Concept and preliminary design of a hospital system *

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Contents

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Abstract

In this module we develop stepwise the concept and the preliminary building program of a hospital of medium size, using as source the document [AM13] of the World Health Organisation.

1 Introduction

2 Model planning

2.1 Data sources

2.2 Reference grid

2.3 Architecture of modeling process

Reference grid

⟨ Reference grid 1 ⟩ ≡

```
""" Reference grid """
X = [0]+[7.5,9.5,7.5]+4*[8.4]+[7.5,9.5,7.5]+[0]
Y = [0]+14*[8.4]+[0]
xgrid = QUOTE(X[1:-1])
ygrid = QUOTE(Y[1:-1])
structuralGrid = PROD([xgrid,ygrid])
ymax = SUM(Y)
```

◇

Macro referenced in 14a.

From array indices to grid coordinates

⟨ From array indices to grid coordinates 2a ⟩ ≡

```
""" From array indices to grid coordinates """
def index2coords(theArray):
    return CONS(AA(T([1,2]))(CAT((theArray).tolist())))
```

◇

Macro referenced in 14a.

3 Building units planning

3.1 Wire-frame input

As already said, the data input for this project was made by hand. Of course, an interactive user-interface in underway. I would like to notice that to enter apart the coordinates of the vertices of cells, as two (or three) adjacent arrays, is much faster and lesser in danger of getting errors than to enter an array of points.

The several building units contained in this storey are given in the below script, each associated to a single ordered polyline, transposed on coordinates. Let us notice the used of a capitalised variable for storage, in order to distinguish from the corresponding `Struct` object with the same name.

⟨ Storey input 2b ⟩ ≡

```
""" Storey input """
⟨ Ground floor 3a ⟩
⟨ Mezanine floor 4b ⟩
⟨ First floor 6b ⟩
⟨ Second floor 8b ⟩
⟨ Third floor 10b ⟩
⟨ Fourth floor 11a ⟩
⟨ Fifth floor 11d ⟩

""" Building unit structure """
⟨ Ground floor structure 4a ⟩
⟨ Mezanine floor structure 6a ⟩
⟨ First floor structure 7b ⟩
⟨ Second floor structure 10a ⟩
⟨ Third floor structure 10d ⟩
⟨ Fourth floor structure 11c ⟩
⟨ Fifth floor structure 12b ⟩
◇
```

Macro referenced in 14a.

3.1.1 Ground floor

Ground floor input

⟨ Ground floor 3a ⟩ ≡

```
""" Ground floor """
OpenCourt10 = metric(TRANS([[3,3,4,4,6,6,6.65,6.65],[4,8,8,7.8,7.8,8,8,4]]))
RadioDiagnosticImaging = metric(TRANS([[7,7,9,10,10,8.7],[4,8,8,8,4,4]]))
ServiceCore10 = metric(TRANS([[1.15, 1.15, 1.3,2.55, 2.55,2], [2.85, 3.7,3.7,3.7,
    2.85,2.85]]))
ServiceCore20 = metric(TRANS([[7,7,8.7,8.8,8.8],[2.8,3.7,3.7,3.7,2.8]]))
```

```
EmergencyDepartment = metric(TRANS([[4.7,4.7,7,7,8.8,8.8,9.65,9.65],[0,3.7,3.7,
    2.8,2.8,3.7,3.7,0]]))
Endoscopy = metric(TRANS([[3,3,3,4.4,4.4],[0,2.5,3.7,3.7,0]]))
OutPatientDepartment10 = metric(TRANS([[4./7.5, 4./7.5,1.15,1.15,2,2,3,3],
    [0,3.7,3.7,2.85,2.85,2.5,2.5,0]]))
OutPatientDepartment20 = metric(TRANS([[0,0,2.65,2.65,1.3],[4,5.85,5.85,4,4]]))
RenalDialysis = metric(TRANS([[0,0,1,2.65,2.65],[5.85,8,8,8,5.85]]))
OpenCourt20 = metric(TRANS([[2,2,2,2,4,4,4,4],[10,11,11.35,12,12,11.35,11,10]]))
ChemiotherapyUnit = metric(TRANS([[0,0,4.5,4.5,4,4,2,2,1],
    [11.35,14,14,11.35,11.35,12,12,11.35,11.35,]]))
Service = metric(TRANS([[0,0,1,1,2,2,2,1],[8.35,10,10,9,9,8.5, 8.35,8.35]]))
PhysicalMedicineDept = metric(TRANS([[2,2,1,1,0,0, 1,2,2,4,4,4.5,4.5,4,4],
    [8.5,9,9,10,10,11,11,11,10,10,11,11,9,9,8.5]]))
MainEntrance = metric(TRANS([[4,4,4,4.5,4.75,4.75,6.65,6.65,6,6],
    [8.4,8.5,9,9,9,11,11, 9,9,8.4]]))
Unknown = metric(TRANS([[7.25,7.25, 6.65,6.65,6.65,10,10,9,8.2],
    [8.35,8.5,8.5,9,11,11,8.35,8.35,8.35]]))
#Mortuary = metric(TRANS([[],[]]))
Corridor0 = metric([[4.4,0],[4.4,3.7],[3,3.7],[3,2.5],[2,2.5],[2,2.85],[2.55,2.85],
    [2.55,3.7],[1.3,3.7],[1.3,4],[2.65,4],[2.65,5.85],[2.65,8],[1,8],[1,8.35],
    [2,8.35],[2,8.5],[4,8.5],[4,8.4],[6,8.4],[6,9],[6.65,9],[6.65,8.5],[7.25,8.5],
    [7.25,8.35],[8.2,8.35],[9,8.35],[9,8],[7,8],[7,4],[8.7,4],[8.7,3.7],
    [7,3.7],[4.7,3.7],[4.7,0]])
Corridor0a = metric(TRANS([[1, 1, 2, 2], [11, 11.35, 11.35, 11]]))
Corridor0b = metric(TRANS([[4.5, 4.5, 4, 4, 4.5, 4.5, 4.75,4.75, 4.75],
    [9, 11, 11, 11.35, 11.35, 14,14, 11, 9]]))
◇
```

