IsoGeometric Analysis for Modelling Damage and Fracture.

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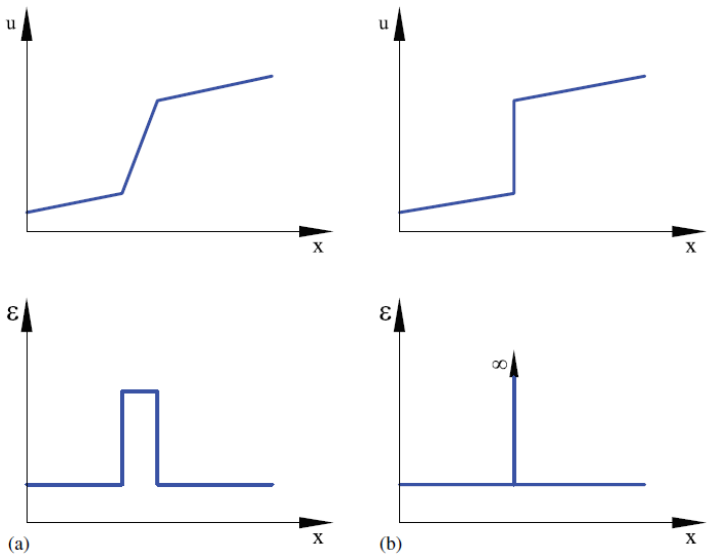
01.- GENERAL VIEW

MAIN PURPOSE:
SIMULATE DAMAGE CRACK ONSET AND PROPAGATION BY USING ISOGEOMETRIC ANALYSIS (IGA)

LOCAL REFINEMENT BY USING T-SPLINES AT CRAK TIP AREA

INITIALLY FOCUSED ON DISCRETE CRACK APPROACH **BUT** CHANGED TO SMEARED CRACK APPROACH

WORK IN PROGRESS, ONLY SOME PRELIMINARY RESULTS USING SIMPLIFIED ALGORITHMS IN 2D



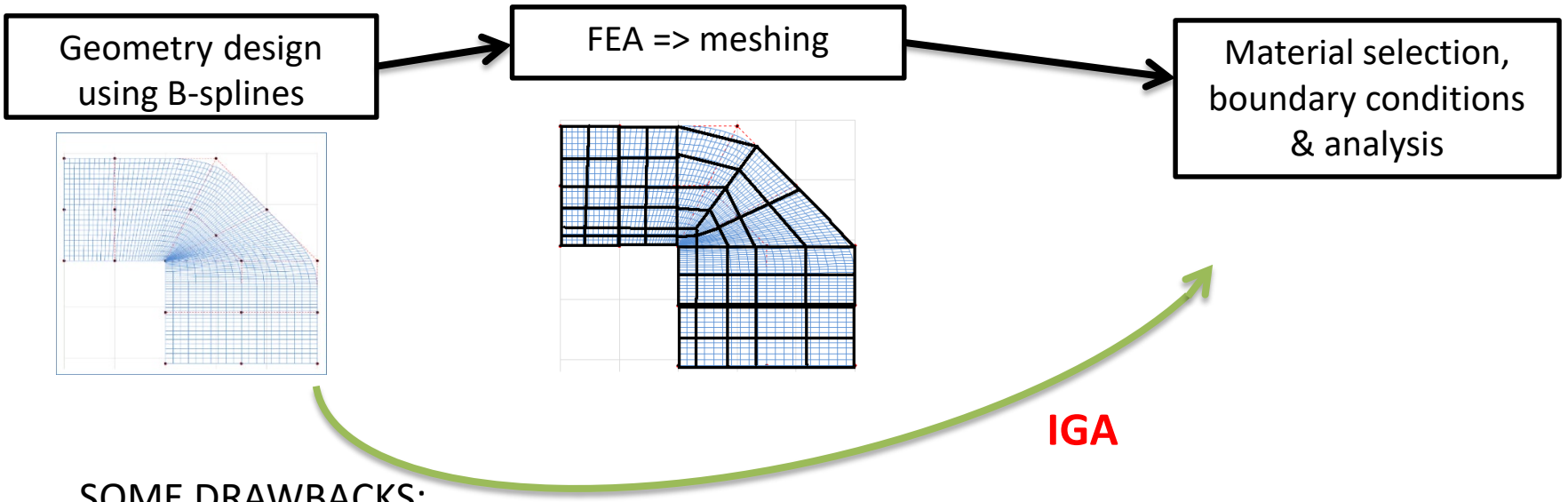
Displacement and strain at crack for smeared and discrete crack approaches (source: Cervera and Chiumenti, 2006)

02.- WHAT IS IGA?

