UEL单元开发（2）——一维杆单元（内含大福利！）

UEL Element Development (2) - One-Dimensional Rod Element (Includes Big Bonus!)

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木木做单元开发也有一段日子了，在编写XFEM的单元时，遇到了瓶颈，打算先告一段落，将自己的一些经验分享出来给大家，希望帮助大家快速入门，在以后的推文中也会以单元开发为主，就像之前讲解Umat一样，用自己通俗易懂的语言讲述下来。

I have been developing UEL elements for some time. While writing XFEM elements, I encountered a bottleneck and decided to take a break to share some of my experiences with everyone, hoping to help everyone quickly get started. In future posts, I will also focus on element development, just like the previous explanation of Umat, using my own easy-to-understand language to describe it.

本篇推文由两部分组成：**「其一」**，以**「一维杆单元」**UEL子程序为主，从理论到代码Step-by-Step向大家讲解，并于Abaqus中标准单元做对比，验证代码的正确性；**「其二」**，木木受邀于**北鲲云超算平台**做主讲人，将在**5月24日晚上七点**于B站进行大约一个小时的讲演汇报，带着大家熟悉Abaqus的基本操作，基于Abaqus的扩展有限元仿真以及如何正确使用超算平台，直播过程中还有大量惊喜礼品、丰富算力金进行抽奖~欢迎大家积极参与。

This tweet consists of two parts: "Firstly", it explains the UEL subroutine for one-dimensional bar elements from theory to code step by step, and compares it with the standard elements in Abaqus to verify the correctness of the code; "Secondly", Mumu has been invited as a keynote speaker on the Beiqun Cloud Supercomputing Platform, and will give a one-hour lecture and report on Bilibili at 7 PM on May 24, familiarizing everyone with the basic operations of Abaqus, extended finite element simulation based on Abaqus, and how to correctly use the supercomputing platform. There will be a lot of surprise gifts and rich computing power for lucky draws during the live broadcast. Everyone is welcome to actively participate.

一维杆单元UEL子程序 One-dimensional bar element UEL subroutine

一维杆单元子程序的代码应该是UEL中最简单的了吧，就好像线弹性Umat那样，囊括了一些UEL的基本思想，可对比之前的二维弹簧单元子程序来学习。

The code for the one-dimensional bar element subroutine should be the simplest in UEL, just like the linear elastic Umat, incorporating some basic ideas of UEL, which can be compared with the previous two-dimensional spring element subroutine for learning.

理论讲解 Theoretical explanation

弹性力学中利用**「最小势能原理」**（或虚功原理）来得到单元刚度方程，具体操作可查看：

The unit stiffness equation is obtained by using the "principle of minimum potential energy" (or virtual work principle) in elasticity mechanics, the specific operation can be viewed as follows:

> “
>
> - 《有限元基础教程》——曾攀 Finite Element Basic Tutorial - Zeng Pan
> - 《北航弹性力学博后讲透弹性力学》——@兵心依旧022（B站Up）
>
> Postdoctoral Lectures on Elasticity Mechanics by Beijing University of Aeronautics and Astronautics - @BingxinYiJiu022 (Bilibili Uploader)
>
> ”

单元刚度矩阵： Unit stiffness matrix:

其中： E为杨氏模量， A为杆的横截面积， L为杆的长度。UEL需要的**「核心」**就是求得单元刚度矩阵，**「残余力RHS」**可以认为是0（Cohesive单元除外），以后会给大家普及国际上流行的**PPR内聚力单元。**

Where: E is the Young's modulus, A is the cross-sectional area of the rod, and L is the length of the rod. The "core" required by UEL is to obtain the element stiffness matrix, and the "residual force RHS" can be considered as 0 (except for Cohesive elements), and I will introduce the internationally popular PPR cohesive element to everyone later.

代码讲解 Code Explanation

篇幅原因，INP文件可在后台回复“**杆单元**”，即可获得，这里仅给出**「关键行」**：

Due to the length of the article, the INP file can be obtained by replying "rod element" in the background, and here only the "key lines" are given:

```
*User element, nodes=2, type=U1001, properties=2, coordinates=2, variables=4
1,2,6
*Element, type=U1001
 1,1,2
*Elset, elset=Set-1
 1
*Uel property, elset=Set-1
 2.0E11,  0.02
```

程序代码如下： The program code is as follows:

