1 quaternary angle tree (leafmin) (N=10 R=4 theta=0.124355)

i	br	$theta$	$-u0$	$a(2*i)$	$-u1$	$a(2*i+1)$	$theta'$
0	2	0.124355	1	0.785398	-1	0.463648	0.446106
1	0	0.446106	-1	0.244979	-1	0.124355	0.076772
2	0	0.076772	-1	0.062419	-1	0.031240	-0.016887
3	3	-0.016887	1	0.015624	1	0.007812	0.006549
4	0	0.006549	-1	0.003906	-1	0.001953	0.000690
5	1	0.000690	-1	0.000977	1	0.000488	0.000202
6	1	0.000202	-1	0.000244	1	0.000122	0.000080
7	0	0.000080	-1	0.000061	-1	0.000031	-0.000012
8	2	-0.000012	1	0.000015	-1	0.000008	-0.000004

2 quaternary angle tree (globalmin) (N=10 R=4 theta=0.124355)

i	br	$theta$	$-u0$	$a(2*i)$	$-u1$	$a(2*i+1)$	$theta'$
0	2	0.124355	1	0.785398	-1	0.463648	0.446106
1	0	0.446106	-1	0.244979	-1	0.124355	0.076772
2	0	0.076772	-1	0.062419	-1	0.031240	-0.016887
3	3	-0.016887	1	0.015624	1	0.007812	0.006549
4	0	0.006549	-1	0.003906	-1	0.001953	0.000690
5	1	0.000690	-1	0.000977	1	0.000488	0.000202
6	1	0.000202	-1	0.000244	1	0.000122	0.000080
7	0	0.000080	-1	0.000061	-1	0.000031	-0.000012
8	2	-0.000012	1	0.000015	-1	0.000008	-0.000004

3 quaternary angle tree (cordic) (N=10 R=4 theta=0.124355)