ORIGINAL IDEA BY Hugues *et al.* (2005)

BASIS FUNCTIONS TO APPROXIMATE THE FIELD SOLUTION ARE NURBS

DRIVING FORCE WAS TO SKIP MESHING STEP



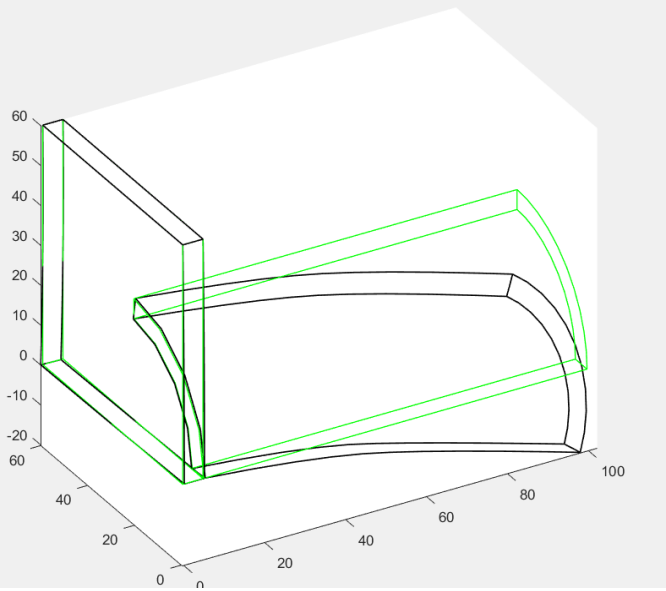
SOME DRAWBACKS:
- CUMBERSOME MANIPULATION (GEOMETRY IN TERMS OF PARAMETERS)
- SOLIDS ARE NOT GIVEN BY CAD SOFTWARES

SOME ADVANTAGES:
- HIGH DEFINITION OF STRESS FIELD INSIDE ONE PATCH

03.- MULTIPATCHING COUPLING

FORMULATION BY Breitenberger *et al.* (2015), CALLED B-REP ANALYSIS

THE IDEA IS TO FORCE TO INTERSECTION LINES (2D) OR INTERSECTION SURFACES (3D) TO DISPLACE THE SAME AMOUNT.



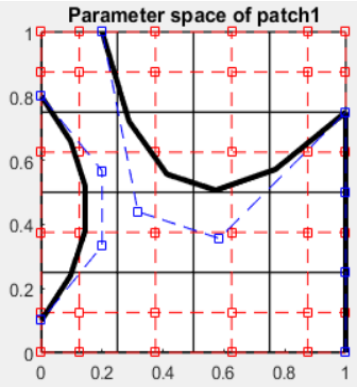
ALLOWS COMPLEX DOMAINS GENERATION FROM SIMPLE ONES

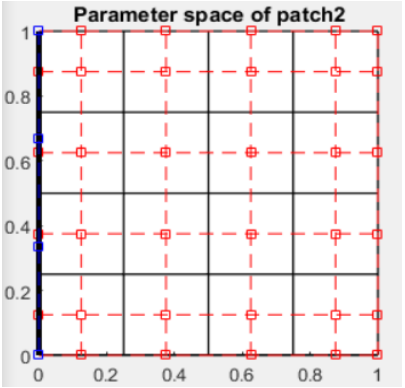
04.- DISCRETIZATION IN TRIANGLES

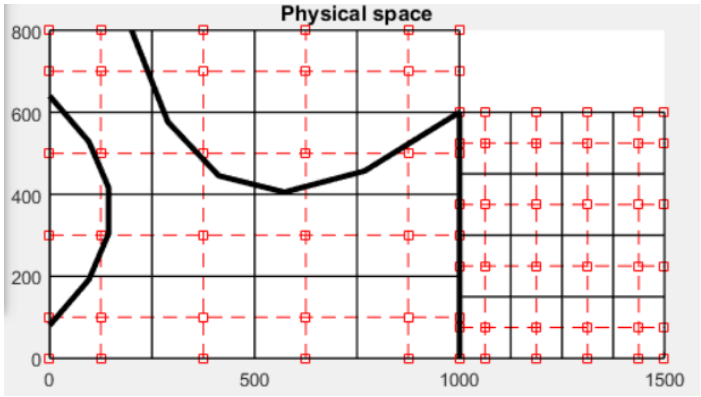
NURBS DOMAINS CAN WORK AS MESHLESS METHOD

