

kuka_otimo_2

April 25, 2018

Otimização do kuka utilizando conhecimento prévio do PID

```
In [56]: include("comum.jl")
include("modelos.jl")
using Evolutionary, Plots;
pyplot();

In [57]: Ts = 0.08
tend = 2.0
t0 = 0.0
popul = 50 # população
iterac = 10 # iterações
xr = SVector{7}([1.,1.,0.5,0.6,0.5,1.2,0.8]);

In [58]: function gerador(n)
    rand(n).*[10000.,10000.,10000.,10000.,1000.,1000.,100.,1000.,10000.,1000.,1000.,10000.]
end;

In [59]: function custo(gain::Vector{Float64})
    kp = SMatrix{7,7}(diagm(gain[1:7]))
    kv = SMatrix{7,7}(diagm(gain[8:end]))
    x, v, t, a, ta, j, tj = kukaRobot(kp, kv, Ts, t0, tend, xr)
    sizeVector = length(x[1])

    erro_sum = 0.
    for i=1:7
        erro = -(x[i]-xr[i])
        erro_sum = erro_sum + sum(abs.(erro[floor(Integer,sizeVector/3):end]))
    end

    jerk_sum = 0.
    for i=1:7
        jerk_sum = jerk_sum + sum(abs.(j[i]))
    end

    erro_sum = erro_sum * 10.
    jerk_sum = jerk_sum * 0.01
end
```

```

        out = erro_sum + jerk_sum
        println("erro: $(erro_sum) jerk: $(jerk_sum)")
        out
    end;

```

In [60]: N = 14

```

    result, fitness, cnt = ga(custo, N; initPopulation = gerador, populationSize = popul,

```

```

erro: 66.33155869034366 jerk: 239.78976437560243
erro: 98.08988566736187 jerk: 56.729780430947244
erro: 73.10188295362809 jerk: 53.74179850584136
erro: 225.81027268887345 jerk: 39.85540366020051
erro: 112.76574088522514 jerk: 22.164950164257366
erro: 31.03181791694153 jerk: 47.27680453404186
erro: 321.8955684857164 jerk: 13.75389419808604
erro: 101.3307174198021 jerk: 59.54877675017
erro: 121.66250406351865 jerk: 52.852396775986094
erro: 80.38781983654968 jerk: 32.893039199933185
erro: 71.98438067949552 jerk: 45.98325129663804
erro: 207.4147074069276 jerk: 22.306050460788224
erro: 131.4603366543497 jerk: 53.250607598737915
erro: 172.19306678155235 jerk: 35.275930747216265
erro: 25.500843625367406 jerk: 43.32332933484733
erro: 227.43611618862911 jerk: 41.751706455670046
erro: 196.5234066754418 jerk: 56.03720658614009
erro: 66.23280624888535 jerk: 39.72392274146946
erro: 175.99415283984743 jerk: 43.61253782094382
erro: 70.53589298114859 jerk: 358.8950751192584
erro: 170.17489272267568 jerk: 153.70249739606302
erro: 151.30339012846014 jerk: 45.06863273261985
erro: 277.2175823001524 jerk: 45.39358208621882
erro: 3.9308468979055466 jerk: 83.06404476214595
erro: 125.37643387785066 jerk: 42.571848575119304

```

Progress: 9%|

| ETA: 0:31:24

```

erro: 25.500843625367406 jerk: 43.32332933484733
erro: 25.500843625367406 jerk: 43.32332933484733
erro: 61.451006236452265 jerk: 29.660012689548267
erro: 190.91686312154468 jerk: 33.19609726606449
erro: 31.03729968567937 jerk: 47.25538426141085
erro: 38.56757009641194 jerk: 56.88065054981229
erro: 30.605296715049647 jerk: 50.19160976283628
erro: 21.024772096984524 jerk: 53.62766006745319
erro: 31.03729968567937 jerk: 47.25538426141085
erro: 31.03729968567937 jerk: 47.25538426141085
erro: 93.00841284964878 jerk: 46.40311876694607

