BRNO UNIVERSITY OF TECHNOLOGY
Faculty of Information Technology

Practical Aspects of Software Design – 2019/2020

Profiling report

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1 Assignment

Using functions from your mathematical library, create a program (as a separate executable) to calculate the sample standard deviation from a sequence of numbers that the program reads from standard input (in C, for example, using the scanf function) until the end of the file and must be eble 1000 numbers. The input file contains only numbers and their number is not given in advance. The sample standard deviation formula to be used:

$$s = \sqrt{\frac{1}{N-1}\left(\sum_{i=1}^{N} x_i^2 - N\bar{x}^2\right)}$$
$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

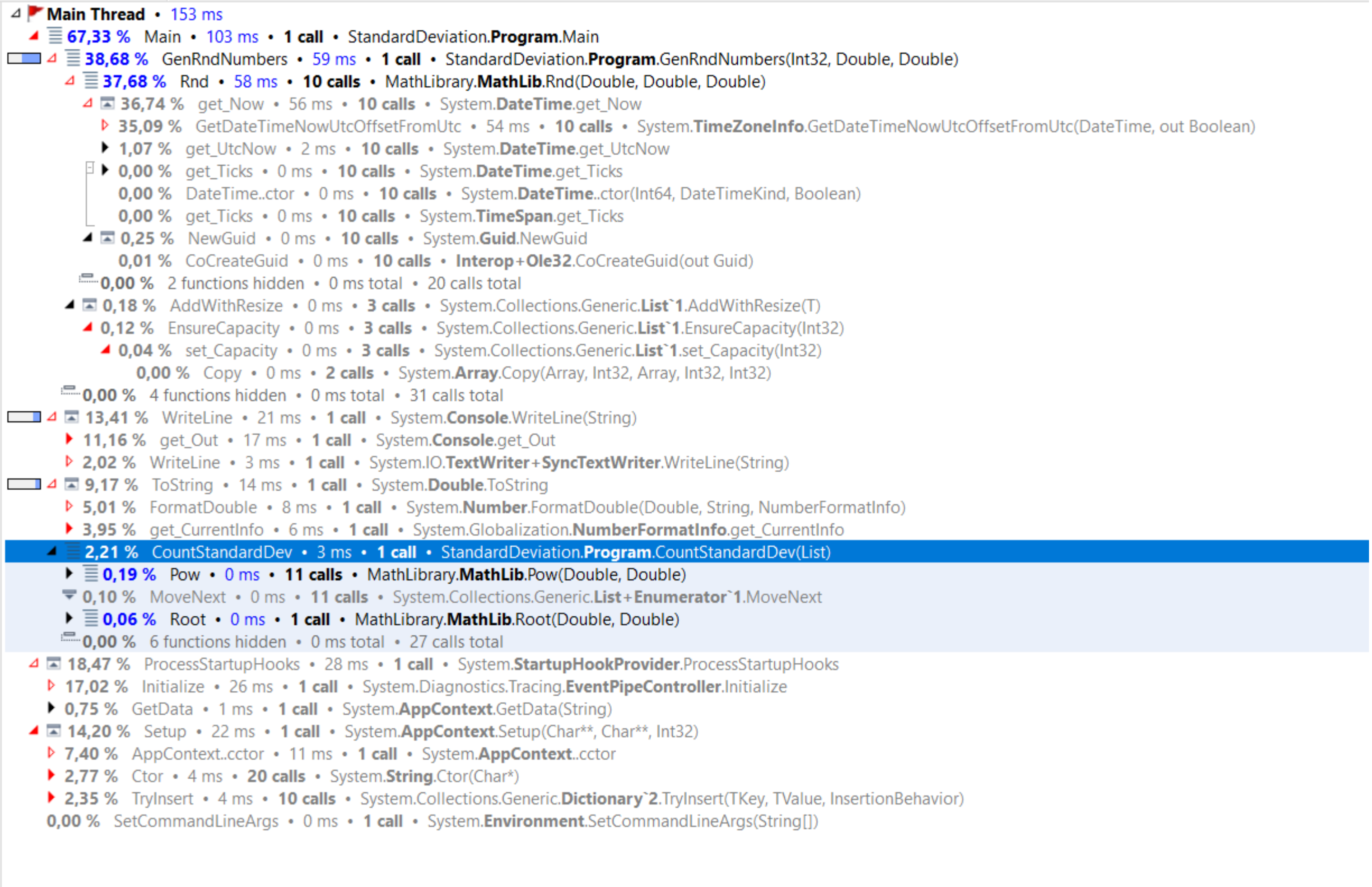
Example of running the program:
`./stddev < data.txt`

Profile this program with inputs of 10, 100 and 1000 numerical values. Submit a protocol containing the profiler output and a brief summary - where the program spends the most time and indicate and where focus on code optimization.

