram of an arterial blood pressure; bottom right: melodic range visualiser. <https://commons.wikimedia.org/wiki/File:3D_battery_charger_RF_spectrum_over_time.jpg> (PD); <https://www.researchgate.net/publication/301644768_Detecting_heart_rate_while_jogging_blind_source_separation_of_gait_and_heart-

beat>; (CC BY 4.0) <https://commons.wikimedia.org/wiki/File:Sonic_visualiser_melodic_range_spectrogram_example.jpg> (PD).

FIG. 41 Two heat maps visualising temperature variations. The larger one, using a scale from blue (cold) to red (hot), represents the different temperatures around the world; the smaller one, on bottom left, uses a lightness gradient to visualise on a matrix the different temperatures over a year in the same place. The months are given on the x-axis, the days on the y-axis. <https://commons.wikimedia.org/wiki/File:Average_Temperature_In_The_Southern_Rockies.png> (PD); <https://commons.wikimedia.org/wiki/File:World_heat_map. png> (PD).

FIG. 42 Historical heat maps in greyscale drawn by hand (Wilkinson and Friendly 2009) and the first results on Google Images (screen capture 10.01.2023) when typing "heat map". We can see that now they usually follow the colours of the spectrogram or a reduced green-red scale. Elaboration by Irene Cazzaro.

FIG. 43 Explanation of hue, lightness and saturation as variation in wavelength. Elaboration by Irene Cazzaro based on <https://www.di.univr.it/documenti/OccorrenzaIns/matdid/matdid311142.pdf>.

FIG. 44 On the left: the visible spectrum of light according to Newton; on the right: the formation of intermediate colours. <https://commons.wikimedia.org/wiki/File:Newton%27s_color_circle.png> (PD); elaboration by Irene Cazzaro based on <http://hyperphysics.phy-astr.gsu.edu/hbase/vision/newtcol.html>.

FIG. 45 The Farbenkugel by Otto Runge (left) and the colour triangle by James Clerk Maxwell (right). <https://upload.wikimedia.org/wikipedia/commons/9/94/Runge_Farbenkugel.jpg> (PD); <https://upload.wikimedia.org/wikipedia/commons/4/42/Maxwell_color_Triangle_Luckiesh_1921.png> (PD).

FIG. 46 Goethe's colour wheel with associated symbolic qualities, 1809. Source: <https://en.wikipedia.org/wiki/Theory_of_Colours#/media/File:Goethe,_Farbenkreis_zur_Symbolisierung_des_menschlichen_Geistes-_und_Seelenlebens,_1809.jpg> (PD).

FIG. 47 Light entering the eye and arriving to the retina, where it is processed by rods and cones. <https://askabiologist.asu.edu/rods-and-cones> (CC BY-NC-SA 3.0).

FIG. 48 Comparison between the colour spaces by Newton and Helmholtz. <https://opg.optica.org/josaa/fulltext.cfm?uri=josaa-34-7-1099&id=367369> OAPA - Copyright Transfer and Open Access Publishing Agreement.

FIG. 49 Psychological theory by Ewald Hering: here the oppositional colours discovered by Hering are positioned in a circle around the one adopted by Newton, so as to complement it. <https://commons.wikimedia.org/wiki/File:Ewald_hering_colors. jpg> (PD).

FIG. 50 The generation of colour oppositions according to Hering's theory. <https://doi.org/10.3390/su15054341> (CC BY 4.0).

FIG. 51 The stage theory: both the trichromatic theory and the opponent theory are incorporated at different levels (respectively receptor and neural stage). Elaboration by Irene Cazzaro based on <https://www.ncbi.nlm.nih.gov/books/NBK11538/figure/ch28kallcolor.F16/?report=objectonly>.

FIG. 52 The Munsell (left) and NCS (right) colour systems. <https://commons.wikimedia.org/wiki/File:Munsell_1943_color_solid_cylindrical_coordinates.png> (CC BY-SA 3.0); <https://commons.wikimedia.org/wiki/File:Animation_of_the_NCS_Colour_System.gif> (CC BY-SA 4.0).