```

erro: 1630.6149517122205 jerk: 25732.39843958034
erro: 31.03729968567937 jerk: 47.25538426141085
erro: 66.23280624888535 jerk: 39.72392274146946
erro: 98.08988566736187 jerk: 56.729780430947244
erro: 101.31189277227051 jerk: 59.549647539719274
erro: 30.246708845855753 jerk: 50.9635817719552
erro: 29.68504518611403 jerk: 45.164258406828246
erro: 54.74656077305306 jerk: 33.9115953882964
erro: 35.230547402964014 jerk: 34.92380300620657
erro: 31.03729968567937 jerk: 47.25538426141085
erro: 80.38781983654968 jerk: 32.893039199933185
erro: 25.500843625367406 jerk: 43.32332933484733
erro: 247.85391315954772 jerk: 16.736342673987174
erro: 165.480049342668 jerk: 43.29462068039469
erro: 25.500843625367406 jerk: 43.32332933484733

Progress: 18%|

| ETA: 0:26:25

erro: 31.032277199928217 jerk: 47.30349254685197
erro: 31.03729968567937 jerk: 47.25538426141085
erro: 20.669684829371356 jerk: 57.24071781574328
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 2.534681788665037e8 jerk: 8.875958431103799e7
erro: 42.00167642413894 jerk: 54.46379304437807
erro: 38.47359031869585 jerk: 47.43823695797613
erro: 38.252983135998186 jerk: 44.90900814429488
erro: 47497.81812251163 jerk: 1.973845306571731e6
erro: 48.612836606132426 jerk: 41.84620396015557
erro: 37.51826259977359 jerk: 45.731775094596514
erro: 51.79207603957502 jerk: 40.21374814605891
erro: 29.68504518611403 jerk: 45.164258406828246
erro: 25.500843625367406 jerk: 43.32332933484733
erro: 25.500843625367406 jerk: 43.32332933484733
erro: 10.217540093026853 jerk: 73.49193682544339
erro: 30.278516952300883 jerk: 45.952568552089936
erro: 34.51188496792562 jerk: 58.12657985362165
erro: 21.024772096984524 jerk: 53.62766006745319
erro: 54.74656077305306 jerk: 33.9115953882964
erro: 21.20834726002942 jerk: 56.22679005389535
erro: 27.145509852663885 jerk: 50.08582707372887
erro: 25.501644843179882 jerk: 43.32664156495636
erro: 21.996387908788574 jerk: 50.20075258554594
erro: 23.72276061753963 jerk: 49.60564275012541
erro: 22.335003315896106 jerk: 40.291040135777294

Progress: 27%|

| ETA: 0:51:45

erro: 21.024772096984524 jerk: 53.62766006745319
erro: 38.252983135998186 jerk: 44.90900814429488
erro: 26.010256746763925 jerk: 48.798134960942754
erro: 24.2907932580423 jerk: 54.28288101152469
erro: 35.13274602589345 jerk: 44.5733270697876
erro: 41.63801592938085 jerk: 49.30770802509586
erro: 33.23061046530371 jerk: 46.273110525344556
erro: 30.023521427825415 jerk: 58.00977986490007
erro: 23.680846155165042 jerk: 51.20731929826758
erro: 20.723996957918757 jerk: 60.133197459256415
erro: 21.024772096984524 jerk: 53.62766006745319
erro: 51.79207603957502 jerk: 40.21374814605891
erro: 20.457873183878824 jerk: 59.07338908366441
erro: 21.468763285641334 jerk: 59.96025195303767
erro: 57.77595722335269 jerk: 37.41035082577937
erro: 68.84241217103336 jerk: 42.66437326352493
erro: 21.024772096984524 jerk: 53.62766006745319
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 30.821398197416077 jerk: 52.68089675507507
erro: 24.944433974391707 jerk: 43.03757268145413
erro: 21.211527786842737 jerk: 56.23402047236011
erro: 25.500843625367406 jerk: 43.32332933484733
erro: 25.147633567705718 jerk: 43.45224282963698
erro: 50.82853356158536 jerk: 51.24160366047402
erro: 28.916027066400503 jerk: 53.71829160686732
erro: 22.335003315896106 jerk: 40.291040135777294

