Automatic generation of simplified buildings from 2D wire-frame *

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Abstract

In this module we develop a small library of functions to generate automatically simplified models of 3D buildings starting from 2D wire-frame drawings. The generated geometries will be exported to xGeoJson, a hierarchical data format extending GeoJson, the standard for geographical web maps, with assemblies and local rectangular coordinates.

Contents

1 Introduction

A simplified 2D layout of building floors may be generated by using either a simple web UI providing only two or three interactive graphics primitives (rect and polyline, in particular)

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or by exporting the output of a drawing program to a standard 2D graphics data format, in particular to `SVG` (Simple Vector Graphics, the vector graphics standard for the web). This information will be used to automatically generate a simplified 3D model of the building and to export its geometry and topology to an external data format called `xGeoJson`, a customised extension of GeoJson an opensource standard for geographical information.

2 Transformation filters

2.1 From `svg` to `lar`

`SVG` primitives to lar Two `SVG` primitives are currently used to define the wire-frame layout of the building floors using either a drawing application or an interactive user interface within the browser: `rect` (for the definition of rectangles) and `polyline` (for the definition of closed polylines).

⟨ transform svg primitives to basic lar format 2a ⟩ ≡

```
""" transform svg primitives to basic lar format """
def rects2polylines(rooms):
   return [[[x,y],[x+dx,y],[x+dx,y+dy],[x,y+dy]] for x,y,dx,dy in rooms]


def polyline2lar(polylines):
   index,defaultValue = -1,-1
   Vdict,FV = dict(),[]
   for k,polyline in enumerate(polylines):
      cell = []
      for vert in polyline:
         key = vcode(vert)
         if Vdict.get(key,defaultValue) == defaultValue:
            index += 1
            Vdict[key] = index
            cell += [index]
         else:
            cell += [Vdict[key]]
      FV += [cell]
   items = TRANS(Vdict.items())
   V = TRANS(sorted(zip(items[1],AA(eval)(items[0]))))[1]
   #FV = AA(sorted)(FV)
   EV = face2edge(FV)
   return V,FV,EV
```
   ◇

Macro referenced in 10.

2.2 From `lar` to `struct`

Mapping of a `lar` model to a list of `lar` structures

⟨ transform a lar model to a list of lar structures 2b ⟩ ≡

```
""" transform a lar model to a list of lar structures """
def lar2Structs(model):
    V,FV,_ = model
    return [ Struct([[[V[v] for v in cell], [range(len(cell))]]]) for cell in FV]
```
◇

Macro referenced in 10.

⟨ Struct class pushing local origin at the bottom of the structure 2c ⟩ ≡

```
class Struct2(Struct):
    def flatten(self):
        structs = copy(self.body)
        structList = lar2Structs(CAT(structs.body))
        return [ absModel2relStruct(struct[0].body) for struct in structList ]
```
◇

Macro referenced in 10.

⟨ transform an absolute lar model to a relative lar structure 3a ⟩ ≡

```
""" transform an absolute lar model to a relative lar structure """
def absModel2relStruct(larModel):
    V,E = larModel
    Vnew = (array(V) - V[0]).tolist()
    return Struct([ t(*V[0]), (Vnew,E) ])
```
◇

Macro referenced in 10.

2.3 Assembling `structures`

2.4 Exporting to `xGeoJson`

Exporting to JSON via YML a lar structure

⟨ Exporting to JSON via YML 3b ⟩ ≡

```
""" exporting to JSON via YML a lar structure """
file_handle = open(path+filename+".yml")
my_dictionary = yaml.safe_load(file_handle)
file_handle.close()
with open(path+filename+".json", 'w') as outfile:
    json.dump(my_dictionary, outfile, sort_keys=True, indent=4, ensure_ascii=False)
#filejson = open("file1.json", 'r')
#dicta = json.loads(filejson.read())
```
◇

Macro referenced in 3c.