2 Tools

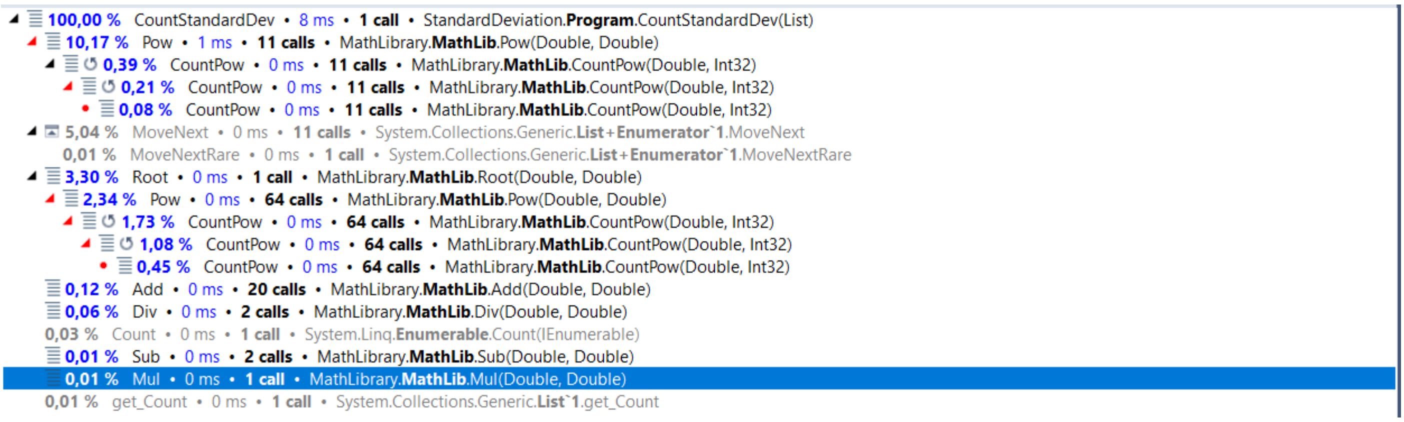
Written in `C#` in Visual Studio 2019 Community. Profiling was made by Jetbrains DotTrace profiling tool.