Progress: 36%|

| ETA: 0:38:07

erro: 57.929099171230014 jerk: 37.36801508887619
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 32.09525595318886 jerk: 37.232947989103636
erro: 35.04091851744627 jerk: 42.388164990339256
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 21.024772096984524 jerk: 53.62766006745319
erro: 27.555186268859405 jerk: 56.8383924581901
erro: 28.227470231925626 jerk: 48.46585903647856
erro: 23.82856742501509 jerk: 57.81034672521458
erro: 24.944433974391707 jerk: 43.03757268145413
erro: 23.4010627992431 jerk: 58.65967285456015
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 30.821398197416077 jerk: 52.68089675507507
erro: 30.821398197416077 jerk: 52.68089675507507
erro: 28.792736621043915 jerk: 46.99230730447991
erro: 41.707133812720215 jerk: 45.23783587215295
erro: 55.746306342713424 jerk: 42.640450016782815
erro: 50.435187912128995 jerk: 45.280585177397604

erro: 71.23974850111034 jerk: 40.32112803125755
erro: 54.0372679968116 jerk: 42.79850713625979
erro: 22.30442475792595 jerk: 42.1053516151885
erro: 22.426835946107573 jerk: 40.80091870766266
erro: 25.617642330362962 jerk: 51.249135806715586
erro: 24.97927148524284 jerk: 54.496919236545025
erro: 22.921563215701333 jerk: 58.42770979855344
erro: 22.335003315896106 jerk: 40.291040135777294

Progress: 45%| | ETA: 0:29:15

erro: 23.177010015862937 jerk: 62.22956012557723
erro: 21.370129678450397 jerk: 56.08850283482425
erro: 24.73163377478137 jerk: 54.09808835370739
erro: 25.343644108029885 jerk: 34.87614678570917
erro: 22.046756426515472 jerk: 43.040717835364106
erro: 24.193966170235043 jerk: 55.584301882622185
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 22.426835946107573 jerk: 40.80091870766266
erro: 46.85572612807246 jerk: 50.49641553702619
erro: 26.237888782498544 jerk: 50.26906367743465
erro: 22.30442475792595 jerk: 42.1053516151885
erro: 22.426835946107573 jerk: 40.80091870766266
erro: 50.435187912128995 jerk: 45.280585177397604
erro: 41.707133812720215 jerk: 45.23783587215295
erro: 41.770102280603574 jerk: 35.881063538537305
erro: 23519.818421567223 jerk: 2.792598806972105e6
erro: 23.58864086482056 jerk: 50.96184217684246
erro: 35.5209017165111 jerk: 51.67653228546802
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 22.86786441466476 jerk: 44.42609816294813
erro: 37.40299862076458 jerk: 43.755452733334586
erro: 43.584521416156655 jerk: 46.101267580119305
erro: 30.25249180544922 jerk: 62.32767174715954
erro: 22.921563215701333 jerk: 58.42770979855344
erro: 71.23974850111034 jerk: 40.32112803125755
erro: 25.343644108029885 jerk: 34.87614678570917

Progress: 55%| | ETA: 0:22:45

erro: 22.149301323277637 jerk: 60.96520015091343
erro: 24.529918909099038 jerk: 57.51875053461563
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 25.386195917106544 jerk: 34.850265937383995
erro: 25.357316798662918 jerk: 63.73318561715183
erro: 27.623875913802838 jerk: 54.14846533828981
erro: 22.335003315896106 jerk: 40.291040135777294

erro: 24.73163377478137 jerk: 54.09808835370739
erro: 32.44570157838681 jerk: 48.149214453457105
erro: 25.722872551182434 jerk: 54.778855044140975
erro: 38.66685352269861 jerk: 49.93713362628448
erro: 39.85017718629251 jerk: 55.4494025252717
erro: 22.024220051728868 jerk: 58.57591302610099
erro: 20.98722581493191 jerk: 50.829488657332945
erro: 43.584521416156655 jerk: 46.101267580119305
erro: 46.85572612807246 jerk: 50.49641553702619
erro: 19.594033742614855 jerk: 48.36628959687267
erro: 19.626593458747422 jerk: 81.9934787229386
erro: 38.92617697453221 jerk: 40.55886294091247
erro: 25.343644108029885 jerk: 34.87614678570917
erro: 25.46047177554254 jerk: 36.750847007644104
erro: 26.107294299944858 jerk: 37.37718833148284
erro: 23.487332930757706 jerk: 54.870450858403395
erro: 34.35351917707791 jerk: 36.65336208417715
erro: 25.39317842914944 jerk: 49.74168107492742
erro: 25.343644108029885 jerk: 34.87614678570917