Macro referenced in 2b.

Ground floor's building units

⟨ Ground floor's building units 3b ⟩ ≡

```
""" Ground floor's building units """
openCourt10 = buildingUnit(OpenCourt10,"OpenCourt10")
radioDiagnosticImaging = buildingUnit(RadioDiagnosticImaging,"RadioDiagnosticImaging")
serviceCore10 = buildingUnit(ServiceCore10,"ServiceCore10")
serviceCore20 = buildingUnit(ServiceCore20,"ServiceCore20")
emergencyDepartment = buildingUnit(EmergencyDepartment,"EmergencyDepartment")
endoscopy = buildingUnit(Endoscopy,"Endoscopy")
outPatientDepartment10 = buildingUnit(OutPatientDepartment10,"OutPatientDepartment10")
outPatientDepartment20 = buildingUnit(OutPatientDepartment20,"OutPatientDepartment20")
renalDialysis = buildingUnit(RenalDialysis,"RenalDialysis")
openCourt20 = buildingUnit(OpenCourt20,"OpenCourt20")
chemiotherapyUnit = buildingUnit(ChemiotherapyUnit,"ChemiotherapyUnit")
service = buildingUnit(Service,"Service")
physicalMedicineDept = buildingUnit(PhysicalMedicineDept,"PhysicalMedicineDept")
```

```
mainEntrance = buildingUnit(MainEntrance,"MainEntrance")
unknown = buildingUnit(Unknown,"Unknown")
#mortuary = buildingUnit(Mortuary,"Mortuary")
corridor0 = buildingUnit(Corridor0,"Corridor0")
corridor0a = buildingUnit(Corridor0a,"Corridor0a")
corridor0b = buildingUnit(Corridor0b,"Corridor0b")
◇
```

Macro referenced in 4a.

⟨ Ground floor structure 4a ⟩ ≡

```
""" Ground floor structure """

⟨ Ground floor's building units 3b ⟩

buildingUnits0 = [openCourt10,radioDiagnosticImaging,serviceCore10,serviceCore20,
    emergencyDepartment,endoscopy,outPatientDepartment10,outPatientDepartment20,
    renalDialysis,openCourt20,chemiotherapyUnit,service,physicalMedicineDept,
    mainEntrance,unknown,corridor0,corridor0a,corridor0b]

groundFloor = Struct(buildingUnits0, "groundFloor")
◇
```

Macro referenced in 2b.