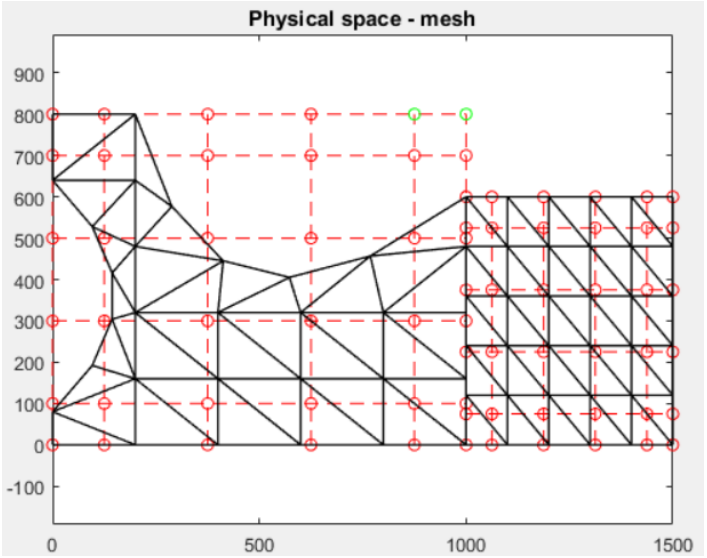
DISCRETIZATION IN TRIANGLES (TETRAHEDRALS FOR 3D)