Progress: 64%| | ETA: 0:17:04

erro: 20.88582423859027 jerk: 35.61785634464529
erro: 25.60755588234029 jerk: 41.33913891212342
erro: 33.614115019232116 jerk: 63.269794822355756
erro: 28.274162817317716 jerk: 58.31849086256036
erro: 29.562525671213393 jerk: 46.44608104165549
erro: 24.432431448897546 jerk: 56.63442887846755
erro: 22.274620541989112 jerk: 47.85011890195176
erro: 21.039528637509672 jerk: 58.157150879389896
erro: 38.66685352269861 jerk: 49.93713362628448
erro: 23.487332930757706 jerk: 54.870450858403395
erro: 27.912808800017434 jerk: 54.34358530619322
erro: 26.517543153308722 jerk: 36.07155526022921
erro: 34.22820302514151 jerk: 49.988771691355296
erro: 1.9019700517704745e6 jerk: 1.296661592293184e8
erro: 23.713060093352887 jerk: 36.97733019991973
erro: 24.331704854720826 jerk: 50.42567647294518
erro: 25.343644108029885 jerk: 34.87614678570917
erro: 25.658114981237617 jerk: 36.67279990370561
erro: 25.386195917106544 jerk: 34.850265937383995
erro: 26.570829233576312 jerk: 52.39013988650134
erro: 34.35351917707791 jerk: 36.65336208417715
erro: 43.584521416156655 jerk: 46.101267580119305
erro: 22.335003315896106 jerk: 40.291040135777294
erro: 25.420368710526475 jerk: 53.92327089230122
erro: 24.928769509667323 jerk: 55.78706486602948

erro: 20.88582423859027 jerk: 35.61785634464529

Progress: 73%| | ETA: 0:15:17

erro: 28.274162817317716 jerk: 58.31849086256036
erro: 29.562525671213393 jerk: 46.44608104165549
erro: 834.963078770892 jerk: 10183.784310592386
erro: 24.63856061916692 jerk: 61.34989067478327
erro: 22.27476569922997 jerk: 47.795001857585724
erro: 24.928769509667323 jerk: 55.78706486602948
erro: 25.048739061593643 jerk: 36.49545003900005
erro: 25.254040774763524 jerk: 37.30225387971106
erro: 33.90068271548884 jerk: 48.68429563346828
erro: 29.08106608311538 jerk: 36.81759653793408
erro: 23.713201188470727 jerk: 36.977050635932436
erro: 20.88582423859027 jerk: 35.61785634464529
erro: 36.63214393662989 jerk: 41.574923683976124
erro: 20.88582423859027 jerk: 35.61785634464529
erro: 24.81363958453329 jerk: 52.95388818845981
erro: 21.95575220363157 jerk: 55.457369483829936
erro: 36.99708484459157 jerk: 53.03850830115387
erro: 25.343644108029885 jerk: 34.87614678570917
erro: 25.658114981237617 jerk: 36.67279990370561
erro: 34.35351917707791 jerk: 36.65336208417715
erro: 34.35351917707791 jerk: 36.65336208417715
erro: 26.517543153308722 jerk: 36.07155526022921
erro: 21.039528637509672 jerk: 58.157150879389896
erro: 21.42178210026848 jerk: 62.90874690655417
erro: 24.060516891148005 jerk: 56.82224402328679
erro: 20.88582423859027 jerk: 35.61785634464529

Progress: 82%| | ETA: 0:09:38

erro: 29.670990710857264 jerk: 47.10426714284575
erro: 27.171723333169908 jerk: 49.63438453835758
erro: 24.46972453565712 jerk: 60.302746806354435
erro: 20.730303286397813 jerk: 47.064046805904844
erro: 20.88582423859027 jerk: 35.61785634464529
erro: 33.90068271548884 jerk: 48.68429563346828
erro: 20.88582423859027 jerk: 35.61785634464529
erro: 41.81420003248837 jerk: 43.378939355909885
erro: 23.498761241061608 jerk: 38.09539742636424
erro: 23.398633736220336 jerk: 41.232216750495546
erro: 27.159502261973326 jerk: 47.38533714622769
erro: 29.13736019342844 jerk: 47.138216993886324
erro: 24.34158037782447 jerk: 52.12549592056259
erro: 28.82967755802795 jerk: 46.645142295642

```

erro: 27.59191061735764 jerk: 65.91625514612758
erro: 25.3763974701575 jerk: 65.35196126069467
erro: 26.856291402669488 jerk: 52.75161682119354
erro: 28.459818214340782 jerk: 52.74643163512766
erro: 22.28858852865454 jerk: 39.364146311154066
erro: 23.87401338812279 jerk: 61.33668822836236
erro: 23.578516556886253 jerk: 60.92002511798667
erro: 9887.868824731991 jerk: 961821.8100089764
erro: 40.4385182468792 jerk: 48.99362956415676
erro: 35.57380594888386 jerk: 47.87219601261638
erro: 29.278878873240085 jerk: 49.0906041670735
erro: 20.88582423859027 jerk: 35.61785634464529