3.1.2 Mezanine floor

Mezanine floor input

⟨ Mezanine floor 4b ⟩ ≡

```
""" Mezanine floor """
MedicalWaste = metric(TRANS([[4./7.5,4./7.5,.8,1.25,1.25],[0,1.5,1.5,1.5,0]]))
CentralStores = metric(TRANS([[1.25,1.25,.8,.8,3.7,3.7,2.55,2.55,2.2,2.2],[0,1.5,1.5,
    2.65,2.65,.35,.35,.65,.65,0]]))
StaffDining = metric(TRANS([[3.95,3.95,6.7,6.7,6.95,6.95],[0,3.7,3.7,2,2,0]]))
CSSD = metric(TRANS([[6.95,6.95,6.95,8.8,8.8,9.65,9.65],[0,2,2.65,2.65,2,2,0]]))
HouseKeeping = metric(TRANS([[8.8,8.8,8.8,8.8,9.65,9.65],[2,2.65,2.8,3.7,3.7,2]]))
CentralStaffChanging11 = metric(TRANS([[4./7.5,4./7.5,1.15,1.15],[2.85,3.7,3.7,2.85]]))
CentralStaffChanging21 = metric(TRANS([[2.55,2.55,3.7,3.7],[2.85,3.7,3.7,2.85]]))
OpenCourt11 = metric(TRANS([[3,3,7,7,7],[4,8,8,6,4]]))
Pharmacy = metric(TRANS([[0,0,2.65,2.65,1.3],[4,6.45,6.45,4,4]]))
CentralWorkshop = metric(TRANS([[0,0,1,2.65,2.65],[6.45,8,8,8,6.45]]))
Laundry = metric(TRANS([[7,7,10,10,8.7],[4,6,6,4,4]]))
AdministrationSuite11 = metric(TRANS([[7,7,9,10,10],[6,8,8,8,6]]))
MainLaboratories = metric(TRANS([[1,1,0,0,2,2,5,5,4,4,4],[8.3,8.4,8.4,11,11,10,10,9,
    9,8.4,8.3]]))
MedicalLibrary = metric(TRANS([[6.7,6.7,8,8,7.75],[9.7,11,11,9.7,9.7]]))
MedicalRecords = metric(TRANS([[8,8,8,8.85,8.85,8.85],[8.3,9.7,11,11,9.75,8.3]]))
```

```
AdministrationSuite21 = metric(TRANS([[8.85,8.85,10,10,9,9],[8.3,9.75,9.75,8.4,8.4,8.3]]))
MeetingRooms = metric(TRANS([[6,6,6,6.7,6.7,7.75,7.75,7.45,7,7],[8.3,8.4,9,9,9.7,9.7,
    8.7,8.7,8.7,8.3]]))
DataCenter = metric(TRANS([[7,7,7.45,7.45],[8.3,8.7,8.7,8.3]]))
ServerRoom = metric(TRANS([[7.45,7.45,7.75,7.75],[8.3,8.7,8.7,8.3]]))
PublicCore = metric(TRANS([[4,4,5,6,6],[8.4,9,9,9,8.4]]))
ServiceCore11 = metric(TRANS([[1.15,1.15,1.3,2.55,2.55],[2.85,3.7,3.7,3.7,2.85]]))
ServiceCore21 = metric(TRANS([[7,7,8.7,8.8,8.8],[2.8,3.7,3.7,3.7,2.8]]))
Corridor1 = metric([[2.2,0],[2.2,0.65],[2.55,0.65],[2.55,0.35],[3.7,0.35],[3.7,2.65],
    [0.8,2.65],[0.8,1.5],[0.5333,1.5],[0.5333,2.85],[1.15,2.85],[2.55,2.85],[3.7,
    2.85],[3.7,3.7],[2.55,3.7],[1.3,3.7],[1.3,4],[2.65,4],[2.65,6.45],[2.65,
    8],[1,8],[1,8.3],[4,8.3],[4,8.4],[6,8.4],[6,8.3],[7,8.3],[7.45,8.3],
    [7.75,8.3],[7.75,8.7],[7.75,9.7],[8,9.7],[8,8.3],[8.85,8.3],[9,8.3],[9,8],
    [7,8],[3,8],[3,4],[7,4],[8.7,4],[8.7,3.7],[7,3.7],[7,2.8],[8.8,2.8],
    [8.8,2.65],[6.95,2.65],[6.95,2],[6.7,2],[6.7,3.7],[3.95,3.7],[3.95,0]])
GroundRoof = metric(TRANS([[4,4,2,2,1,1,0,0,4.75,4.75],[10,12,12,11,11,11.35,11.35,14,
    14,10]]))
◇
```

Macro referenced in 2b.

Mezanine floor's building units

⟨ Mezanine floor's building units 5 ⟩ ≡

```
""" Mezanine floor's building units """
medicalWaste = buildingUnit(MedicalWaste,"MedicalWaste")
centralStores = buildingUnit(CentralStores,"CentralStores")
staffDining = buildingUnit(StaffDining,"StaffDining")
cSSD = buildingUnit(CSSD,"CSSD")
houseKeeping = buildingUnit(HouseKeeping,"HouseKeeping")
centralStaffChanging11 = buildingUnit(CentralStaffChanging11,"CentralStaffChanging1")
centralStaffChanging21 = buildingUnit(CentralStaffChanging21,"CentralStaffChanging2")
pharmacy = buildingUnit(Pharmacy,"Pharmacy")
centralWorkshop = buildingUnit(CentralWorkshop,"CentralWorkshop")
laundry = buildingUnit(Laundry,"Laundry")
administrationSuite11 = buildingUnit(AdministrationSuite11,"AdministrationSuite11")
mainLaboratories = buildingUnit(MainLaboratories,"MainLaboratories")
medicalLibrary = buildingUnit(MedicalLibrary,"MedicalLibrary")
medicalRecords = buildingUnit(MedicalRecords,"MedicalRecords")
administrationSuite21 = buildingUnit(AdministrationSuite21,"AdministrationSuite21")
meetingRooms = buildingUnit(MeetingRooms,"MeetingRooms")
dataCenter = buildingUnit(DataCenter,"DataCenter")
serverRoom = buildingUnit(ServerRoom,"ServerRoom")
publicCore = buildingUnit(PublicCore,"PublicCore")
serviceCore11 = buildingUnit(ServiceCore11,"ServiceCore11")
serviceCore21 = buildingUnit(ServiceCore21,"ServiceCore21")
corridor1 = buildingUnit(Corridor1,"Corridor1")
```

```
groundRoof = buildingUnit(GroundRoof,"GroundRoof")
◇
```

Macro referenced in 6a.