FACILITATES INTEGRATION OF TRIMMED DOMAINS



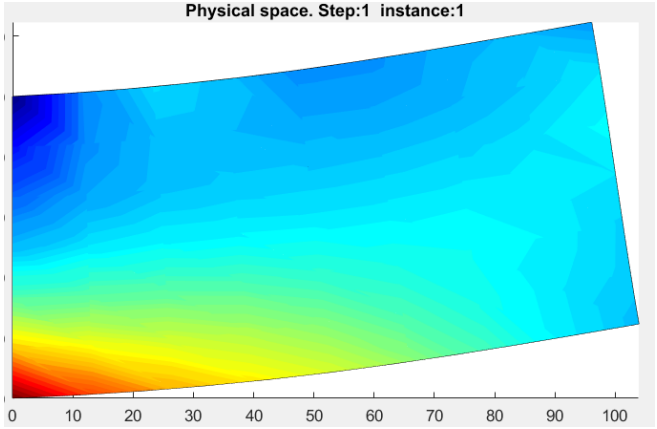


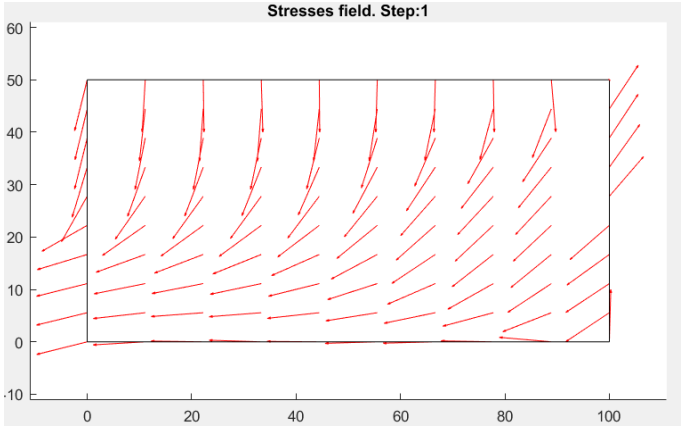




05.- STRESS FIELD IN IGA

CONTINUITY WITHIN THE PATCH = NURBS DEGREE – 1





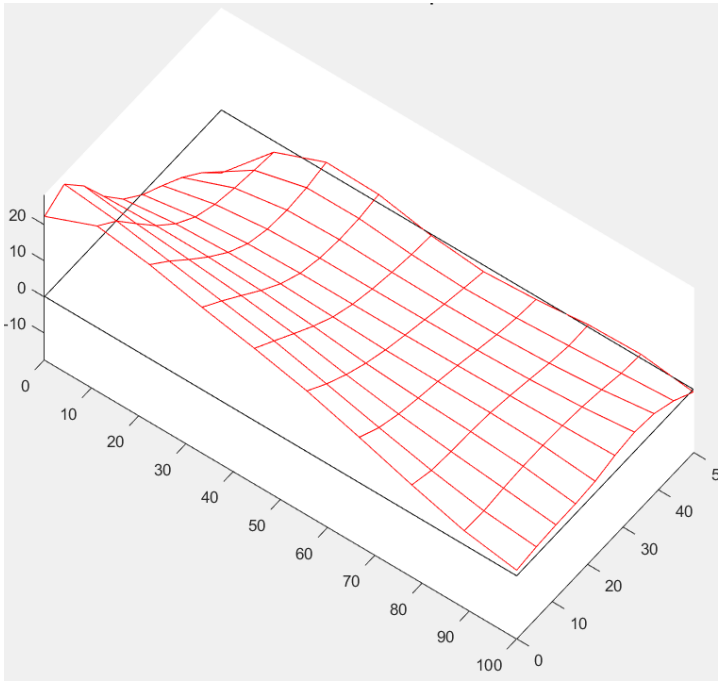
Crack onset / propagation = f (d)

$d = f(\sigma)$

e.g.

1st principal stress (Cervera & Chiumenti, 2006)

Von Mises stress (Lemaitre, 1985)