FIG. 53 Comparison of some RGB and CMYK chromaticity gamuts on a CIE 1931 XY chromaticity diagram <https://en.wikipedia.org/wiki/Color_space#/media/File:CIE1931xy_gamut_comparison.svg> (PD).

FIG. 54 The stages of colour appearance in a culture according to Berlin and Kay (1969). Visualisation by Irene Cazzaro.

FIG. 55 Felix Thürlemann, identification of the four psychological primaries according to Hering's theory. Here they are arranged in a series that can be infinitely repeated (or closed in a circle). Coloration of the diagram that in the original paper was presented in black and white, with the names of the respective colours in each area (1982). Visualisation by Irene Cazzaro.

FIG. 56 Different graphical tools to add information to a map (elaboration by Irene Cazzaro based on Bertin 1967).

FIG. 57 Studies on visualisation styles and tools (Tufte 1990; 1997): above, two different colour scales have been applied to the same map to show how, in that case, the one with minor colour variation with respect to reality (on the left) works better and has become a standard in cartography; however, this is different from the use of false colours in 3D digital models. As we can see below, there are some fields in which a colour scale proves to be more effective, such as in the animation of this thunderstorm. This means that choosing a correct visualisation depends on the aim of our work. Courtesy of the author.

FIG. 58 Comparison between uncertainty scales used in different domains (mainly architecture and archaeology) with descriptions in different languages. Visualisation by Irene Cazzaro.

FIG. 59 Source-based uncertainty scale (Apollonio 2015). Courtesy of the author.

FIG. 60 Relationships between a source-based uncertainty scale and the operations done to reconstruct an element: interpretation, deduction, conjecture, etc. (Apollonio 2016). Courtesy of the author.

FIG. 61 left: Byzantium 1200 source-based scale of knowledge; right: Modification of the scale on the left by changing the colours and reducing the levels from 10 to 8. The scale is still source-based, with some adjustments in the description and order of the levels (Ortiz-Cordero, León Pastor, and Hidalgo Fernández 2018). Courtesy of the authors.

FIG. 62 Iconicity scale according to Moles (1971). From the representation with higher degree of similarity to the referent, we have: 3D representation, photography, illustration, scheme, pictogram, diagram, ideogram, word-image, onomatopoeia, arbitrary word, abstract symbol, unspoken symbol. Visualisation by Irene Cazzaro based on <https://visualdsgn.fr/degre-iconicite-representation-visuelle/>.

FIG. 63 Qualitative uncertainty scales: on the left, evaluation of reconstruction variants in Sciedoc; on the right, evaluation of overall, archaeological, comparative and documentary reliability (high, medium, low) in the 3DVisa platform. <http://www. sciedoc.org/>; <http://3dvisa.cch.kcl.ac.uk/project6.html>.

FIG. 64 The level of knowledge is expressed by a qualitative judgement (high, moderate, weak), but correlated to archaeological uncertainty through a description (Landes et al. 2019). Courtesy of the authors.

FIG. 65 Another example of correlation: the two scales used for defining the plausibility of the variants and the categorisation of the used sources (Grellert et al. 2019). Courtesy of the authors.

FIG. 66 This scale concerns the relationship between a source (no matter which kind) and a reconstruction element involving more or less objectivity, consistency, deduction, hypothesis (elaboration by Irene Cazzaro based on Dell'Unto et al. 2013).

FIG. 67 Here we can see as well the connection to the sources, but the stress is on the type of conjectures we do in analysing them (Apollonio, Fallavollita, and Foschi 2021). <https://cris.unibo.it/handle/11585/847767> (open access from 11/01/2023).

FIG. 68 Different granularity in the uncertainty scales proposed by Apollonio et al. (2021), see the link in the previous caption. In the scale with 5 levels, the 3-4 and 5-6 are collapsed (differentiating the authors of indirect sources is no longer relevant in this case). In the scale with 3 levels, 1-2 are collapsed, as well as the levels from 3 to 6: in this case, the only differentiation that remains is between direct sources, indirect sources and pure hypotheses. This might be used when the maximum accuracy is not required or the range of available sources is not so wide.