3 Results of Profiling



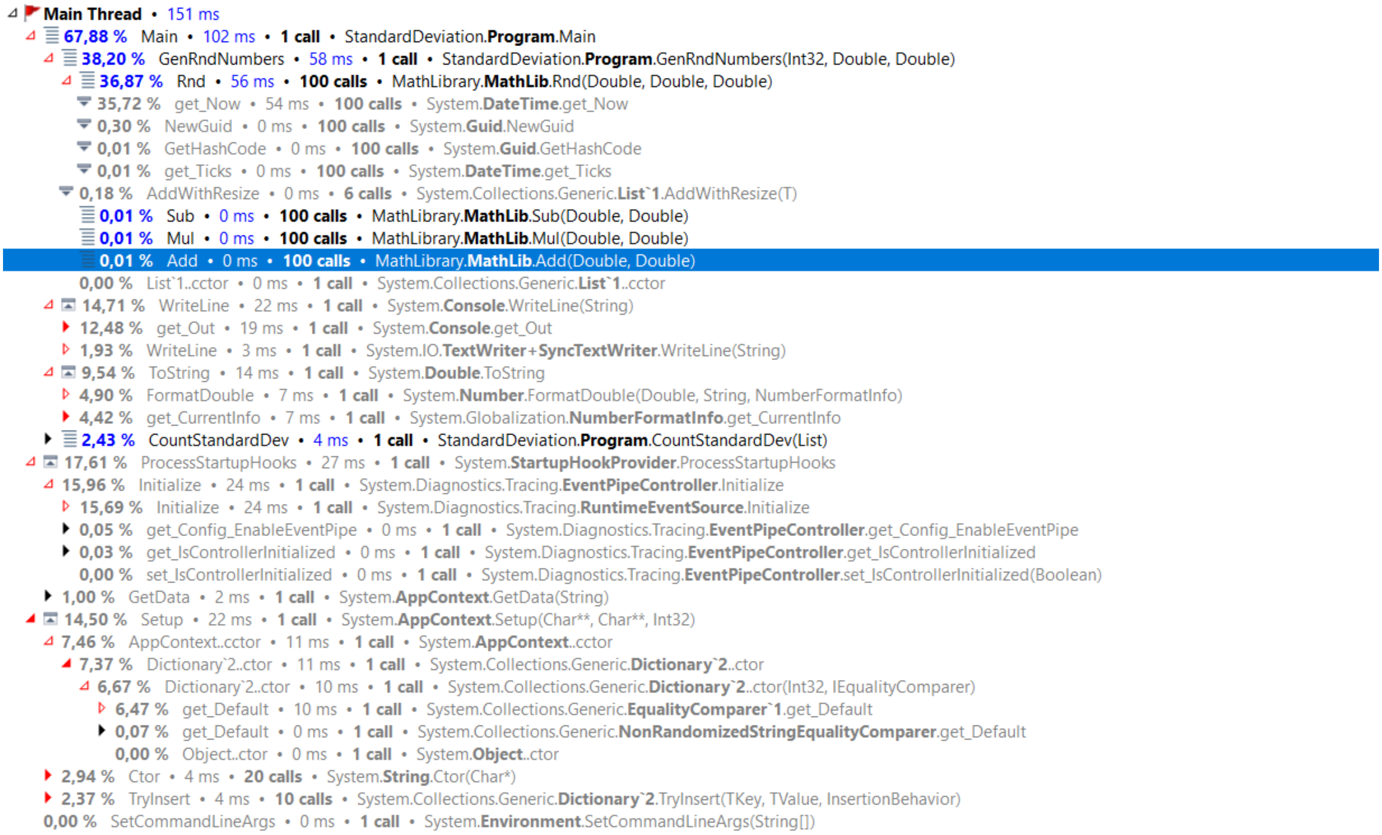
```
Main Thread • 153 ms
  67,33 % Main • 103 ms • 1 call • StandardDeviation.Program.Main
    38,68 % GenRndNumbers • 59 ms • 1 call • StandardDeviation.Program.GenRndNumbers(Int32, Double, Double)
      37,68 % Rnd • 58 ms • 10 calls • MathLibrary.MathLib.Rnd(Double, Double, Double)
        36,74 % get_Now • 56 ms • 10 calls • System.DateTime.get_Now
          35,09 % GetDateTimeNowUtcOffsetFromUtc • 54 ms • 10 calls • System.TimeZoneInfo.GetDateTimeNowUtcOffsetFromUtc(DateTime, out Boolean)
          1,07 % get_UtcNow • 2 ms • 10 calls • System.DateTime.get_UtcNow
          0,00 % get_Ticks • 0 ms • 10 calls • System.DateTime.get_Ticks
          0,00 % DateTime..ctor • 0 ms • 10 calls • System.DateTime..ctor(Int64, DateTimeKind, Boolean)
          0,00 % get_Ticks • 0 ms • 10 calls • System.TimeSpan.get_Ticks
        0,25 % NewGuid • 0 ms • 10 calls • System.Guid.NewGuid
          0,01 % CoCreateGuid • 0 ms • 10 calls • Interop+Ole32.CoCreateGuid(out Guid)
        0,00 % 2 functions hidden • 0 ms total • 20 calls total
      0,18 % AddWithResize • 0 ms • 3 calls • System.Collections.Generic.List`1.AddWithResize(T)
        0,12 % EnsureCapacity • 0 ms • 3 calls • System.Collections.Generic.List`1.EnsureCapacity(Int32)
          0,04 % set_Capacity • 0 ms • 3 calls • System.Collections.Generic.List`1.set_Capacity(Int32)
            0,00 % Copy • 0 ms • 2 calls • System.Array.Copy(Array, Int32, Array, Int32, Int32)
      0,00 % 4 functions hidden • 0 ms total • 31 calls total
    13,41 % WriteLine • 21 ms • 1 call • System.Console.WriteLine(String)
      11,16 % get_Out • 17 ms • 1 call • System.Console.get_Out
      2,02 % WriteLine • 3 ms • 1 call • System.IO.TextWriter+SyncTextWriter.WriteLine(String)
    9,17 % ToString • 14 ms • 1 call • System.Double.ToString
      5,01 % FormatDouble • 8 ms • 1 call • System.Number.FormatDouble(Double, String, NumberFormatInfo)
      3,95 % get_CurrentInfo • 6 ms • 1 call • System.Globalization.NumberFormatInfo.get_CurrentInfo
    2,21 % CountStandardDev • 3 ms • 1 call • StandardDeviation.Program.CountStandardDev(List)
      0,19 % Pow • 0 ms • 11 calls • MathLibrary.MathLib.Pow(Double, Double)
      0,10 % MoveNext • 0 ms • 11 calls • System.Collections.Generic.List+Enumerator`1.MoveNext
      0,06 % Root • 0 ms • 1 call • MathLibrary.MathLib.Root(Double, Double)
      0,00 % 6 functions hidden • 0 ms total • 27 calls total
  18,47 % ProcessStartupHooks • 28 ms • 1 call • System.StartupHookProvider.ProcessStartupHooks
    17,02 % Initialize • 26 ms • 1 call • System.Diagnostics.Tracing.EventPipeController.Initialize
    0,75 % GetData • 1 ms • 1 call • System.AppContext.GetData(String)
  14,20 % Setup • 22 ms • 1 call • System.AppContext.Setup(Char**, Char**, Int32)
    7,40 % AppContext..cctor • 11 ms • 1 call • System.AppContext..cctor
    2,77 % Ctor • 4 ms • 20 calls • System.String.Ctor(Char*)
    2,35 % TryInsert • 4 ms • 10 calls • System.Collections.Generic.Dictionary`2.TryInsert(TKey, TValue, InsertionBehavior)
  0,00 % SetCommandLineArgs • 0 ms • 1 call • System.Environment.SetCommandLineArgs(String[])
```