```

Progress: 91%| | ETA: 0:04:37

```

erro: 25.238837859190838 jerk: 42.52046414758702
erro: 20.88582423859027 jerk: 35.61785634464529
erro: 24.192445516429405 jerk: 57.32332217624677
erro: 35.57965274076254 jerk: 47.33210885193823
erro: 26.413847811687354 jerk: 48.91514778866034
erro: 20.88582423859027 jerk: 35.61785634464529
erro: 20.88582423859027 jerk: 35.61785634464529
erro: 23.398633736220336 jerk: 41.232216750495546
erro: 21.69446301774995 jerk: 42.166288581175266
erro: 22.68760778924076 jerk: 36.138153530821846
erro: 3200.018311718207 jerk: 614650.2330415085
erro: 30.091621439096244 jerk: 53.67679879125324
erro: 32.78992447392675 jerk: 41.92149469722459
erro: 32.63094551053224 jerk: 54.7138930735065
erro: 23.142729274098826 jerk: 40.100229482900495
erro: 24.405940501514046 jerk: 34.566698681200776
erro: 25.404811862676056 jerk: 52.05043879993605
erro: 26.299892058725028 jerk: 47.84528782225544
erro: 23.719481694689875 jerk: 56.41789953333279
erro: 22.0803133407978 jerk: 60.46795170962313
erro: 25.579451506602343 jerk: 59.66553948701231
erro: 26.106856984007422 jerk: 57.42722667672378
erro: 30.020470124914553 jerk: 49.30930678063311
erro: 29.670990710857264 jerk: 47.10426714284575
erro: 29.670990710857264 jerk: 47.10426714284575
erro: 20.88582423859027 jerk: 35.61785634464529

```

Progress: 100%|| Time: 0:48:54

```

In [61]: t_end_new = tend
         kp = SMatrix{7,7}(diagm(result[1:7]))