FIG. 69 The matrix proposed by Paradis and Beard (1994) with the two sets of parameters indicating the basic requirements for casual observation to become useful data (location, theme, time) and the evaluation of data quality (accuracy, resolution, consistency, lineage). Visualisation by Irene Cazzaro.

FIG. 70 Shape, material and appearance concur to the definition of uncertainty (Apollonio 2016). Courtesy of the author.

FIG. 71 Uncertainty classification according to more than one parameter. The table on the left (elaboration by Irene Cazzaro based on Thomson et al. 2005) has been then taken up by Aurélie Favre-Brun, who groups the nine categories into three macro-categories (Favre-Brun 2013): quality (accuracy, precision, completeness), coherence (consistency, lineage, currency), objectivity (credibility, subjectivity, interrelatedness). Courtesy of the author. The diagram on the right is an elaboration by Fabrizio Apollonio identifying the connections between terms composing these three macro-categories (Grellert et al. 2019). Courtesy of the authors.

FIG. 72 A similar matrix (Favre-Brun 2013) to evaluate the information corresponding to each element in which the construction is segmented. The evaluation is done by attributing different values to spatial, dimensional, temporal, visual and morphological uncertainty. Courtesy of the author.

FIG. 73 Some of the colour scales found in the ColourBrewer. The selected one is colourblind safe. <https://colorbrewer2.org/#type=diverging&scheme=RdYlBu&n=3> (screen capture 19.10.2024).

FIG. 74 Example of documentation for the model of the new synagogue in Wroclaw (Poland), in which a simple "certainty" matrix related to the entire structure was included. Information and sources of the project are accessible here: <https://www.new-synagogue-breslau-3d.hs-mainz.de/>. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 75 Classification of some of the most used 3d viewers according to their features: above we can see the most developed ones (Smithsonian, Sketchfab, CyArk); in the middle those offering basic possibilities (MyMiniFactory, p3d.in, 3D Warehouse), below we have interfaces that generate previews of the downloadable models, without allowing further interaction. Visualisation by Irene Cazzaro.

FIG. 76 The ScieDoc interface traces the process that led to the reconstruction by means of sources and argumentation. A numerical evaluation of uncertainty is also allowed. <http://www.sciedoc.org/> (screen capture 31.10.2024).

FIG. 77 Uncertainty data visualised on the model once imported in ArcGIS (Perlinska 2014). Courtesy of the author.

FIG. 78 Visualisation of the "missing parts" of a sculpture reconstructed and uploaded to 3D Hop. Here the user can choose which elements to display: the original ones (which are reality-based, therefore certain) and/or the integrations, which are always, to some extent, hypothetical. <http://vcg.isti.cnr.it/3dhop/> (screen capture 31.10.2024).

FIG. 79 The use of colour scales (in the form of gradients) in Plas.io. Gradients are not exactly what we are looking for; still, a colour is attributed to a parameter – height, in this case. Attributing colours according to a value is what we also seek for uncertainty visualisation. <https://plas.io/> (screen capture 31.10.2024).

FIG. 80 The application of colour to different elements based on their nature in Potree. A similar visualisation can also indicate uncertainty levels. Here the colours can be changed according to the user's needs. <http://potree.org/potree/examples/classifications.html> (screen capture 31.10.2024).

FIG. 81 The interface of the DFG viewer and some of the uploaded models. <https://3d-repository.hs-mainz.de/> (screen capture 14.11.2023).

FIG. 82 Virtual reconstruction of the Speyer synagogue in its second Romanesque phase (about 1250), in the context of the project SpSya1250. The different kinds of software that have been used are, from top left clockwise: SketchUp, Blender, Rhinoceros, Archicad.

FIG. 83 Screenshot of the Wikipedia page that is under development (screen capture 25.01.2023).

FIG. 84 The already existing Wikidata page about the former synagogue in Speyer (screen capture 25.01.2023).