Results of profiling with 10 values.



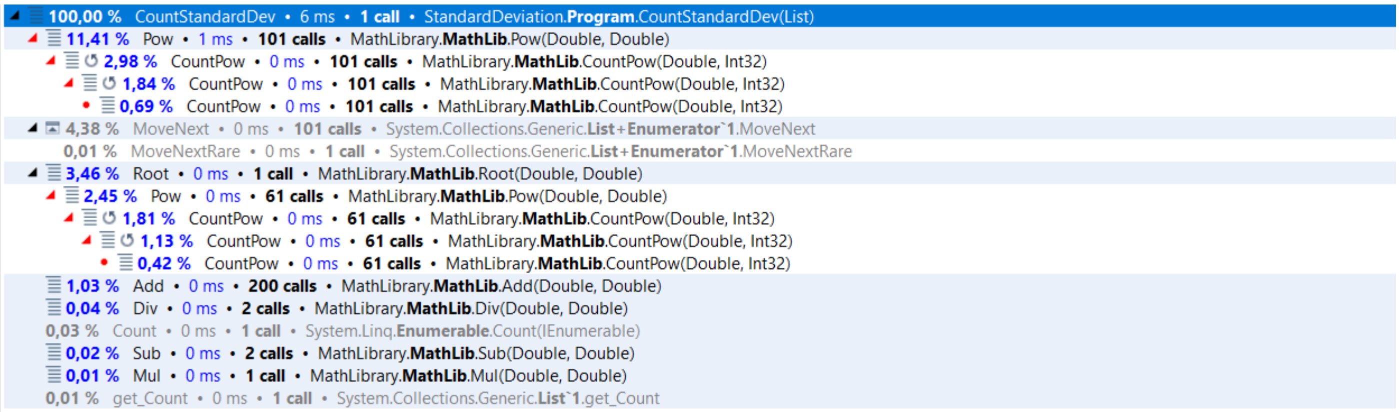
```
100,00 %  CountStandardDev • 8 ms • 1 call • StandardDeviation.Program.CountStandardDev(List)
  10,17 %  Pow • 1 ms • 11 calls • MathLibrary.MathLib.Pow(Double, Double)
    0,39 %  CountPow • 0 ms • 11 calls • MathLibrary.MathLib.CountPow(Double, Int32)
      0,21 %  CountPow • 0 ms • 11 calls • MathLibrary.MathLib.CountPow(Double, Int32)
        0,08 %  CountPow • 0 ms • 11 calls • MathLibrary.MathLib.CountPow(Double, Int32)
  5,04 %  MoveNext • 0 ms • 11 calls • System.Collections.Generic.List+Enumerator`1.MoveNext
    0,01 %  MoveNextRare • 0 ms • 1 call • System.Collections.Generic.List+Enumerator`1.MoveNextRare
  3,30 %  Root • 0 ms • 1 call • MathLibrary.MathLib.Root(Double, Double)
    2,34 %  Pow • 0 ms • 64 calls • MathLibrary.MathLib.Pow(Double, Double)
      1,73 %  CountPow • 0 ms • 64 calls • MathLibrary.MathLib.CountPow(Double, Int32)
        1,08 %  CountPow • 0 ms • 64 calls • MathLibrary.MathLib.CountPow(Double, Int32)
          0,45 %  CountPow • 0 ms • 64 calls • MathLibrary.MathLib.CountPow(Double, Int32)
  0,12 %  Add • 0 ms • 20 calls • MathLibrary.MathLib.Add(Double, Double)
  0,06 %  Div • 0 ms • 2 calls • MathLibrary.MathLib.Div(Double, Double)
  0,03 %  Count • 0 ms • 1 call • System.Linq.Enumerable.Count(IEnumerable)
  0,01 %  Sub • 0 ms • 2 calls • MathLibrary.MathLib.Sub(Double, Double)
  0,01 %  Mul • 0 ms • 1 call • MathLibrary.MathLib.Mul(Double, Double)
  0,01 %  get_Count • 0 ms • 1 call • System.Collections.Generic.List`1.get_Count
```

Results of profiling with 10 values, detail of `CountStandartDevCountStandartDev` function.



