

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

Alberto Paoluzzi

March 29, 2016

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	1
2	Transformation filters	2
2.1	From svg to lar	2
2.2	From lar to struct	2
2.3	Assembling structures	3
2.4	Exporting to xGeoJson	3
3	Iot3D Exporting	11
4	Examples	11
4.1	A complete 3D building example	11

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)

*This document is part of the *Linear Algebraic Representation with CoChains* (LAR-CC) framework [CL13]. March 29, 2016

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(4)(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 YAML a lar structure

⟨ Exporting to JSON via YAML 3b ⟩ ≡

```

""" exporting to JSON via YAML a lar structure """
file_handle = open(path+filename+".yaml")
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+".yaml", "w")
    print >> theFile, "---"
    print "filename =", path+filename+".yaml"
    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 YAML 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(4))(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]))
```

```

    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"]

```

```

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

```



```

    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(4))(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()

```

```

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+".yaml", "w")
    print >> out, "---"
    print "filename =", path+filename+".yaml"
    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 [3c](#).

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.