print a lar structure to a geoJson file

⟨ Print a lar structure to a geoJson file 3c ⟩ ≡

```
""" print a lar structure to a geoJson file """
import yaml
import json



def printStruct2GeoJson(path,struct):
    if struct.__name__() == None:
        filename = str(id(struct))
    else:
        filename = struct.__name__()
    theFile = open(path+filename+".yml", "w")
    print >> theFile, "---"
    print "filename =", path+filename+".yml"
    dim = checkStruct(struct.body)
    CTM, stack = scipy.identity(dim+1), []
    fathers = [filename]
    #import pdb; pdb.set_trace()

    tabs = (3*1)*" "

    import hijson
    V,boundaryEdges = hijson.structBoundaryModel(struct)    #+new
    boundaryPolygons = hijson.boundaryModel2polylines((V,boundaryEdges))   #+new

    printStructObject(theFile,tabs, 0,struct.name,struct.category,boundaryPolygons, "building")
    printTraversal(theFile, struct, 0, fathers,filename,[0,0,0])

    theFile.close()
```
    ⟨ Exporting to JSON via YML 3b ⟩

⟨ Print a Model object in a geoJson file 4 ⟩
⟨ Print a Mat object in a geoJson file 5a ⟩
⟨ Print a Struct object in a geoJson file 5b ⟩
⟨ Traverse a structure to print a geoJson file 6 ⟩
◇

Macro referenced in 10.

Print a `Model` object in a xGeoJson file

⟨ Print a Model object in a geoJson file 4 ⟩ ≡

```
""" Print a model object in a geoJson file """
def printModelObject(theFile,tabs, i,name,category,verts,cells,father,tvect=[0,0,0]):
```

```
        tab = "  "
        print >> theFile, "-   ","id:", name
        print >> theFile, tab, "type:", "Feature"
        print >> theFile, tab, "geometry:"
        print >> theFile, tab+tab, "type:", "Polygon"
        print >> theFile, tab+tab, "coordinates:"
        print >> theFile, tab+tab+tab, AA(eval)(AA(vcode)(verts))
        print >> theFile, tab, "properties:"
        print >> theFile, tab+tab, "class:", category
        print >> theFile, tab+tab, "parent:", father
        print >> theFile, tab+tab, "son:", i
        print >> theFile, tab+tab, "description:", name
        print >> theFile, tab+tab, "tVector:", [tvect[0],tvect[1],tvect[2]]
        print >> theFile, tab+tab, "rVector:", [0, 0, 0]
    ◇
```

Macro referenced in 3c.

Print a `Mat` object in a `xGeoJson` file

⟨ Print a Mat object in a geoJson file 5a ⟩ ≡

```
    """ Print a mat object in a geoJson file """
    def printMatObject(theFile,tabs, theMat):
        tab = "  "
        print >> theFile, tab+tab, "tVector:", theMat.T[-1,:-1].tolist()
    ◇
```

Macro referenced in 3c.

Print a `Struct` object in a `xGeoJson` file

⟨ Print a Struct object in a geoJson file 5b ⟩ ≡

```
    """ Print a struct object in a geoJson file """
    def printStructObject(theFile,tabs, i,name,category, boundaryPolyline,father,tvect=[0,0,0]):
        tab = "  "
        print >> theFile, "-   ","id:", name
        print >> theFile, tab,"type:", "Feature"
        print >> theFile, tab,"geometry:"
        print >> theFile, tab+tab, "type:", "Polygon"
        print >> theFile, tab+tab, "coordinates:", boundaryPolyline
        print >> theFile, tab,"properties:"
        print "category=", category
        print >> theFile, tab+tab, "class:", category
        print >> theFile, tab+tab, "parent:", father
        print >> theFile, tab+tab, "son:", i
        print >> theFile, tab+tab, "description:", name
        print >> theFile, tab+tab, "tVector:", [tvect[0],tvect[1],tvect[2]]
```

```
              print >> theFile, tab+tab, "rVector:", [0, 0, 0]
```

⟨ Print a SINGLE Wall LAR model in a geoJson file 5c ⟩
◇

Macro referenced in 3c.

⟨ Print a SINGLE Wall LAR model in a geoJson file 5c ⟩ ≡
```
      """ Print a struct object in a geoJson file """
      def printWallObject(theFile, name,i,category, edge,father,tvect=[0,0,0]):
        tab = "  "
        print >> theFile, "-   ","id:", name
        print >> theFile, tab,"type:", "Feature"
        print >> theFile, tab,"geometry:"
        print >> theFile, tab+tab, "type:", "LineString"
        print >> theFile, tab+tab, "coordinates:", edge
        print >> theFile, tab,"properties:"
        print "category=", category
        print >> theFile, tab+tab, "class:", category
        print >> theFile, tab+tab, "parent:", father
        print >> theFile, tab+tab, "son:", i
        print >> theFile, tab+tab, "description:", name
        print >> theFile, tab+tab, "tVector:", [tvect[0],tvect[1],tvect[2]]
        print >> theFile, tab+tab, "rVector:", [0, 0, 0]
```
◇

Macro referenced in 5b.