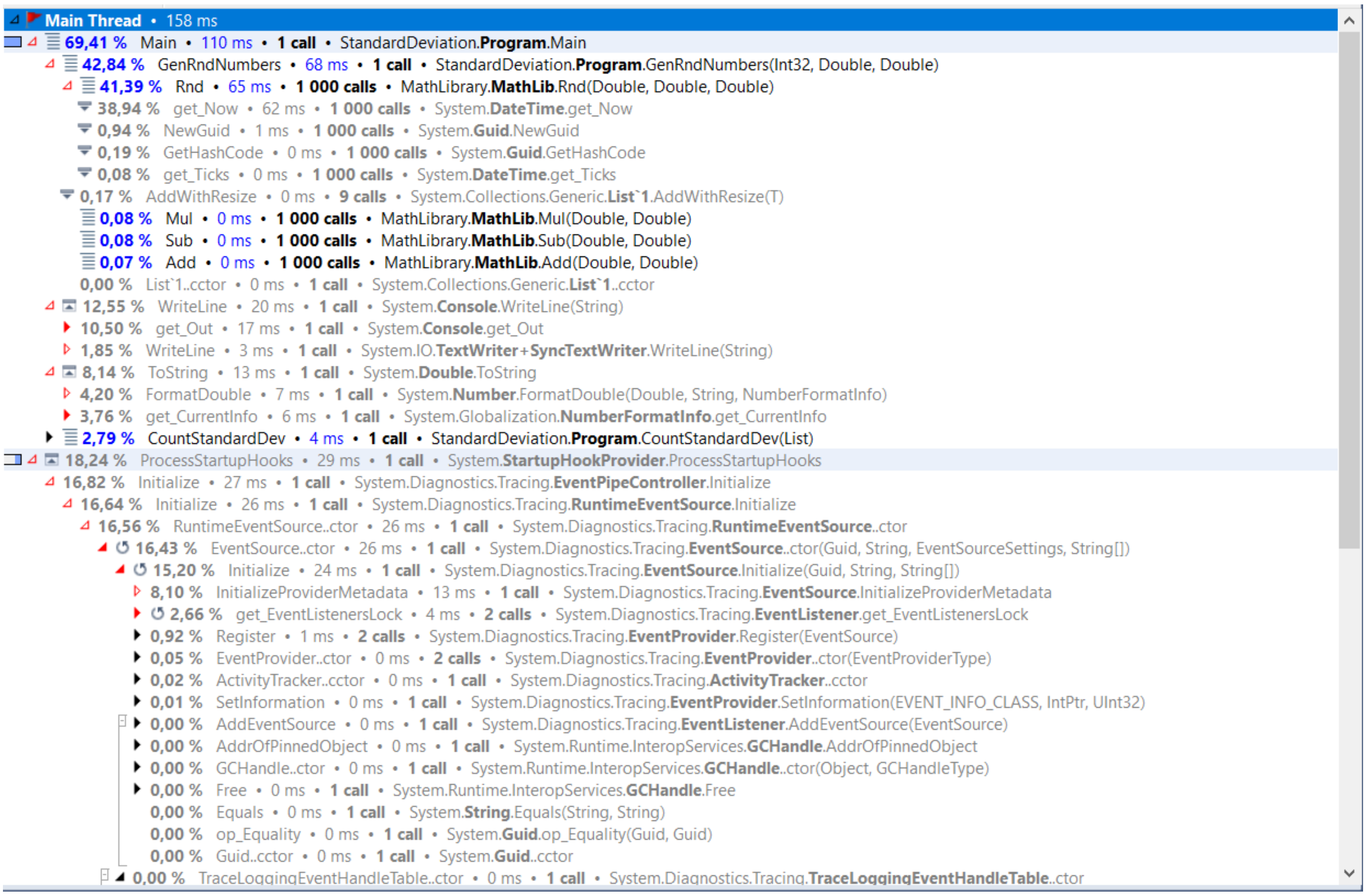
```
Main Thread • 151 ms
  67,88 %  Main • 102 ms • 1 call • StandardDeviation.Program.Main
    38,20 %  GenRndNumbers • 58 ms • 1 call • StandardDeviation.Program.GenRndNumbers(Int32, Double, Double)
      36,87 %  Rnd • 56 ms • 100 calls • MathLibrary.MathLib.Rnd(Double, Double, Double)
        35,72 %  get_Now • 54 ms • 100 calls • System.DateTime.get_Now
        0,30 %  NewGuid • 0 ms • 100 calls • System.Guid.NewGuid
        0,01 %  GetHashCode • 0 ms • 100 calls • System.Guid.GetHashCode
        0,01 %  get_Ticks • 0 ms • 100 calls • System.DateTime.get_Ticks
      0,18 %  AddWithResize • 0 ms • 6 calls • System.Collections.Generic.List`1.AddWithResize(T)
        0,01 %  Sub • 0 ms • 100 calls • MathLibrary.MathLib.Sub(Double, Double)
        0,01 %  Mul • 0 ms • 100 calls • MathLibrary.MathLib.Mul(Double, Double)
        0,01 %  Add • 0 ms • 100 calls • MathLibrary.MathLib.Add(Double, Double)
      0,00 %  List`1..cctor • 0 ms • 1 call • System.Collections.Generic.List`1..cctor
    14,71 %  WriteLine • 22 ms • 1 call • System.Console.WriteLine(String)
      12,48 %  get_Out • 19 ms • 1 call • System.Console.get_Out
      1,93 %  WriteLine • 3 ms • 1 call • System.IO.TextWriter+SyncTextWriter.WriteLine(String)
    9,54 %  ToString • 14 ms • 1 call • System.Double.ToString
      4,90 %  FormatDouble • 7 ms • 1 call • System.Number.FormatDouble(Double, String, NumberFormatInfo)
      4,42 %  get_CurrentInfo • 7 ms • 1 call • System.Globalization.NumberFormatInfo.get_CurrentInfo
    2,43 %  CountStandardDev • 4 ms • 1 call • StandardDeviation.Program.CountStandardDev(List)
  17,61 %  ProcessStartupHooks • 27 ms • 1 call • System.StartupHookProvider.ProcessStartupHooks
