Usage

The code is available for download in Python, C++, as well as Fortran 77. The code contains example programs for each language.

Dependencies

- Only Linux and OSX are supported.
- Python package relies on Numpy and Scipy libraries. We recommend that the user installs anaconda for either python2 or python3 before using the library.
- C++ package relies either on Boost dependency or GSL dependency.
- Fortran 77 package is a standalone and has no external dependencies.

Installation

Clone the codes from https://github.com/UCLA-TMD/Ogata.

For python add the Ogata/python/ directory to the environmental variable PYTHONPATH by executing the following.

```
PYTHONPATH=path2Ogata:$PYTHONPATH
```

Python Example

Here we will give an example use for FBT in python 2.7. This follows 'example.py' in the repository and is used to numerically perform the integration

$$\int_0^\infty db_\perp b_\perp e^{-b_\perp} J_\nu(b_\perp q_\perp).$$

Begin by importing all external dependencies.

```
import numpy as np
import pylab as py
from  matplotlib import rc
rc('font',**{'family':'sans-serif','sans-serif':['Helvetica']})
rc('text',usetex=True)
```

Now import the adaptive quadrature class and initialize for $\nu = 0$.

```
from FBT import FBT
nu = 0
fbt = FBT(nu)
```

Define our function.

```
test = lambda b: b*np.exp(-b)
```

Set our parameters.

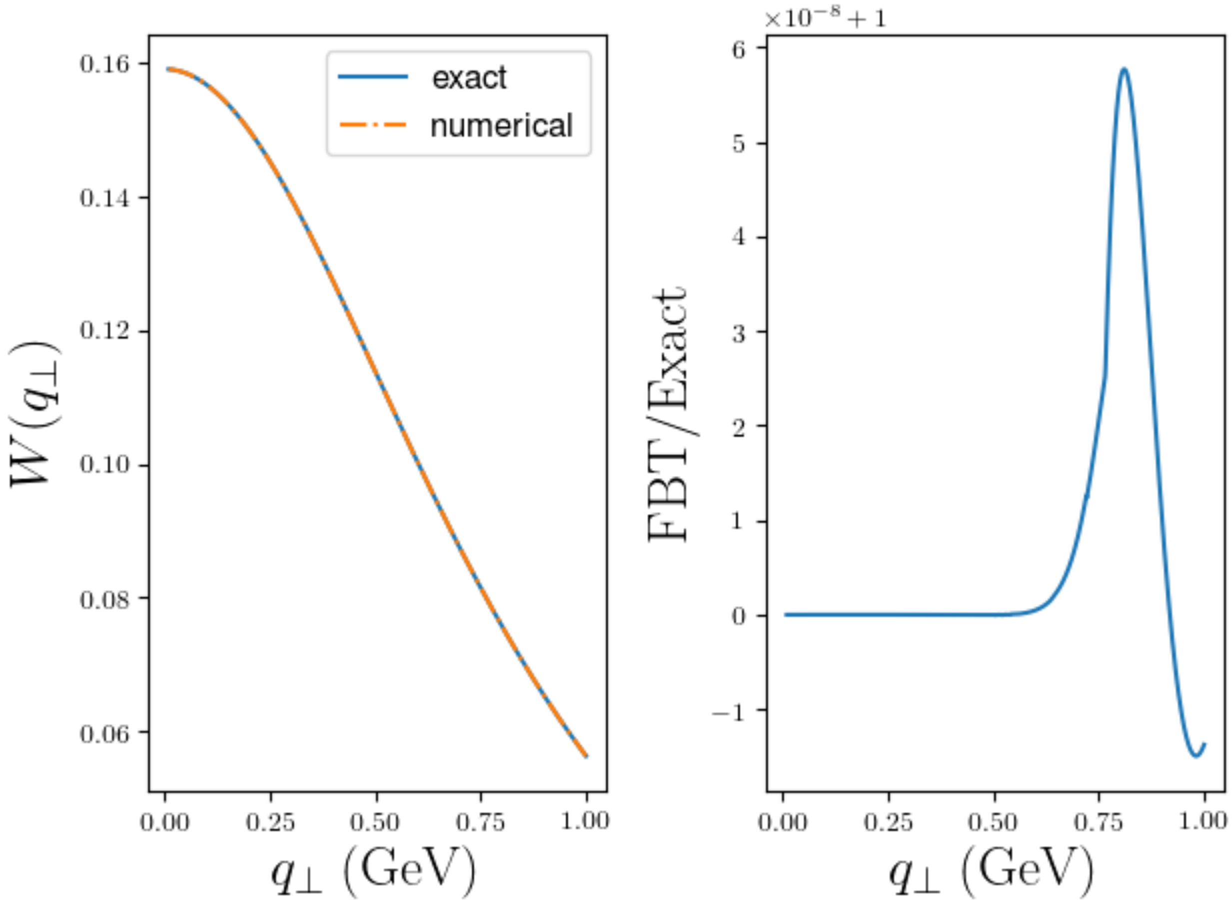
```
N=10
Q=1.0 # inverse of where test(b) peaks in bt space
q=np.linspace(0.01,1,1000)
nu=0
```