Traverse a structure to print a geoJson file

⟨ Traverse a structure to print a geoJson file 6 ⟩ ≡
```
      """ Traverse a structure to print a geoJson file """
      def old_printTraversal(theFile,obj, level=0, fathers=[],father="",tvect=[0,0,0]):
        import hijson
        tabs = (4*level)*" "
        for i in range(len(obj)):
          if isinstance(obj[i],Model):
            i,verts,cells = obj[i]
            if obj[i].__name__() == None:
              name = father+'-'+ str(id(obj[i]))
            else:
              name = father+'-'+ str(obj[i].__name__())
            printModelObject(theFile,tabs, i,name,None,verts,cells,father)
            fathers += [father]
          elif (isinstance(obj[i],tuple) or isinstance(obj[i],list)) and len(obj[i])==2:
            verts,cells = obj[i]
            name = father+'-'+ str(id(obj[i]))
```

```python
          printModelObject(theFile,tabs, i,name,None,verts,cells,father)
          fathers += [father]
      elif isinstance(obj[i],Mat):
        printMatObject(theFile,tabs, obj[i])
      elif isinstance(obj[i], Struct):
        if obj[i].__name__() == None:
          name = father+'-'+ str(id(obj[i]))
        else:
          name = father+'-'+ str(obj[i].__name__())

        box = obj[i].box
        tvect = box[0]

        if obj[i].category in ["internal_wall", "external_wall", "corridor_wall"]:
            edge = evalStruct(obj[i])[0][0]
            category = obj[i].__category__()
            printWallObject(theFile, name,i,category, edge,father,tvect=[0,0,0])
        else:
            V,boundaryEdges = hijson.structBoundaryModel(obj[i])
            coordinates = hijson.boundaryModel2polylines((V,boundaryEdges))
            transfMat = array(t(*[-x for x in tvect]))

            def transformCycle(transfMat,cycle):
                affineCoordinates = [point+[1] for point in cycle]
                localCoords = (transfMat.dot(array(affineCoordinates).T)).T
                localCoordinates = [[x,y,z] for x,y,z,w in localCoords.tolist()]
                return localCoordinates

            coordinates = [transformCycle(transfMat,cycle) for cycle in coordinates]
            category = obj[i].__category__()
            printStructObject(theFile,tabs, i,name,category,coordinates,father,tvect)

      level += 1
      fathers.append(name)
      printTraversal(theFile,obj[i], level, fathers,name, tvect)
      name = fathers.pop()
      level -= 1
  return fathers



###

wall_categories = ["internal_wall", "external_wall", "corridor_wall"]

room_categories = ["room"]
```

```python
indent = 2 * " "

def get_id(obj, father_id):
    return father_id + '_' + obj.name

def is_struct(obj):
    return isinstance(obj, Struct)

def is_wall(obj):
    return obj.category in wall_categories

def is_room(obj):
    return obj.category in room_categories

def is_model(obj):
    return isinstance(obj, Model)

def is_mat(obj):
    return isinstance(obj,Mat)

def is_list(obj):
    return isinstance(obj, tuple) or isinstance(obj, list)

def print_wall(out, obj, parent_id):
    obj_id = get_id(obj, parent_id)
    edge = evalStruct(obj)[0][0]
    category = obj.category
    tvect = obj.box[0]
    print >> out, "-    ", "id:", obj_id
    print >> out, indent, "type:", "Feature"
    print >> out, indent, "geometry:"
    print >> out, indent+indent, "type:", "LineString"
    print >> out, indent+indent, "coordinates:", edge
    print >> out, indent, "properties:"
    print "category=", category
    print >> out, indent+indent, "class:", category
    print >> out, indent+indent, "parent:", parent_id
    print >> out, indent+indent, "description:", ""
    print >> out, indent+indent, "tVector:", [tvect[0],tvect[1],tvect[2]]
    print >> out, indent+indent, "rVector:", [0, 0, 0]


def transformCycle(transfMat,cycle):
    affineCoordinates = [point+[1] for point in cycle]
    localCoords = (transfMat.dot(array(affineCoordinates).T)).T
```

```python
        localCoordinates = [[x,y,z] for x,y,z,w in localCoords.tolist()]
        return localCoordinates

def print_struct(out, obj, parent_id):
    tvect = obj.box[0]
    import hijson
    V,boundaryEdges = hijson.structBoundaryModel(obj)
    coordinates = hijson.boundaryModel2polylines((V,boundaryEdges))
    transfMat = array(t(*[-x for x in tvect]))
    coordinates = [transformCycle(transfMat,cycle) for cycle in coordinates]
    category = obj.category

    print >> out, "-   ","id:", name
    print >> out, indent,"type:", "Feature"
    print >> out, indent,"geometry:"
    print >> out, indent+indent, "type:", "Polygon"
    print >> out, indent+indent, "coordinates:", coordinates
    print >> out, indent,"properties:"
    print "category=", category
    print >> out, indent+indent, "class:", category
    print >> out, indent+indent, "parent:", parent_id
    print >> out, indent+indent, "description:", ""
    print >> out, indent+indent, "tVector:", [tvect[0],tvect[1],tvect[2]]
    print >> out, indent+indent, "rVector:", [0, 0, 0]

def print_model(out, obj, parent_id):
    obj_id = get_id(obj, parent_id)
    category = obj.category
    verts,cells = obj
    tvect = obj.box[0]
    print >> out, "-   ", "id:", obj_id
    print >> out, indent, "type:", "Feature"
    print >> out, indent, "geometry:"
    print >> out, indent+indent, "type:", "Polygon"
    print >> out, indent+indent, "coordinates:", AA(eval)(AA(vcode)(verts))
    print >> out, indent, "properties:"
    print >> out, indent+indent, "class:", category
    print >> out, indent+indent, "parent:", parent_id
    print >> out, indent+indent, "description:", ""
    print >> out, indent+indent, "tVector:", [tvect[0],tvect[1],tvect[2]]
    print >> out, indent+indent, "rVector:", [0, 0, 0]

def print_mat(out, obj, parent_id):
    print >> out, indent+indent, "tVector:", obj.T[-1,:-1].tolist()
```