⟨ Mezanine floor structure 6a ⟩ ≡

```
""" Mezanine floor structure """

⟨ Mezanine floor's building units 5 ⟩

buildingUnits1 = [medicalWaste, centralStores, staffDining, cSSD, houseKeeping,
    centralStaffChanging11, centralStaffChanging21, pharmacy, centralWorkshop, laundry,
    administrationSuite11, mainLaboratories, medicalLibrary, medicalRecords,
    administrationSuite21, meetingRooms, dataCenter, serverRoom, publicCore,
    serviceCore11, serviceCore21, corridor1, groundRoof]

mezanineFloor = Struct(buildingUnits1, "mezanineFloor")
◇
```

Macro referenced in 2b.

3.1.3 First floor

First floor

⟨ First floor 6b ⟩ ≡

```
""" First floor """
OpenCourt3 = metric(TRANS([[3.,3.,7.,7.],[4.,8.,8.,4.]]))
Surgery = metric(TRANS([[4.15,4.15,7.,7.,8.8,8.8,9.65,9.65],[0,3.7,3.7, 2.8,2.8, 3.7,3.7,0]]))
CatheterizationLab = metric(TRANS([[3,3,4.15,4.15],[0,3.7,3.7,0]]))
ServiceCore32 = metric(TRANS([[7.,7.,8.7,8.8,8.8],[2.8,3.7,3.7,3.7,2.8]]))
CoronaryCareUnit = metric(TRANS([[7.,7.,8.3,9.,10.,10.,8.7],[4.,8.,8.,8.,8.,4.,4.]]))
DeliveryAndNicu = metric(TRANS([[0,0, 1.7,2.65,2.65,1.3],[4.,8.,8.,8.,4.,4.]]))
ServiceCore31 = metric(TRANS([[1.15, 1.15, 1.3,2.65, 2.65], [2.85, 3.7,3.7, 3.7, 2.85]]))
IntensiveCareUnit = metric(TRANS([[4./7.5, 4./7.5,1.15,1.15,2.65, 2.65,1.95,1.95],
    [0.,3.7,3.7,2.85,2.85,.6,.6,0.]]))
ServiceCore33 = metric(TRANS([[1.95,1.95,2.65, 2.65],[0,.6,.6,0]]))
PublicCore3 = metric(TRANS([[1.7,1.7,4.,4.,6.,6.,8.3,8.3,7,3,2.65],
    [8,8.4,8.4,9,9,8.4,8.4,8,8,8,8]]))
Corridor3 = metric(TRANS([[2.65,2.65,2.65,2.65,1.3,1.3,2.65,2.65,3.0,3.0,7.0,8.7,8.7,
    7.0,4.15,3.0,3.0],[0.0,0.6,2.85,3.7,3.7,4.0,4.0,8.0,8.0,4.0,4.0,4.0,3.7,
    3.7,3.7,3.7,0.0]]))
MezanineRoof = metric(TRANS([[1,1,0,0,2,2,4.75,4.75,10,10,9,9,8.3,8.3, 6,6,4,4 ,1.7,1.7],
    [8,8.4,8.4,11,11,10,10,11,11,8.4,8.4,8,8,8.4,8.4,9,9,8.4,8.4,8]]))
◇
```

Macro referenced in 2b.

First floor's building units

⟨ First floor's building units 7a ⟩ ≡

```
""" First floor's building units """
openCourt3 = buildingUnit(OpenCourt3,"OpenCourt3")
surgery = buildingUnit(Surgery,"Surgery")
catheterizationLab = buildingUnit(CatheterizationLab,"CatheterizationLab")
serviceCore32 = buildingUnit(ServiceCore32,"ServiceCore32")
coronaryCareUnit = buildingUnit(CoronaryCareUnit,"CoronaryCareUnit")
deliveryAndNicu = buildingUnit(DeliveryAndNicu,"DeliveryAndNicu")
serviceCore31 = buildingUnit(ServiceCore31,"ServiceCore31")
intensiveCareUnit = buildingUnit(IntensiveCareUnit,"IntensiveCareUnit")
serviceCore33 = buildingUnit(ServiceCore33,"ServiceCore33")
publicCore3 = buildingUnit(PublicCore3,"PublicCore3")
corridor3 = buildingUnit(Corridor3,"Corridor3")
mezanineRoof = buildingUnit(MezanineRoof,"MezanineRoof")
◇
```

Macro referenced in 7b.