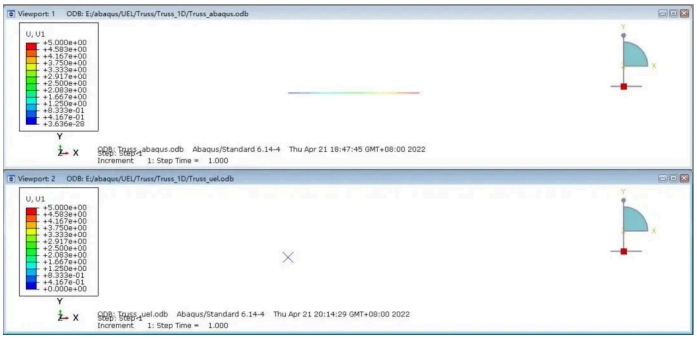
```
      SUBROUTINE UEL(RHS,AMATRX,SVARS,ENERGY,NDOFEL,NRHS,NSVARS,
     1 PROPS,NPROPS,COORDS,MCRD,NNODE,U,DU,V,A,JTYPE,TIME,DTIME,
     2 KSTEP,KINC,JELEM,PARAMS,NDLOAD,JDLTYP,ADLMAG,PREDEF,NPREDF,
     3 LFLAGS,MLVARX,DDLMAG,MDLOAD,PNEWDT,JPROPS,NJPROP,PERIOD)
C
      INCLUDE 'ABA_PARAM.INC'
C
      DIMENSION RHS(MLVARX,*),AMATRX(NDOFEL,NDOFEL),PROPS(*),
     1 SVARS(*),ENERGY(8),COORDS(MCRD,NNODE),U(NDOFEL),
     2 DU(MLVARX,*),V(NDOFEL),A(NDOFEL),TIME(2),PARAMS(*),
     3 JDLTYP(MDLOAD,*),ADLMAG(MDLOAD,*),DDLMAG(MDLOAD,*),
     4 PREDEF(2,NPREDF,NNODE),LFLAGS(*),JPROPS(*)

      INTEGER I,J
C     获取材料属性
      Y_M = PROPS(1)
      AREA = PROPS(2)
C     获取节点坐标计算单元长度
      LEN_EL = ABS(COORDS(1,2)-COORDS(1,1))
      write(6,*) LEN_EL
C     构造刚度矩阵
      K_EL = Y_M*AREA/LEN_EL
      AMATRX(1,1) = K_EL
      AMATRX(1,2) = -K_EL
      AMATRX(2,1) = -K_EL
      AMATRX(2,2) = K_EL
C     求RHS

      DO I = 1,NDOFEL
          RHS(I,1) = 0
          DO J = 1,NDOFEL
              RHS(I,1) = RHS(I,1) - AMATRX(I,J)*U(J)
          ENDDO
      ENDDO

      RETURN
      END
```

程序很简单，注释的很明白哦~UEL的作用就是构造一个的那元，核心就是构造出**单元刚度矩阵**，不需要常规有限元进行刚度矩阵组装，考虑摩擦等等一连串的流程，很方便即可开发出自己想要的单元（**「前提」**

是：理论掌握扎实！）

The program is simple, and the comments are very clear~ The role of UEL is to construct a that element, the core is to construct the element stiffness matrix, there is no need to assemble the stiffness matrix conventionally in finite element analysis, considering friction and a series of processes, it is very convenient to develop the desired element (the "premise" is: solid theoretical knowledge!)

与Abaqus标准Truss单元对比 Compare with Abaqus Standard Truss Element



结果一致，程序正确！ Results are consistent, the program is correct!

直播抽奖 Live lottery

接下来是预约直播抽奖环节了，较早关注木木的粉丝应该知道，木木不定期会搞一次抽奖活动，虽然是小小的礼品，但也代表了木木的心意，嘻嘻~

The next segment is the live broadcast lottery event. Those who have been following Mu Mu for a while should know that Mu Mu holds a lottery event irregularly. Although it's just a small gift, it represents Mu Mu's sincerity, hahaha~

木木受邀于北鲲云超算平台做主讲人，将在**5月24日晚上七点**于B站进行大约一个小时的讲演汇报，带着大家熟悉Abaqus的基本操作，基于Abaqus的扩展有限元仿真以及如何正确使用超算平台，直播过程中还有大量惊喜礼品、丰富算力金进行抽奖~欢迎大家积极参与。

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展示部分奖品：很精致哦~ Display some prizes: Very exquisite~

木木粉丝专属福利 Exclusive 福利 for Mumu Fans

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Scan the QR code below to register and get a trial bonus of "200 yuan"!!! It can be used for a long time!

推荐阅读 Recommended Reading

基于Matlab的J积分与等参单元求解应力强度因子…

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大龙猫 Big Cat