```



```

kv = SMatrix{7,7}(diagm(result[8:end]))

x, v, t, a, ta, j, tj = kukaRobot(kp, kv, Ts, t0, t_end_new, xr);

In [62]: for i=1:7
    erro = xr[i] - x[i][end]
    println("erro final $(i) = $(erro)")
end

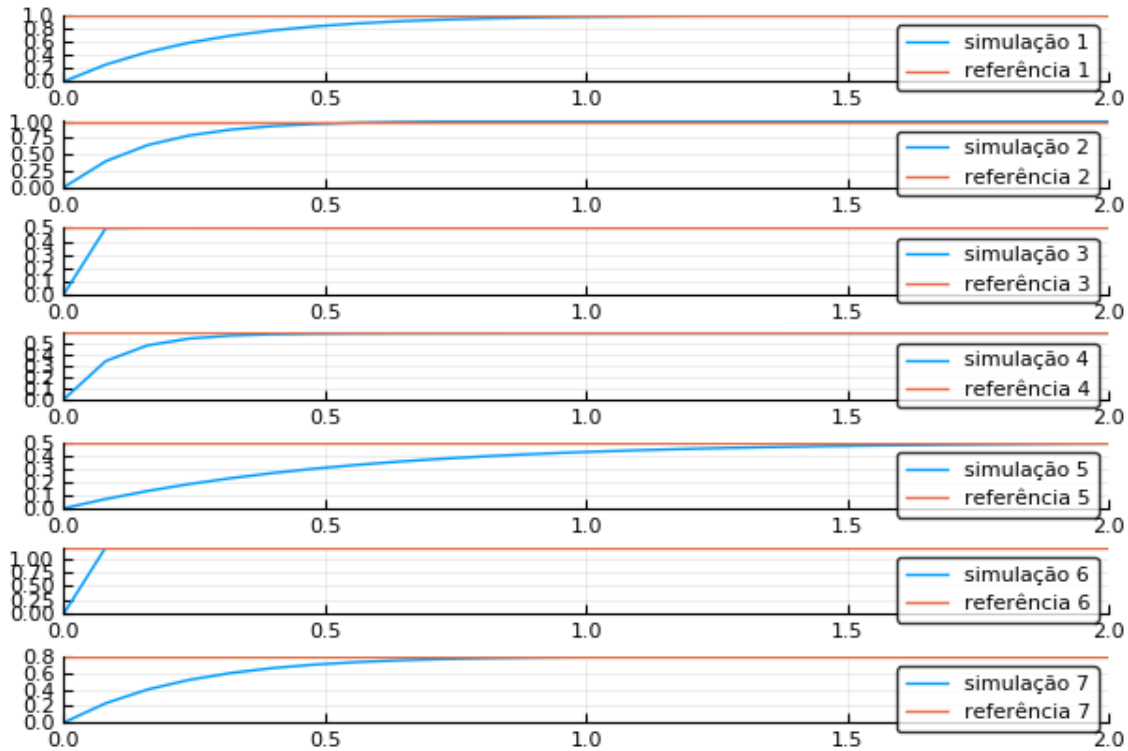
erro final 1 = 0.0005906653921418092
erro final 2 = -0.00428228899049099
erro final 3 = -0.0005478132060371399
erro final 4 = 0.001635399548539751
erro final 5 = 0.011836976686002587
erro final 6 = -0.002106747831435385
erro final 7 = 0.0001479618496730284

In [72]: function plotx(i)
    p1 = plot(t,x[i], label = "desejado")
    p1= plot!([xr[i]],seriestype=:hline, label = "referência");
end
function plotx()
    p1 = plot(t,x[1], label = "simulação 1")
    p1= plot!([xr[1]],seriestype=:hline, label = "referência 1")
    p2 = plot(t,x[2], label = "simulação 2")
    p2= plot!([xr[2]],seriestype=:hline, label = "referência 2")
    p3 = plot(t,x[3], label = "simulação 3")
    p3= plot!([xr[3]],seriestype=:hline, label = "referência 3")
    p4 = plot(t,x[4], label = "simulação 4")
    p4= plot!([xr[4]],seriestype=:hline, label = "referência 4")
    p5 = plot(t,x[5], label = "simulação 5")
    p5= plot!([xr[5]],seriestype=:hline, label = "referência 5")
    p6 = plot(t,x[6], label = "simulação 6")
    p6= plot!([xr[6]],seriestype=:hline, label = "referência 6")
    p7 = plot(t,x[7], label = "simulação 7")
    p7= plot!([xr[7]],seriestype=:hline, label = "referência 7")
    plot(p1,p2,p3,p4,p5,p6,p7, layout =(7,1))
end;

In [73]: plotx()

Out[73]:

```



```
In [79]: println("Somatório do módulo do jerk")
         for i = 1:7
             println("junta $(i) -> $(sum(abs.(j[i])))")
         end
         soma_jerk= 0.
         for i = 1:7
             soma_jerk += sum(abs.(j[i]))
         end
         println("jerk total: $(soma_jerk)")
```

```
Somatório do módulo do jerk
junta 1 -> 638.5471019803335
junta 2 -> 1091.4276796517734
junta 3 -> 106.08612291577205
junta 4 -> 883.7998461779902
junta 5 -> 163.3607046783051
junta 6 -> 74.27755937203386
junta 7 -> 604.2866196883213
jerk total: 3561.785634464529
```

```
In [80]: println("Máximo módulo do jerk")
         for i = 1:7
             println("junta $(i) -> $(maximum(abs.(j[i])))")
```

```
end
soma_jerk_max = 0.
for i = 1:7
    soma_jerk_max += maximum(abs.(j[i]))
end
println("jerk máximo total: $(soma_jerk_max)")
```

```
Máximo módulo do jerk
junta 1 -> 532.1749232942382
junta 2 -> 849.589553332606
junta 3 -> 69.3197425500541
junta 4 -> 648.201810552396
junta 5 -> 143.36242855958778
junta 6 -> 49.93778977570984
junta 7 -> 492.7692498391387
jerk máximo total: 2785.355497903731
```