FIG. 85 Applying different structural categories to the building and identification of the types of structural elements. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 86 Simple uncertainty scale elaborated for the models to be uploaded to the DFG viewer. Visualisation by Irene Cazzaro.

FIG. 87 The model of the Speyer synagogue uploaded to the DFG Repository, with its metadata (screen capture 25.01.2023).

FIG. 88 External and internal view of the synagogue. Renderings uploaded to Wikimedia Commons. Visualisation by Irene Cazzaro.

FIG. 89 Application of the uncertainty scale to the exterior and interior of the synagogue. Visualisation by Irene Cazzaro.

FIG. 90 Tables documenting the reconstruction steps and the choices made to reconstruct every single object as defined in the semantic segmentation. Visualisation by Irene Cazzaro.

FIG. 91 Evaluation of uncertainty based on morphology, position, dimensions, texture, historical period. Visualisation by Irene Cazzaro.

FIG. 92 Uncertainty evaluation based on the assessment of objectivity, quality and coherence parameters, according to Thomson et al. (2005). This evaluation has been performed on four elements belonging to different categories: "still existing", "reconstructed by inference based on direct sources", "reconstructed by analogy", "reconstructed by hypothesis". Visualisation by Irene Cazzaro.

FIG. 93 Variant of the Speyer synagogue with circular windows. Visualisation by Irene Cazzaro.

FIG. 94 Variant with circular windows: levels of uncertainty applied using Rhinoceros. The levels of uncertainty are still the same; just the shape of the windows has been changed. Visualisation by Irene Cazzaro.

FIG. 95 Variant of the synagogue in its Gothic phase (around 1350). Visualisation by Irene Cazzaro.

FIG. 96 The uncertainty scale applied to the 1350 Gothic variant using SketchUp. Visualisation by Irene Cazzaro.

FIG. 97 Calculation of the average uncertainty for the model of the Speyer synagogue. Visualisation by Irene Cazzaro.

FIG. 98 At LOD 1 or 2, we would consider the (average) uncertainty level of the entire building, without differentiating it according to its elements. In this case, the average uncertainty level would be 3. Visualisation by Irene Cazzaro.

FIG. 99 If we imagine working at the detail of the single element, in this case the portal, a further subdivision into parts is probably necessary: in this case, we would indicate the level of uncertainty of each single sub-element. This visualisation is a pure example: the sources that we have to reconstruct the portal don't allow reasoning at this level. Visualisation by Irene Cazzaro.

FIG. 100 On the left: the model with the "pure" RGB colours identified in the handout. Variations, however, may be possible. In the model on the right, the colours are still perceived as blue-green-yellow-red. These have been taken from the colour scale by Apollonio et al. (2021). Visualisation by Irene Cazzaro.

FIG. 101 A colourblind-safe uncertainty scale according to the ColorBrewer by Cynthia Brewer. Here the four colours used in the previous visualisations have been replaced by the series "blue", "light blue", "yellow", "orange". Visualisation by Irene Cazzaro.

FIG. 102 Adoption of a scale based on the variation in lightness from black to white. Visualisation by Irene Cazzaro.

FIG. 103 The application of textures (stripes and dots) besides plain colours may define all the levels of the scale. Visualisation by Irene Cazzaro.

FIG. 104 Adoption of a scale based on the variation in lightness from red to white. Visualisation by Irene Cazzaro.

FIG. 105 Adoption of a scale based on the variation in lightness from green to white. Visualisation by Irene Cazzaro.

FIG. 106 Adoption of a scale based on the variation in lightness from blue to white. Visualisation by Irene Cazzaro.

FIG. 107 Uncertainty expressed through different degrees of transparency – as far as they can be distinguished. Visualisation by Irene Cazzaro.

FIG. 108 Combination of opacity, transparency and wireframe to visualise more uncertainty levels. Visualisation by Irene Cazzaro.

FIG. 109 Mesh produced by Sander Münster and elaborated by Irene Cazzaro. The pictures taken by Irene Cazzaro have been initially used.