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```python
def print_traversal(out, obj, parent_id='', level=0):

    if is_struct(obj):

        if is_wall(obj):
            print_wall(out, obj, parent_id)
            return

        print_struct(out, obj, parent_id)

        parent_id = get_id(obj, parent_id)
        print_traversal(out, obj.body, parent_id)
        return

    if is_model(obj):
        print_model(out, obj, parent_id)
        return

    if is_list(obj):
        parent_id = get_id(obj, parent_id)
        print_traversal(out, obj[0], parent_id)

        if len(obj) > 1:
            print_traversal(out, obj[1:], parent_id)

        return

    if is_mat(obj):
        print_mat(out, obj, parent_id)
        return

def printStruct2GeoJson(path, struct):
    if struct.__name__() == None:
        filename = str(id(struct))
    else:
        filename = struct.__name__()
    out = open(path+filename+".yml", "w")
    print >> out, "---"
    print "filename =", path+filename+".yml"
    dim = checkStruct(struct.body)
    CTM, stack = scipy.identity(dim+1), []
    fathers = [filename]
    #import pdb; pdb.set_trace()

    import hijson
    V,boundaryEdges = hijson.structBoundaryModel(struct)    #+new
```

```
        boundaryPolygons = hijson.boundaryModel2polylines((V,boundaryEdges))  #+new

        print_traversal(out, struct)

        out.close()

    ◇
```
Macro referenced in .

3   Iot3D Exporting

```
"larlib/larlib/iot3d.py" 10 ≡
    """Module with automatic generation of simplified 3D buildings"""
    from larlib import *

    ⟨From Struct object to LAR boundary model ?⟩
    ⟨Struct class pushing local origin at the bottom of the structure 2c⟩
    ⟨transform svg primitives to basic lar format 2a⟩
    ⟨transform a lar model to a list of lar structures 2b⟩
    ⟨transform an absolute lar model to a relative lar structure 3a⟩
    ⟨Print a lar structure to a geoJson file 3c⟩
    ◇
```

4   Examples

4.1   A complete 3D building example

In this section a complete 3D building example is developed, that starts by importing the
data associated to the rect and polyline primitives of the 2D layout exported as svg file,
and finishes by generating a complete 3D mock-up of a quite complex multi-floor office
building.