⟨ First floor structure 7b ⟩ ≡

```
""" First floor structure """

⟨ First floor's building units 7a ⟩

buildingUnits2 = [surgery,catheterizationLab,serviceCore32,coronaryCareUnit,
    deliveryAndNicu,serviceCore31,intensiveCareUnit,serviceCore33,publicCore3,
    corridor3,mezanineRoof]

firstFloor = Struct(buildingUnits2, "firstFloor")
◇
```

Macro referenced in 2b.

3.1.4 Ward sections

Ward sections Here input by polylines and structure modeling are freely mixed. Just notice that the affine maps included in structures are given in grid coordinates. This fact does not permit an immediate transformation in Cartesian coordinates using the `metric` function.

⟨ Ward sections 8a ⟩ ≡

```
""" Ward sections """
room = TRANS([[0,0,1,1,2./3,2./3],[0,0.5,0.5,0.25,0.25,0]])
restRoom = TRANS([[2./3,2./3,1,1],[0,0.25,0.25,0]])
nursing1 = TRANS([[0,0,.2,.2],[0,.4,.4,.0]])
nursing2 = TRANS([[.2,.2,.4,.4],[0,.4,.4,.0]])
```

```
nursing3 = TRANS([[0,0,.4,.4],[.4,.8,.8,.4]])
nursing4 = TRANS([[0,0,.4,.4],[.8,1.1,1.1,.8]])
nursing5 = TRANS([[0,0,.4,.4],[1.1,1.4,1.4,1.1]])

service2 = Struct([polyline2lar([nursing1,nursing2,nursing3,nursing4,nursing5])])
service1 = Struct([t(0,1.4),s(1,-1),service2])
wardServices = Struct([t(1.3,.3),service1,t(0,2),service2])
HospitalRoom = Struct([polyline2lar([room,restRoom])],"Room")
DounbleRoom =  Struct([HospitalRoom,t(0,1),s(1,-1),HospitalRoom])
HalfWard = Struct(4*[DounbleRoom,t(0,1)])
Ward = Struct([HalfWard, wardServices, t(3,0),s(-1,1), HalfWard])
V,FV = struct2lar(Ward)
EV = face2edge(FV)
theWard = lar2lines((V,FV))
◇
```

Macro referenced in 8b.

3.1.5 Second floor

Second floor

⟨ Second floor 8b ⟩ ≡

⟨ Ward sections 8a ⟩

```
""" Second floor """
PublicCore4 = metric(TRANS([[1.7,1.7,4,4,6,6,8.3,8.3, 8,7+2./3, 7, 3, 2+1./3,2],
    [8,8.4,8.4,9,9,8.4,8.4,8,8,8,8,8,8,8]]))
ObstetricGinecologicWard = AA(metric)((AA(larTranslate([0,4]))(theWard)))
SurgicalWard1 = AA(metric)((AA(larTranslate([7,4]))(theWard)))
Filter1 = metric(TRANS([[1,1,1.35,1.35,1.15],[3.7,4,4,3.7,3.7]]))
Filter2 = metric(TRANS([[8.65,8.65,9,9,8.8],[3.7,4,4,3.7,3.7]]))
ServiceCore14 = metric(TRANS([[1.15, 1.15, 1.35,2.55, 2.55], [2.8, 3.7,3.7, 3.7, 2.8]]))
ServiceCore24 = metric(TRANS([[7,7,8.65,8.8,8.8],[2.8,3.7,3.7,3.7,2.8]]))
FirstRoof = metric(TRANS([[4./7.5, 4./7.5,1.15,1.15,2.55,2.55,7,7,8.8,8.8,9.65,9.65],
    [0,3.7,3.7,2.8,2.8,3.7,3.7,2.8,2.8,3.7,3.7,0]]))
Corridor4a = metric([[1.35,3.7],[1.35,4],[2,4],[2.3333,4],[3,4],[7,4],[7.6667,4],[8,4],
    [8.65,4],[8.65,3.7],[7,3.7],[2.55,3.7]])
Corridor4b = metric([[1,4.0],[1,4.25],[1,4.5],[1,4.75],[1,5.0],[1,5.25],[1,5.5],
    [1,5.75],[1,6.0],[1,6.25],[1,6.5],[1,6.75],[1,7.0],[1,7.25],[1,7.5],
    [1,7.75],[1,8.0],[2,8.0],[2,7.75],[2,7.5],[2,7.25],[2,7.0],[2,6.75],
    [2,6.5],[2,6.25],[2,6.0],[2,5.75],[2,5.5],[2,5.25],[2,5.0],[2,4.75],
    [2,4.5],[2,4.25],[2,4.0],[1.35,4.0]])
Corridor4b1 = metric([[1.3,4.3],[1.3,4.6],[1.3,4.9],[1.3,5.3],[1.3,5.7],[1.5,5.7],[1.7,5.7],
    [1.7,5.3],[1.7,4.9],[1.7,4.6],[1.7,4.3]])
Corridor4b2 = metric([[1.3,6.3],[1.3,6.7],[1.3,7.1],[1.3,7.4],[1.3,7.7],[1.7,7.7],[1.7,7.4],
```

```
    [1.7,7.1],[1.7,6.7],[1.7,6.3],[1.5,6.3]])
Corridor4c = metric([[8,4.0],[8,4.25],[8,4.5],[8,4.75],[8,5.0],[8,5.25],[8,5.5],
    [8,5.75],[8,6.0],[8,6.25],[8,6.5],[8,6.75],[8,7.0],[8,7.25],[8,7.5],
    [8,7.75],[8,8.0],[8.3,8.0],[9,8.0],[9,7.75],[9,7.5],[9,7.25],[9,7.0],
    [9,6.75],[9,6.5],[9,6.25],[9,6.0],[9,5.75],[9,5.5],[9,5.25],[9,5.0],
    [9,4.75],[9,4.5],[9,4.25],[9,4.0],[8.65,4.0]])
Corridor4c1 = metric([[8.3,4.3],[8.3,4.6],[8.3,4.9],[8.3,5.3],[8.3,5.7],[8.5,5.7],[8.7,5.7],
    [8.7,5.3],[8.7,4.9],[8.7,4.6],[8.7,4.3]])
Corridor4c2 = metric([[8.3,6.3],[8.3,6.7],[8.3,7.1],[8.3,7.4],[8.3,7.7],[8.7,7.7],[8.7,7.4],
    [8.7,7.1],[8.7,6.7],[8.7,6.3],[8.5,6.3]])
◇
```