    15,96 %  Initialize • 24 ms • 1 call • System.Diagnostics.Tracing.EventPipeController.Initialize
      15,69 %  Initialize • 24 ms • 1 call • System.Diagnostics.Tracing.RuntimeEventSource.Initialize
      0,05 %  get_Config_EnableEventPipe • 0 ms • 1 call • System.Diagnostics.Tracing.EventPipeController.get_Config_EnableEventPipe
      0,03 %  get_IsControllerInitialized • 0 ms • 1 call • System.Diagnostics.Tracing.EventPipeController.get_IsControllerInitialized
      0,00 %  set_IsControllerInitialized • 0 ms • 1 call • System.Diagnostics.Tracing.EventPipeController.set_IsControllerInitialized(Boolean)
    1,00 %  GetData • 2 ms • 1 call • System.AppContext.GetData(String)
  14,50 %  Setup • 22 ms • 1 call • System.AppContext.Setup(Char**, Char**, Int32)
    7,46 %  AppContext..cctor • 11 ms • 1 call • System.AppContext..cctor
      7,37 %  Dictionary`2..ctor • 11 ms • 1 call • System.Collections.Generic.Dictionary`2..ctor
        6,67 %  Dictionary`2..ctor • 10 ms • 1 call • System.Collections.Generic.Dictionary`2..ctor(Int32, IEqualityComparer)
          6,47 %  get_Default • 10 ms • 1 call • System.Collections.Generic.EqualityComparer`1.get_Default
          0,07 %  get_Default • 0 ms • 1 call • System.Collections.Generic.NonRandomizedStringEqualityComparer.get_Default
          0,00 %  Object..ctor • 0 ms • 1 call • System.Object..ctor
    2,94 %  Ctor • 4 ms • 20 calls • System.String.Ctor(Char*)
    2,37 %  TryInsert • 4 ms • 10 calls • System.Collections.Generic.Dictionary`2.TryInsert(TKey, TValue, InsertionBehavior)
    0,00 %  SetCommandLineArgs • 0 ms • 1 call • System.Environment.SetCommandLineArgs(String[])
```