```
"test/py/iot3d/test01.py" 11 ≡
    """Automatic construction of a simplified 3D building from 2D layout"""
    import sys
    PATH = "/Users/paoluzzi/Documents/RICERCA/sogei/edifici/"
    sys.path.insert(0, PATH)

    from buildings import *
    from larlib import *

    # LAR models (absolute coordinates)
    ala_est = larEmbed(1)(polyline2lar(rects2polylines(eastRooms) + eastTip))
    ala_sud = larEmbed(1)(polyline2lar(rects2polylines(southRooms) + southTip))
```

```
ala_ovest = larEmbed(1)(polyline2lar(rects2polylines(westRooms) + westTip))
ala_nord = larEmbed(1)(polyline2lar(rects2polylines(northRooms) + northTip))
ascensori = larEmbed(1)(polyline2lar(elevators))
spazioComune = larEmbed(1)(polyline2lar(AA(REVERSE)(newLanding)))

# test of input consistency (flat assembly of LAR models)
pianoTipo = Struct([ala_est,ala_sud,ala_ovest,ala_nord,ascensori,spazioComune],"pianoTipo")
##VIEW(EXPLODE(1.2,1.2,1.2)(MKPOLS(struct2lar(pianoTipo))))
##VIEW(SKEL_1(EXPLODE(1.2,1.2,1.2)(MKPOLS(struct2lar(pianoTipo)))))

# LAR to structs
Ala_est = Struct(lar2Structs(ala_est),"Ala_est")
Ala_sud = Struct(lar2Structs(ala_sud),"Ala_sud")
Ala_ovest = Struct(lar2Structs(ala_ovest),"Ala_ovest")
Ala_nord = Struct(lar2Structs(ala_nord),"Ala_nord")
Ascensori = Struct(lar2Structs(ascensori),"Ascensori")
SpazioComune = Struct(lar2Structs(spazioComune),"SpazioComune")

model = struct2lar(Ala_est)
##VIEW(EXPLODE(1.2,1.2,1.2)(MKPOLS(model)))
for k,room in enumerate(Ala_est.body):
   print room.body

# hierarchical assembly of simplest LAR models
TreAli = Struct([Ala_est,Ala_sud,Ala_ovest,Ascensori,SpazioComune],"TreAli")
##VIEW(EXPLODE(1.2,1.2,1.2)(MKPOLS(struct2lar(TreAli))))
Ali_B_C_D = Struct(6*[TreAli, t(0,0,30)],"Ali_B_C_D")
##VIEW(EXPLODE(1.2,1.2,1.2)(MKPOLS(struct2lar(Ali_B_C_D))))

Ala_A = Struct(4*[Ala_nord,  t(0,0,30)],"Ala_A")
ALA_A = EXPLODE(1.2,1.2,1.2)(MKPOLS(struct2lar(Ala_A)))
##VIEW(EXPLODE(1.2,1.2,1.2)([ ALA_A, COLOR(BLUE)(SKEL_1(ALA_A)) ]))

Edificio = Struct([ Ala_A, Ali_B_C_D ],"Edificio")
out = struct2lar(Edificio)
if len(out)==2: V,FV = out
else: V,FV,EV = out

EDIFICIO = STRUCT(MKPOLS((V,FV)))
##VIEW(STRUCT([ EDIFICIO, COLOR(BLUE)(SKEL_1(EDIFICIO)) ]))

VV = AA(LIST)(range(len(V)))
SK = SKEL_1(EDIFICIO)
##VIEW(larModelNumbering(1,1,1)(V,[VV,[],FV],STRUCT([ COLOR(BLUE)(SK), EDIFICIO ]),20))

Va,EVa = struct2lar(TreAli)
```

```
Vb,EVb = struct2lar(Ala_A)
a = PROD([ SKEL_1(STRUCT(MKPOLS( ([ v[:2] for v in Va], EVa) ))), QUOTE(5*[30]) ])
b = PROD([ SKEL_1(STRUCT(MKPOLS( ([ v[:2] for v in Vb], EVb) ))), QUOTE(3*[30]) ])
glass = MATERIAL([1,0,0,0.3,  0,1,0,0.3,  0,0,1,0.3, 0,0,0,0.3, 100])
##VIEW(glass(STRUCT([a,b])))

##VIEW(STRUCT([ glass(STRUCT([a,b])), EDIFICIO, COLOR(BLUE)(SKEL_1(EDIFICIO)) ]))


printStruct2GeoJson(PATH,pianoTipo)
printStruct2GeoJson(PATH,Edificio)
◇
```

References

[CL13] CVD-Lab, *Linear algebraic representation*, Tech. Report 13-00, Roma Tre University, October 2013.