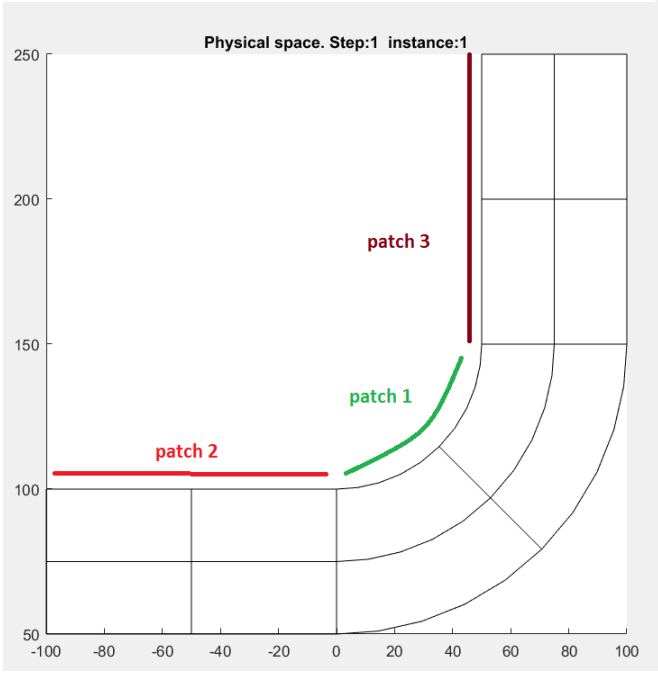


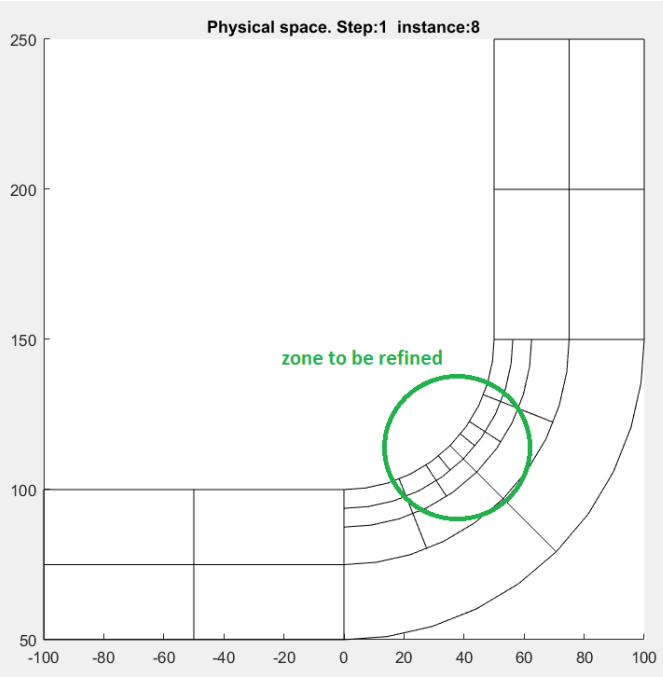
06.- LOCAL REFINEMENT WITH T-SPLINES

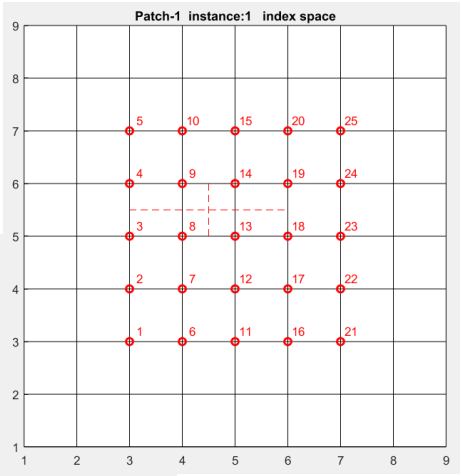
TO BE CENTRAL PART OF THE RESEARCH

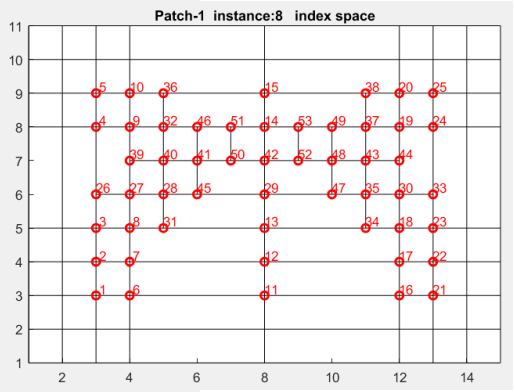
ZONE AROUND SINGULARITY (CRACK TIP) TO BE LOCALLY REFINED. THEN, BETTER PREDICTION OF THE CRACK PROPAGATION

LOCAL REFINEMENT IMPLEMENTED ACCORDING TO Scott *et al.* (2012), BUT ROUTINE STILL NOT INSERTED INTO ANALYSIS







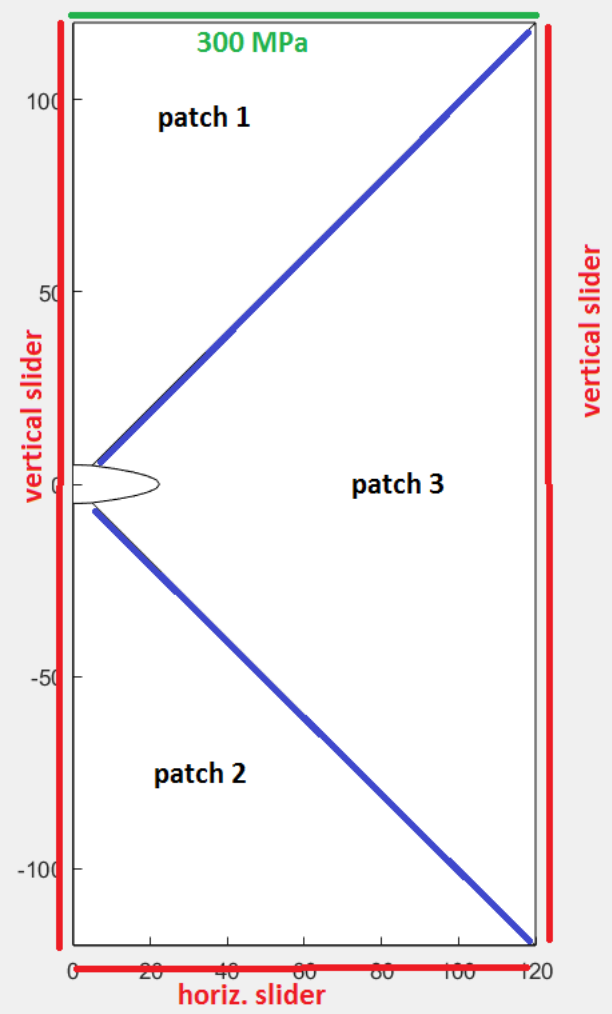


07.- EXAMPLE

INFINITE PLATE IN TENSION
INTERNAL ELLIPTICAL HOLE 10 x 44 mm
PLANE STRAIN
ELASTIC LIMIT: 300 MPa
FRACTURE TOUGHNESS: 50 MPa m^1/2
FRACTURE DAMAGE THRESHOLD: 0.55
APPLIED TENSION: 300 Mpa