Macro referenced in 2b.

Second floor's building units

⟨ Second floor's building units 9 ⟩ ≡

```
""" Second floor's building units """
publicCore4 = buildingUnit(PublicCore4,'PublicCore4')
obstetricGinecologicWard = buildingUnit(ObstetricGinecologicWard,'ObstetricGinecologicWard')
surgicalWard1 = buildingUnit(SurgicalWard1,'SurgicalWard1')
filter1 = buildingUnit(Filter1,'Filter1')
filter2 = buildingUnit(Filter2,'Filter2')
serviceCore14 = buildingUnit(ServiceCore14,'ServiceCore14')
serviceCore24 = buildingUnit(ServiceCore24,'ServiceCore24')
firstRoof = buildingUnit(FirstRoof,'FirstRoof')
serviceCore11 = buildingUnit(ServiceCore11,'ServiceCore11')
serviceCore21 = buildingUnit(ServiceCore21,'ServiceCore21')
corridor4a = buildingUnit(Corridor4a,'Corridor4a')
corridor4b = buildingUnit(Corridor4b,'Corridor4b')
corridor4b1 = buildingUnit(Corridor4b1,'Corridor4b1')
corridor4b2 = buildingUnit(Corridor4b2,'Corridor4b2')
corridor4c = buildingUnit(Corridor4c,'Corridor4c')
corridor4c1 = buildingUnit(Corridor4c1,'Corridor4c1')
corridor4c2 = buildingUnit(Corridor4c2,'Corridor4c2')
◇
```

Macro referenced in 10a.

⟨ Second floor structure 10a ⟩ ≡

```
""" Second floor structure """

⟨ Second floor's building units 9 ⟩

buildingUnits3 = [publicCore4,obstetricGinecologicWard,surgicalWard1,filter1,filter2,
serviceCore14,serviceCore24,firstRoof,corridor4a,
corridor4b,corridor4b1,corridor4b2,corridor4c,corridor4c1,corridor4c2]
```

```
secondFloor = Struct(buildingUnits3, "secondFloor")
```
◇

Macro referenced in 2b.

3.1.6 Third floor

Third floor

⟨ Third floor 10b ⟩ ≡

```
""" Third floor floor """
GeneralWard1 = AA(metric)(AA(larTranslate([0,4]))(theWard))
SurgicalWard2 = AA(metric)(AA(larTranslate([7,4]))(theWard))
```
◇

Macro referenced in 2b.

Third floor's building units

⟨ Third floor's building units 10c ⟩ ≡

```
""" Third floor's building units """
generalWard1 = buildingUnit(GeneralWard1,'GeneralWard1')
surgicalWard2 = buildingUnit(SurgicalWard2,'SurgicalWard2')
```
◇

Macro referenced in 10d.

⟨ Third floor structure 10d ⟩ ≡

```
""" Third floor structure """

⟨ Third floor's building units 10c ⟩

buildingUnits4 = [generalWard1,surgicalWard2,publicCore4,serviceCore14,serviceCore24,
            filter1,filter2,corridor4a,corridor4b,corridor4b1,corridor4b2,corridor4c,
            corridor4c1,corridor4c2]

thirdFloor = Struct(buildingUnits4, "thirdFloor")
```
◇

Macro referenced in 2b.