Gather data.

```
exact = lambda qT: (1+qT**2)**(-1.5) #Known analytic Hankel transform
wexact = [exact(_q) for _q in q]
wfbt  = [fbt.fbt(test,_q,N,Q,nu) for _q in q]
ratios = [wfbt[i]/wexact[i] for i in range(len(q))]
```

Plot.

```
ax=py.subplot(121)
ax.plot(q,wexact,'-',label='exact')
ax.plot(q,wfbt,'-.',label='numerical')
ax.set_xlabel(r'$q_{\perp}\; \rm (GeV)$',fontsize=20)
ax.set_ylabel(r'$W(q_{\perp})$',fontsize=20)
ax.legend(fontsize=12)
ax=py.subplot(122)
ax.plot(q,ratios)
ax.set_xlabel(r'$q_{\perp}\; \rm (GeV)$',fontsize=20)
ax.set_ylabel(r'\rm fbt/Exact',fontsize=20)
py.tight_layout()
py.show()
```



FORTRAN77 Example

Here we will give an example use for FBT in FORTRAN77.

$$\int_0^\infty db_\perp b_\perp e^{-b_\perp} J_\nu(b_\perp q_\perp).$$

The program example.f writes the FBT result along with the exact result to “output.dat” for a range of values of $q_\perp$.

```
program example
implicit none
real*8 qt,Q,z,fuu,ex,exact,test_fun
external test_fun,fbt
integer nu,n
integer i

open(unit = 1, file = "output.dat")
write(1, *) 'qT fbt exact'

do i = 1, 100
qt = 0.01*i
Q=1d0
nu=0              ! nu the order of the Bessel function
z=1d0             ! z momentum fraction for fragmentation, set equal to one for other
applications
n = 10            ! number of nodes
ex = exact(qT)    ! analytic result
call fbt(test_fun,qt,Q,nu,z,n,fuu)
write(1,*) qT,fuu,ex
enddo
close(1)

end program
```

The test function is defined in this program.

```
real*8 function test_fun(b)
implicit none
real*8 b

test_fun = b*dexp(-b)

end function
```