3 PATCHES:

DEGREE: 3
CONTROL POINTS: 5 IN EACH DIRECTION



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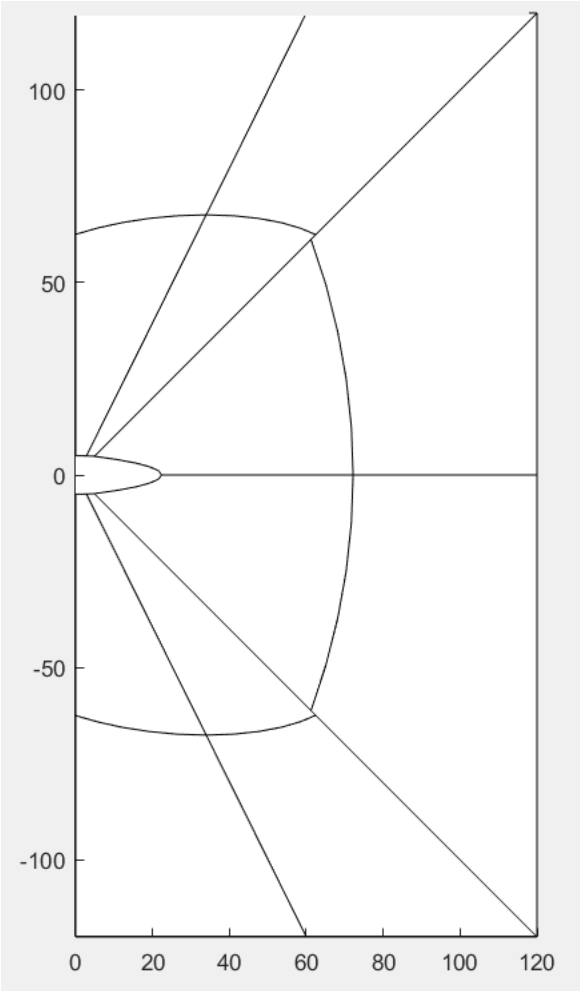
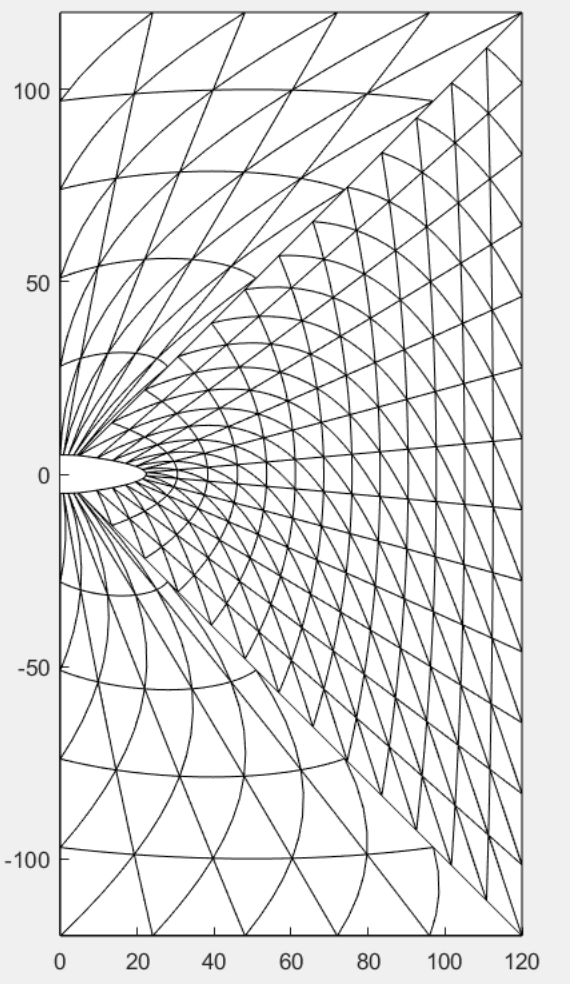
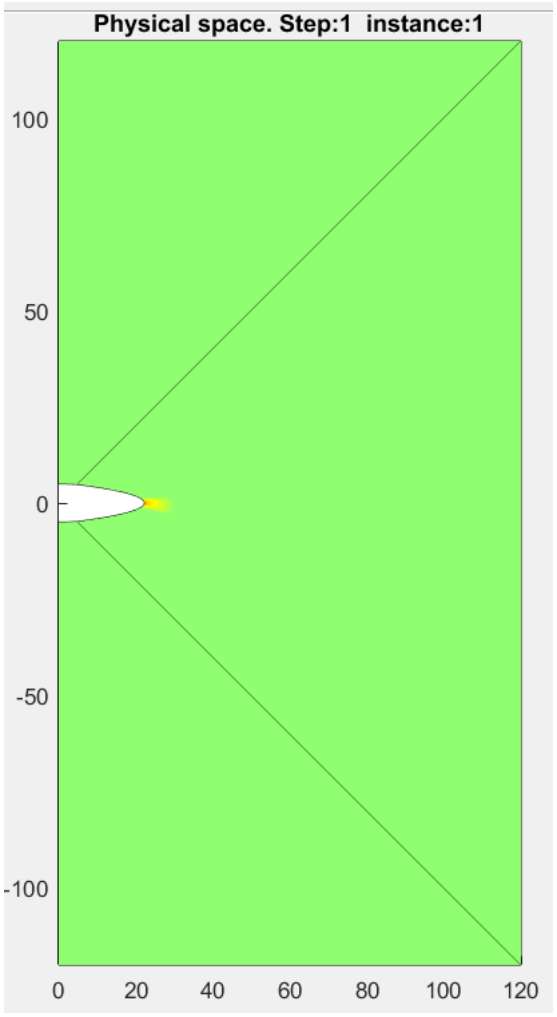