i	br	$theta$	$-u0$	$a(2*i)$	$-u1$	$a(2*i+1)$	$theta'$
0	1	0.124355	-1	0.785398	1	0.463648	-0.197396
1	2	-0.197396	1	0.244979	-1	0.124355	-0.076772
2	3	-0.076772	1	0.062419	1	0.031240	0.016887
3	0	0.016887	-1	0.015624	-1	0.007812	-0.006549
4	3	-0.006549	1	0.003906	1	0.001953	-0.000690
5	2	-0.000690	1	0.000977	-1	0.000488	-0.000202
6	2	-0.000202	1	0.000244	-1	0.000122	-0.000080
7	3	-0.000080	1	0.000061	1	0.000031	0.000012
8	1	0.000012	-1	0.000015	1	0.000008	0.000004

```
quaternary angle tree search (N=10)
theta= atan(pow(2,-3) =   0.124355

====================================
* the leaf optimal path
====================================
* leaf min node : depth=  9 theta= -4.309751e-06 id=221607

path type : leafmin
dp= 0 th=+0.124355       br= 2  :  -1.249046  -0.321751   0.321751   1.249046
dp= 1 th=+0.446106       br= 0  :  -0.369334  -0.120624   0.120624   0.369334
dp= 2 th=+0.0767719      br= 0  :  -0.093659  -0.031179   0.031179   0.093659
dp= 3 th=-0.0168868      br= 3  :  -0.023436  -0.007811   0.007811   0.023436
dp= 4 th=+0.00654932     br= 0  :  -0.005859  -0.001953   0.001953   0.005859
dp= 5 th=+0.000689965    br= 1  :  -0.001465  -0.000488   0.000488   0.001465
dp= 6 th=+0.000201684    br= 1  :  -0.000366  -0.000122   0.000122   0.000366
dp= 7 th=+7.96136e-05    br= 0  :  -0.000092  -0.000031   0.000031   0.000092
dp= 8 th=-1.19391e-05    br= 2  :  -0.000023  -0.000008   0.000008   0.000023
dp= 9 th=-4.30975e-06

leafmin path=2 0 0 3 0 1 1 0 2
latex quaternary_tree_1_leafmin.tex > /dev/null
dvipdf quaternary_tree_1_leafmin.dvi > /dev/null
xreader -w quaternary_tree_1_leafmin.pdf > /dev/null

====================================
* the global optimal path
====================================
level min node : depth=  0 theta= +1.243550e-01 id=0
level min node : depth=  1 theta= -1.973956e-01 id=2
level min node : depth=  2 theta= -7.677189e-02 id=11
level min node : depth=  3 theta= -1.688675e-02 id=53
level min node : depth=  4 theta= -6.549318e-03 id=193
level min node : depth=  5 theta= -6.899649e-04 id=776
level min node : depth=  6 theta= -2.016839e-04 id=3107
level min node : depth=  7 theta= -7.961359e-05 id=12431
level min node : depth=  8 theta= -1.193915e-05 id=55401
level min node : depth=  9 theta= -4.309751e-06 id=221607

* global min node : depth=  9 theta= -4.309751e-06 id=221607

path type : globalmin
dp= 0 th=+0.124355       br= 2  :  -1.249046  -0.321751   0.321751   1.249046
dp= 1 th=+0.446106       br= 0  :  -0.369334  -0.120624   0.120624   0.369334
dp= 2 th=+0.0767719      br= 0  :  -0.093659  -0.031179   0.031179   0.093659
dp= 3 th=-0.0168868      br= 3  :  -0.023436  -0.007811   0.007811   0.023436
dp= 4 th=+0.00654932     br= 0  :  -0.005859  -0.001953   0.001953   0.005859
dp= 5 th=+0.000689965    br= 1  :  -0.001465  -0.000488   0.000488   0.001465
dp= 6 th=+0.000201684    br= 1  :  -0.000366  -0.000122   0.000122   0.000366
dp= 7 th=+7.96136e-05    br= 0  :  -0.000092  -0.000031   0.000031   0.000092
dp= 8 th=-1.19391e-05    br= 2  :  -0.000023  -0.000008   0.000008   0.000023
dp= 9 th=-4.30975e-06

globalmin path=2 0 0 3 0 1 1 0 2
latex quaternary_tree_2_globalmin.tex > /dev/null
dvipdf quaternary_tree_2_globalmin.dvi > /dev/null
xreader -w quaternary_tree_2_globalmin.pdf > /dev/null

====================================
* the cordic path
====================================
* cordic min node : depth=  9 theta= +4.309751e-06 id=198913

path type : cordic
dp= 0 th=+0.124355       br= 1  :  -1.249046  -0.321751   0.321751   1.249046
dp= 1 th=-0.197396       br= 2  :  -0.369334  -0.120624   0.120624   0.369334
dp= 2 th=-0.0767719      br= 3  :  -0.093659  -0.031179   0.031179   0.093659
dp= 3 th=+0.0168868      br= 0  :  -0.023436  -0.007811   0.007811   0.023436
```

```
dp= 4 th=-0.00654932     br= 3  :  -0.005859  -0.001953   0.001953   0.005859
dp= 5 th=-0.000689965    br= 2  :  -0.001465  -0.000488   0.000488   0.001465
dp= 6 th=-0.000201684    br= 2  :  -0.000366  -0.000122   0.000122   0.000366
dp= 7 th=-7.96136e-05    br= 3  :  -0.000092  -0.000031   0.000031   0.000092
dp= 8 th=+1.19391e-05    br= 1  :  -0.000023  -0.000008   0.000008   0.000023
dp= 9 th=+4.30975e-06

cordic path=1 2 3 0 3 2 2 3 1
latex quaternary_tree_3_cordic.tex > /dev/null
dvipdf quaternary_tree_3_cordic.dvi > /dev/null
xreader -w quaternary_tree_3_cordic.pdf > /dev/null
* deallocate nodes in the leafmin path
* deallocate nodes in the globalmin path
* deallocate nodes in the cordic path
```