FIG. 110 In this case, the mesh has been used to visualise the still existing parts of the building, whereas a non-photorealistic model with colours indicating the different degrees of uncertainty (according to the scale seen before) represent all the source-based reconstructed elements. Visualisation by Irene Cazzaro based on the previous figure.

FIG. 111 Attribution of "wall surface" as boundary surface type. Visualisation by Irene Cazzaro.

FIG. 112 The attributes related to the still existing part of the wall are added; as a generic attribute, the uncertainty level is also included. Visualisation by Irene Cazzaro.

FIG. 113 The same has been done for Wall 2, whose uncertainty level is 3-deduction. Visualisation by Irene Cazzaro.

FIG. 114 Attributes were added to the roof in the same way. Here the uncertainty level is “1-hypothesis”. Visualisation by Irene Cazzaro.

FIG. 115 Attributes are added to closure surfaces. Visualisation by Irene Cazzaro.

FIG. 116 Attributes are added to the variant with circular windows. Visualisation by Irene Cazzaro.

FIG. 117 The attributes are applied to the entire building, at another level of the hierarchy. Visualisation by Irene Cazzaro.

FIG. 118 The attributes are applied to the entire building, at another level of the hierarchy. Visualisation by Irene Cazzaro.

FIG. 119 The attributes are applied to the entire building, at another level of the hierarchy. Visualisation by Irene Cazzaro.

FIG. 120 The CityGML export. Visualisation by Irene Cazzaro.

FIG. 121 Visualisation of the model and of some elements that compose it, together with the assigned attributes, in FZK Viewer. Visualisation by Irene Cazzaro.

FIG. 122 Visualisation of the variant with circular windows and its related attributes in FZK Viewer: the deducted wall. Visualisation by Irene Cazzaro.

FIG. 123 Visualisation of the variant with circular windows and its related attributes in FZK Viewer: the circular windows. Visualisation by Irene Cazzaro.

FIG. 124 Gothic variant: the attributes are added to the entire building. Visualisation by Irene Cazzaro.

FIG. 125 Gothic variant: the attributes are added to every single element. This is only an example concerning the windows that have been transformed in the passage from the Romanesque to the Gothic synagogue. Visualisation by Irene Cazzaro.

FIG. 126 The structure of the model in CityEditor. Visualisation by Irene Cazzaro.

FIG. 127 The visualisation of the Gothic variant and its attributes in FZK Viewer: here the entire building can be seen. Visualisation by Irene Cazzaro.

FIG. 128 The visualisation of the Gothic variant and its attributes in FZK Viewer: Gothic windows. Visualisation by Irene Cazzaro.

FIG. 129 The visualisation of the Gothic variant and its attributes in FZK Viewer: deducted part of the wall. Visualisation by Irene Cazzaro.

FIG. 130 Adding the uncertainty property in Archicad. Step 1. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 131 Adding the uncertainty property in Archicad. Step 2. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 132 Adding the uncertainty property in Archicad. Step 3. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 133 Adding the uncertainty property in Archicad. Step 4. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 134 Adding the uncertainty property in Archicad. Step 5. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 135 Adding the uncertainty property in Archicad. Step 6. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 136 Adding the uncertainty property in Archicad. Step 7. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 137 Adding the uncertainty property in Archicad. Step 8. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 138 Adding the uncertainty property in Archicad. Step 9. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 139 Adding the uncertainty property in Archicad. Step 10. Visualisation by Igor Bajena. Courtesy of the author.

FIG. 140 Application of the average uncertainty level "3-deduction" to the entire building. Visualisation by Irene Cazzaro based on the model by Katarzyna Prokopiuk.

FIG. 141 Application of the uncertainty level “3-deduction” to walls, doors and windows. Visualisation by Irene Cazzaro based on the model by Katarzyna Prokopiuk.

FIG. 142 Application of the uncertainty level “1-hypothesis” to the ceiling and the floor. Visualisation by Irene Cazzaro based on the model by Katarzyna Prokopiuk.

FIG. 143 The uncertainty parameter is still accessible once the CityGML file has been exported and opened with FZK Viewer. Visualisation by Irene Cazzaro based on the model by Katarzyna Prokopiuk.