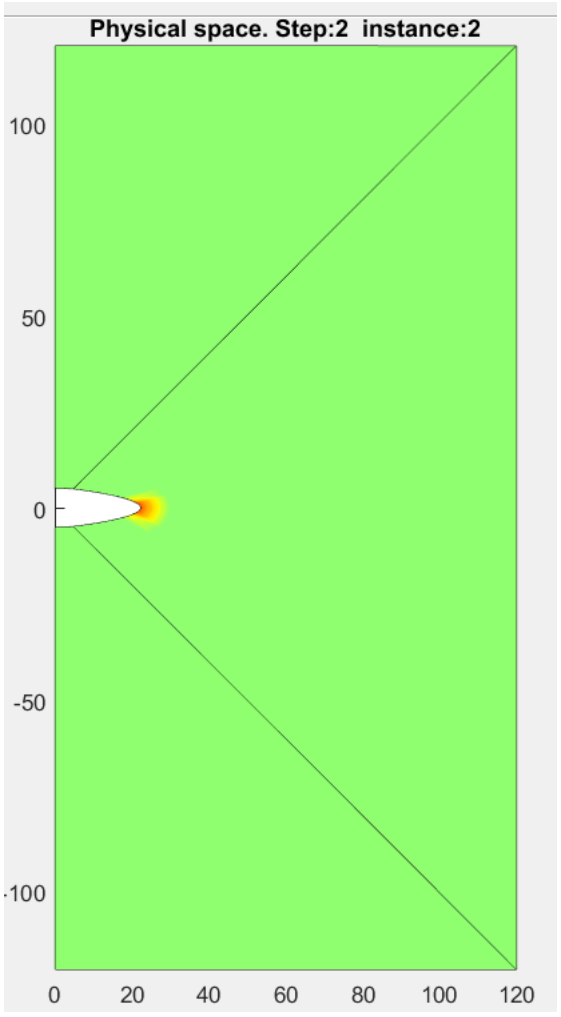
PATCHES KNOT SPANS (“ELEMENTS”)