Results of profiling with 100 values.



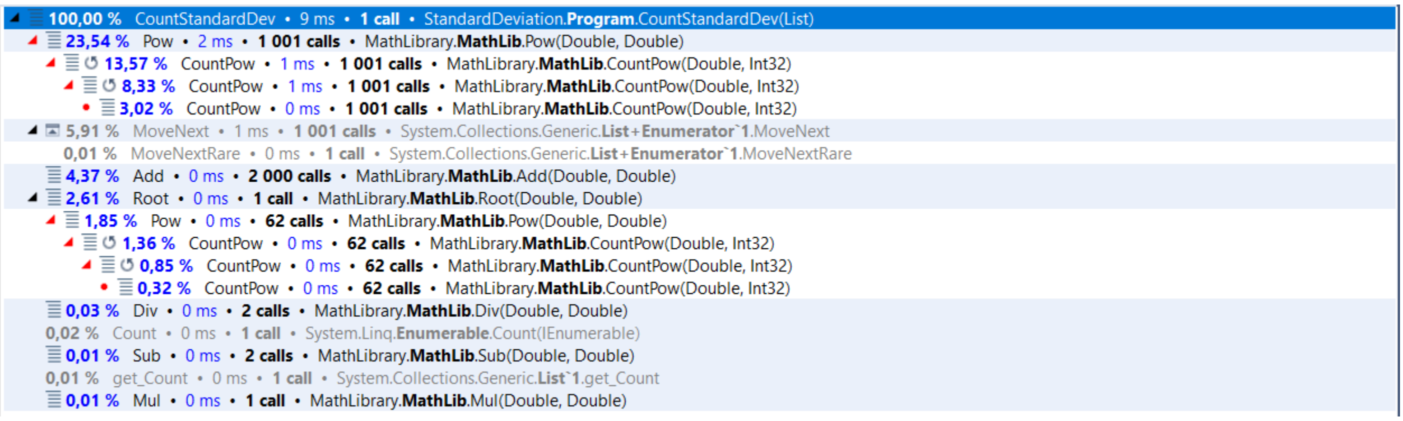
```
100,00 % CountStandardDev • 6 ms • 1 call • StandardDeviation.Program.CountStandardDev(List)
  11,41 % Pow • 1 ms • 101 calls • MathLibrary.MathLib.Pow(Double, Double)
    2,98 % CountPow • 0 ms • 101 calls • MathLibrary.MathLib.CountPow(Double, Int32)
      1,84 % CountPow • 0 ms • 101 calls • MathLibrary.MathLib.CountPow(Double, Int32)
        0,69 % CountPow • 0 ms • 101 calls • MathLibrary.MathLib.CountPow(Double, Int32)
  4,38 % MoveNext • 0 ms • 101 calls • System.Collections.Generic.List+Enumerator`1.MoveNext
    0,01 % MoveNextRare • 0 ms • 1 call • System.Collections.Generic.List+Enumerator`1.MoveNextRare
  3,46 % Root • 0 ms • 1 call • MathLibrary.MathLib.Root(Double, Double)
    2,45 % Pow • 0 ms • 61 calls • MathLibrary.MathLib.Pow(Double, Double)
      1,81 % CountPow • 0 ms • 61 calls • MathLibrary.MathLib.CountPow(Double, Int32)
        1,13 % CountPow • 0 ms • 61 calls • MathLibrary.MathLib.CountPow(Double, Int32)
          0,42 % CountPow • 0 ms • 61 calls • MathLibrary.MathLib.CountPow(Double, Int32)
  1,03 % Add • 0 ms • 200 calls • MathLibrary.MathLib.Add(Double, Double)
  0,04 % Div • 0 ms • 2 calls • MathLibrary.MathLib.Div(Double, Double)
  0,03 % Count • 0 ms • 1 call • System.Linq.Enumerable.Count(IEnumerable)
  0,02 % Sub • 0 ms • 2 calls • MathLibrary.MathLib.Sub(Double, Double)
  0,01 % Mul • 0 ms • 1 call • MathLibrary.MathLib.Mul(Double, Double)
  0,01 % get_Count • 0 ms • 1 call • System.Collections.Generic.List`1.get_Count
```