3.1.7 Fourth floor

Fourth floor

⟨ Fourth floor 11a ⟩ ≡

```
""" Fourth floor floor """
PediatricWard1 = AA(metric)(AA(larTranslate([0,4]))(theWard))
PediatricWard2 = AA(metric)(AA(larTranslate([7,4]))(theWard))
```
◇

Macro referenced in 2b.

Fourth floor's building units

⟨ Fourth floor's building units 11b ⟩ ≡

```
""" Fourth floor's building units """
pediatricWard1 = buildingUnit(PediatricWard1,'PediatricWard1')
pediatricWard2 = buildingUnit(PediatricWard2,'PediatricWard2')
```

◇

Macro referenced in 11c.

⟨ Fourth floor structure 11c ⟩ ≡

```
""" Fourth floor structure """

⟨ Fourth floor's building units 11b ⟩

buildingUnits5 = [pediatricWard1,pediatricWard2,publicCore4,serviceCore14,serviceCore24,
            filter1,filter2,corridor4a,corridor4b,corridor4b1,corridor4b2,corridor4c,
            corridor4c1,corridor4c2]

fourthFloor = Struct(buildingUnits5, "fourthFloor")
```

◇

Macro referenced in 2b.

3.1.8 Fifth floor

Fifth floor

⟨ Fifth floor 11d ⟩ ≡

```
""" Fifth floor floor """
GeneralWard2 = AA(metric)(AA(larTranslate([0,4]))(theWard))
GeneralWard3 = AA(metric)(AA(larTranslate([7,4]))(theWard))
```

◇

Macro referenced in 2b.

Fifth floor's building units

⟨ Fifth floor's building units 12a ⟩ ≡

```
""" Fifth floor's building units """
generalWard2 = buildingUnit(GeneralWard2,'GeneralWard2')
generalWard3 = buildingUnit(GeneralWard3,'GeneralWard3')
```

◇

Macro referenced in 12b.

⟨ Fifth floor structure 12b ⟩ ≡

```
""" Fifth floor structure """

⟨ Fifth floor's building units 12a ⟩

buildingUnits6 = [generalWard2,generalWard3,publicCore4,serviceCore14,serviceCore24,
            filter1,filter2,corridor4a,corridor4b,corridor4b1,corridor4b2,corridor4c,
            corridor4c1,corridor4c2]

fifthFloor = Struct(buildingUnits6, "fifthFloor")
◇
```

Macro referenced in 2b.

3.2 Preliminary 2.5D mock-up

3.2.1 Building structure

3.2.2 Storey viewing

Storey viewing

⟨ Storey viewing 12c ⟩ ≡

```
""" Storey viewing """
def structDraw(color,scaling):
    def structDraw0(obj): return obj.draw(color,scaling)
    return structDraw0

ground,W,EV = floor(X,Y)(groundFloor)
ground2D = STRUCT([ground, COLOR(RED)(STRUCT(MKPOLS((W,EV))))] + \
            AA(structDraw(RED,10))(buildingUnits0))
VIEW(ground2D)

mezanine,W,EV = floor(X,Y)(mezanineFloor)
mezanine2D = STRUCT([mezanine, COLOR(RED)(STRUCT(MKPOLS((W,EV))))] + \
            AA(structDraw(RED,10))(buildingUnits1))
VIEW(mezanine2D)

first,W,EV = floor(X,Y)(firstFloor)
first2D = STRUCT([first, COLOR(RED)(STRUCT(MKPOLS((W,EV))))] + \
            AA(structDraw(RED,10))(buildingUnits2))
VIEW(first2D)

second,W,EV = floor(X,Y)(secondFloor)
second2D = STRUCT([second, COLOR(RED)(STRUCT(MKPOLS((W,EV))))] + \
            AA(structDraw(RED,10))(buildingUnits3))
VIEW(second2D)
```

```
third,W,EV = floor(X,Y)(thirdFloor)
third2D = STRUCT([third, COLOR(RED)(STRUCT(MKPOLS((W,EV))))] + \
            AA(structDraw(RED,10))(buildingUnits4))
VIEW(third2D)

fourth,W,EV = floor(X,Y)(fourthFloor)
fourth2D = STRUCT([fourth, COLOR(RED)(STRUCT(MKPOLS((W,EV))))] + \
            AA(structDraw(RED,10))(buildingUnits5))
VIEW(fourth2D)

fifth,W,EV = floor(X,Y)(fifthFloor)
fifth2D = STRUCT([fifth, COLOR(RED)(STRUCT(MKPOLS((W,EV))))] + \
            AA(structDraw(RED,10))(buildingUnits6))
VIEW(fifth2D)
◇
```

Macro referenced in 14a.

aaaa

⟨ aaaa 13a ⟩ ≡

```
""" aaaa """

◇
```

Macro defined by 13ab.
Macro never referenced.