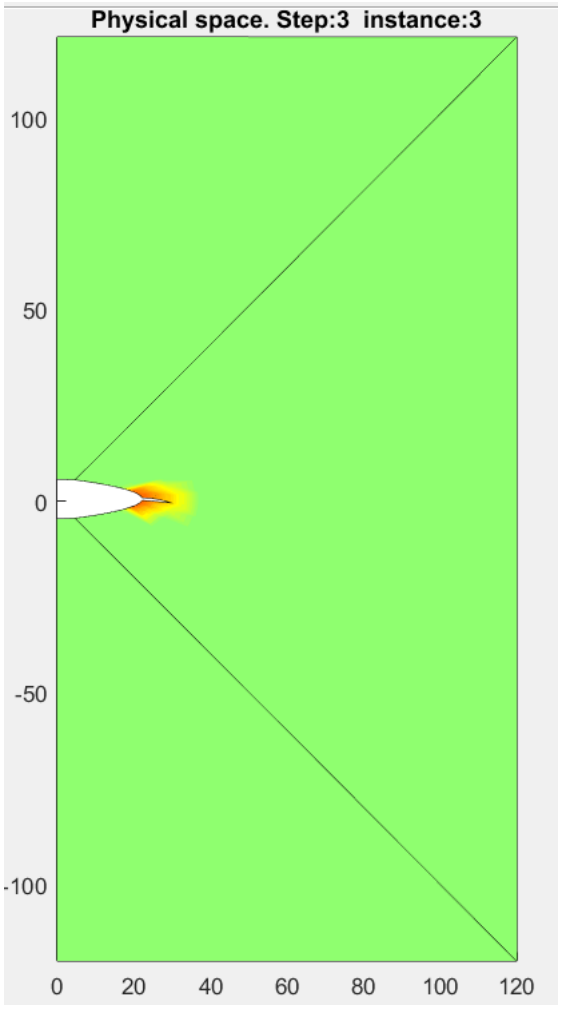


TRIANGULAR DISCRETIZATION

07.- EXAMPLE







DAMAGE EVOLUTION AND CRACK ONSET

08.- FUTURE WORK

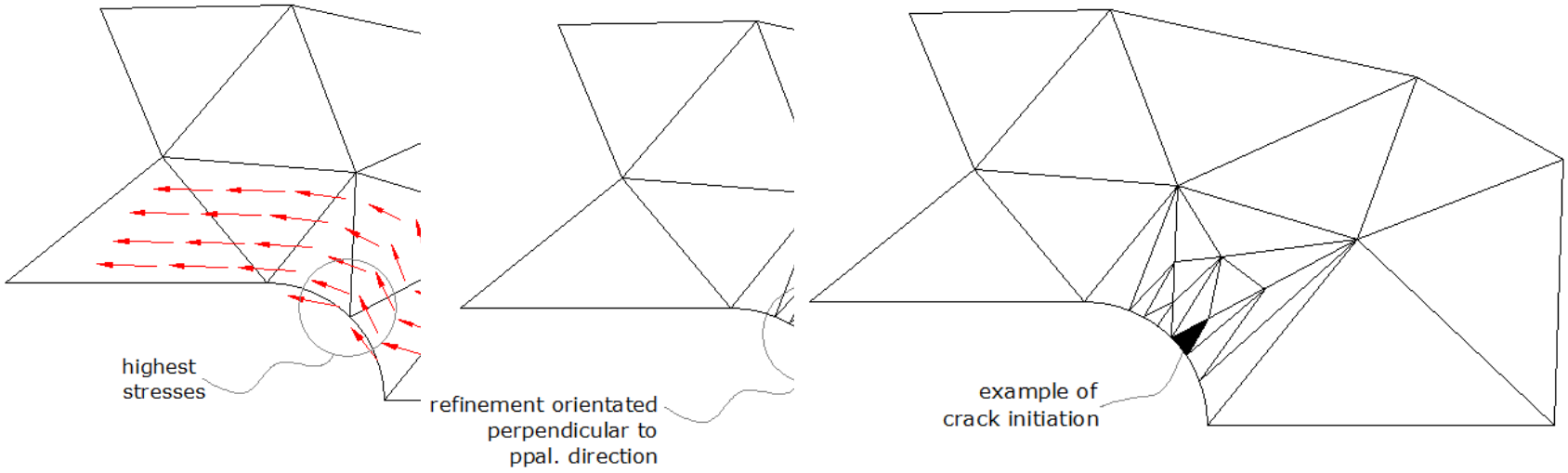
DEVELOP LOCAL T-SPLINE REFINEMENT FOR OTHER DEGREE THAN 3

APPLY LOCAL REFINEMENT AT CRACK TIP AREA

DEVELOP A PROPER RETURN MAPPING ALGORITHM WITH COUPLED DAMAGE

EXTEND THE ALGORITHM TO 3D GEOMETRIES

APPLY LOCAL REFINEMENT TO THE DISCRETIZATION MESH AT THE RIGTH LOCATION IN ORDER REPRODUCE MORE ACCURATELY CRACK PROPAGATION



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THANK YOU FOR

YOUR ATTENTION