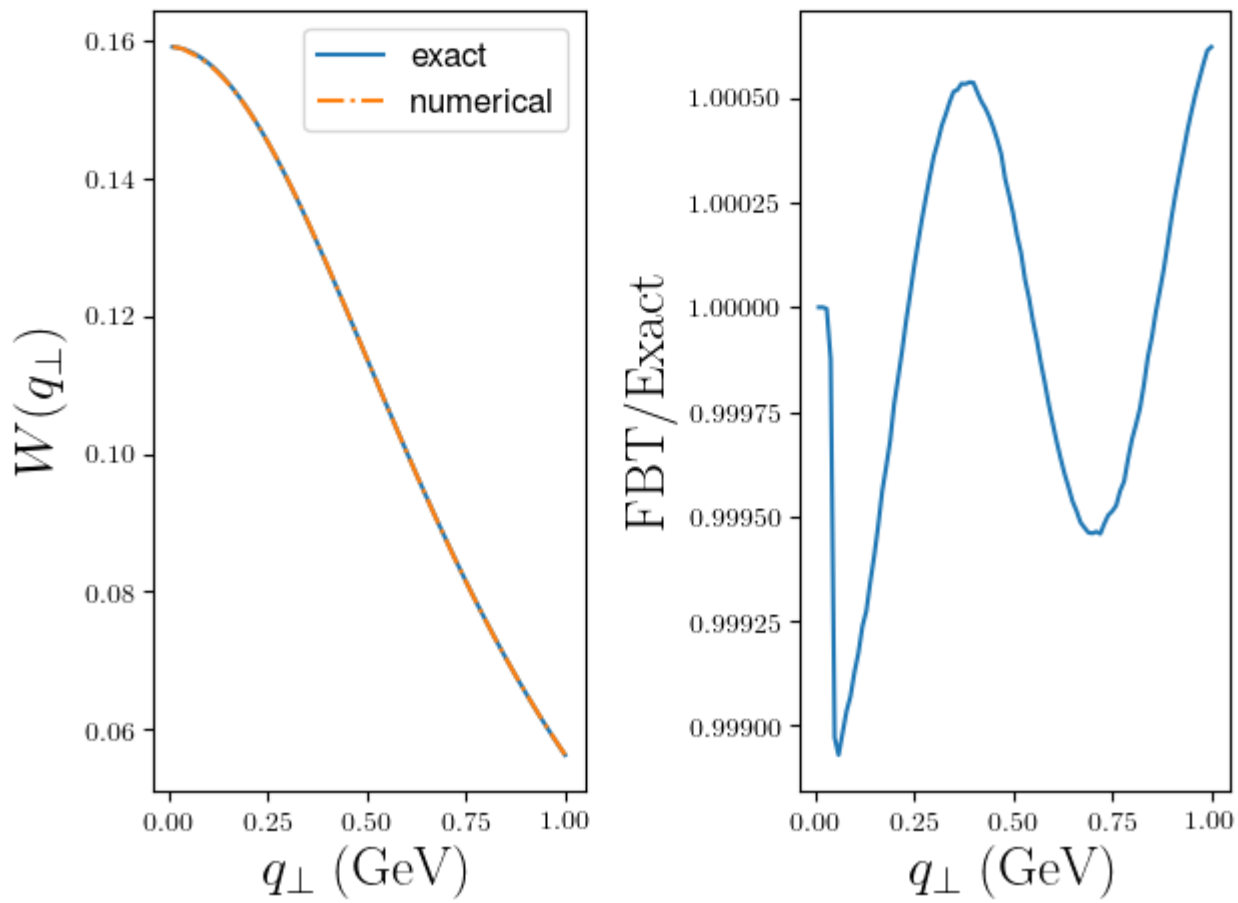
The analytic Bessel transform of the test function is also in this file.

```
real*8 function exact(qT)
real*8 qT
real*8 pi

pi = datan(1d0)*4d0

exact = (1d0+qT*qT)**(-1.5d0)/2d0/pi

end
```

To generate the test, issue the following commands.

```
make
./example.out
python plot.py
```

The output should be the following figure.



exact
numerical
$W(q_\perp)$
0.16
0.14
0.12
0.10
0.08
0.06
0.00
0.25
0.50
0.75
1.00
$q_\perp$ (GeV)
FBT/Exact
1.00050
1.00025
1.00000
0.99975
0.99950
0.99925
0.99900
$q_\perp$ (GeV)