3.3 Vertical communications

aaaa

⟨ aaaa 13b ⟩ ≡

```
""" aaaa """

◇
```

Macro defined by 13ab.
Macro never referenced.

3.4 Design review

4 System semantics

4.1 Topological requirements

4.2 Geometrical requirements

5 Code exporting

The `Hospital.py` module

"lib/py/hospital.py" 14a ≡

```
""" The 'Hospital' module """

from pyplasm import *

""" import modules from larcc/lib """
sys.path.insert(0, 'lib/py/')
from architectural import *
from iot3d import *
DEBUG = True
```

⟨ Reference grid 1 ⟩
⟨ Coding utilities 14b ⟩
⟨ From array indices to grid coordinates 2a ⟩
⟨ Storey input 2b ⟩
⟨ Storey viewing 12c ⟩
◇

5.1 Code utilities

Coding utilities

⟨ Coding utilities 14b ⟩ ≡

```
""" Coding utilities """
```

⟨ From grid to metric coordinates 15a ⟩
⟨ Mapping a grid frame to a Cartesian one 15b ⟩
⟨ Solidify the boundary of polyline-like building units 16a ⟩
⟨ Make a struct object from a 2D polyline 16b, ... ⟩
◇

Macro referenced in 14a.

From grid to metric coordinates

⟨ From grid to metric coordinates 15a ⟩ ≡

```
""" From grid to metric coordinates """
def grid2coords(X,Y):
    xMeasures = list(cumsum(X))
    yMeasures = list(cumsum(Y))
    def grid2coords0(point):
        x,y = point[0:2]
        xint,yint = int(x), int(y)
        xdec,ydec = float(x-xint), float(y-yint)
        xcoord = xMeasures[xint] + xdec*X[xint+1]
        ycoord = yMeasures[yint] + ydec*Y[yint+1]
        if len(point)==2: return [xcoord, ycoord]
        else: return [xcoord, ycoord, point[2]]
    return grid2coords0

def coordMaps(ymax):
    def coordMaps0(polyline):
        polyline = AA(grid2coords(X,Y))(polyline)
        polyline = vmap(ymax)(polyline)
        return [eval(vcode(point)) for point in polyline]
    return coordMaps0

metric = coordMaps(ymax)
◇
```

Macro referenced in 14b.

Mapping the grid frame to a Cartesian right-hand frame

⟨ Mapping a grid frame to a Cartesian one 15b ⟩ ≡

```
""" Mapping the grid frame to a Cartesian right-hand frame """
def vmap(ymax):
    def vmap0(V):
        if len(V[0])==3: W = [[x,ymax-y,z] for x,y,z in V]
        else: W = [[x,ymax-y] for x,y in V]
        return W
    return vmap0

def embed(z):
    def embed0(p):
        return p+[z]
    return embed0
◇
```

Macro referenced in 14b.

Solidify the boundary of polyline-like building units

⟨ Solidify the boundary of polyline-like building units 16a ⟩ ≡

```
""" Solidify the boundary of polyline-like building units """
def floor(X,Y):
    def floor0(structure2D):
        V,FV = struct2lar(structure2D)
        EV = face2edge(FV)
        BE = [EV[e] for e in boundaryCells(FV,EV)]
        theFloor = SOLIDIFY(STRUCT([POLYLINE([V[v],V[w]]) for v,w in BE]))
        return theFloor,V,EV
    return floor0
```

◇

Macro referenced in 14b.

Make a struct object from a 2D polyline

⟨ Make a struct object from a 2D polyline 16b ⟩ ≡

```
""" Make a struct object from a 2D polyline """
isPolyline = ISSEQOF(ISSEQOF(ISNUM))
isPolylineSet = ISSEQOF(ISSEQOF(ISSEQOF(ISNUM)))

def buildingUnit(polyline,string):
    if ISSEQOF(ISSEQOF(ISNUM))(polyline): model = polyline2lar([polyline])
    else: model = polyline2lar(polyline)
    return Struct([model],str(string))
```

◇

Macro defined by 16bc.
Macro referenced in 14b.

Extract 1-cells from the lar of a polylineSet

⟨ Make a struct object from a 2D polyline 16c ⟩ ≡

```
""" Make a struct object from a 2D polyline """
def lineSet(polylineSet):
    EV = []
    for polyline in polylineSet:
        EV += [(v,w) if v<w else (w,v) for v,w in zip(polyline,polyline[1:]+[polyline[0]])]
    return AA(list)(EV)
```

◇

Macro defined by 16bc.
Macro referenced in 14b.

The 2.5D mock-up

"test/py/hospital/mock-up.py" 16d ≡

```
""" The 2.5D mock-up of an hospital building """

```

◇

References

[AM13] Adham R. Ismail Abdel-Moneim, *Hospital planning and medical equipment design*, Future Healthcare – The opportunities of new technology (Oslo, Norway), 38th World Hospital Congress, 18–20 June 2013.

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