Results of profiling with 100 values, detail of `CountStandartDevCountStandartDev` function.



```
Main Thread • 158 ms
  69,41 % Main • 110 ms • 1 call • StandardDeviation.Program.Main
    42,84 % GenRndNumbers • 68 ms • 1 call • StandardDeviation.Program.GenRndNumbers(Int32, Double, Double)
      41,39 % Rnd • 65 ms • 1 000 calls • MathLibrary.MathLib.Rnd(Double, Double, Double)
        38,94 % get_Now • 62 ms • 1 000 calls • System.DateTime.get_Now
        0,94 % NewGuid • 1 ms • 1 000 calls • System.Guid.NewGuid
        0,19 % GetHashCode • 0 ms • 1 000 calls • System.Guid.GetHashCode
        0,08 % get_Ticks • 0 ms • 1 000 calls • System.DateTime.get_Ticks
      0,17 % AddWithResize • 0 ms • 9 calls • System.Collections.Generic.List`1.AddWithResize(T)
        0,08 % Mul • 0 ms • 1 000 calls • MathLibrary.MathLib.Mul(Double, Double)
        0,08 % Sub • 0 ms • 1 000 calls • MathLibrary.MathLib.Sub(Double, Double)
        0,07 % Add • 0 ms • 1 000 calls • MathLibrary.MathLib.Add(Double, Double)
        0,00 % List`1..cctor • 0 ms • 1 call • System.Collections.Generic.List`1..cctor
    12,55 % WriteLine • 20 ms • 1 call • System.Console.WriteLine(String)
      10,50 % get_Out • 17 ms • 1 call • System.Console.get_Out
      1,85 % WriteLine • 3 ms • 1 call • System.IO.TextWriter+SyncTextWriter.WriteLine(String)
    8,14 % ToString • 13 ms • 1 call • System.Double.ToString
      4,20 % FormatDouble • 7 ms • 1 call • System.Number.FormatDouble(Double, String, NumberFormatInfo)
      3,76 % get_CurrentInfo • 6 ms • 1 call • System.Globalization.NumberFormatInfo.get_CurrentInfo
    2,79 % CountStandardDev • 4 ms • 1 call • StandardDeviation.Program.CountStandardDev(List)
  18,24 % ProcessStartupHooks • 29 ms • 1 call • System.StartupHookProvider.ProcessStartupHooks
    16,82 % Initialize • 27 ms • 1 call • System.Diagnostics.Tracing.EventPipeController.Initialize
      16,64 % Initialize • 26 ms • 1 call • System.Diagnostics.Tracing.RuntimeEventSource.Initialize
        16,56 % RuntimeEventSource..ctor • 26 ms • 1 call • System.Diagnostics.Tracing.RuntimeEventSource..ctor
          16,43 % EventSource..ctor • 26 ms • 1 call • System.Diagnostics.Tracing.EventSource..ctor(Guid, String, EventSourceSettings, String[])
            15,20 % Initialize • 24 ms • 1 call • System.Diagnostics.Tracing.EventSource.Initialize(Guid, String, String[])
              8,10 % InitializeProviderMetadata • 13 ms • 1 call • System.Diagnostics.Tracing.EventSource.InitializeProviderMetadata
              2,66 % get_EventListenersLock • 4 ms • 2 calls • System.Diagnostics.Tracing.EventListener.get_EventListenersLock
              0,92 % Register • 1 ms • 2 calls • System.Diagnostics.Tracing.EventProvider.Register(EventSource)
              0,05 % EventProvider..ctor • 0 ms • 2 calls • System.Diagnostics.Tracing.EventProvider..ctor(EventProviderType)
              0,02 % ActivityTracker..cctor • 0 ms • 1 call • System.Diagnostics.Tracing.ActivityTracker..cctor
              0,01 % SetInformation • 0 ms • 1 call • System.Diagnostics.Tracing.EventProvider.SetInformation(EVENT_INFO_CLASS, IntPtr, UInt32)
              0,00 % AddEventSource • 0 ms • 1 call • System.Diagnostics.Tracing.EventListener.AddEventSource(EventSource)
              0,00 % AddrOfPinnedObject • 0 ms • 1 call • System.Runtime.InteropServices.GCHandle.AddrOfPinnedObject
              0,00 % GCHandle..ctor • 0 ms • 1 call • System.Runtime.InteropServices.GCHandle..ctor(Object, GCHandleType)
              0,00 % Free • 0 ms • 1 call • System.Runtime.InteropServices.GCHandle.Free
              0,00 % Equals • 0 ms • 1 call • System.String.Equals(String, String)
              0,00 % op_Equality • 0 ms • 1 call • System.Guid.op_Equality(Guid, Guid)
              0,00 % Guid..cctor • 0 ms • 1 call • System.Guid..cctor
            0,00 % TraceLoggingEventHandleTable..ctor • 0 ms • 1 call • System.Diagnostics.Tracing.TraceLoggingEventHandleTable..ctor
```

Results of profiling with 1000 values.



```
◢ 100,00 %  CountStandardDev • 9 ms • 1 call • StandardDeviation.Program.CountStandardDev(List)
  ◢ 23,54 %  Pow • 2 ms • 1 001 calls • MathLibrary.MathLib.Pow(Double, Double)
    ◢ 13,57 %  CountPow • 1 ms • 1 001 calls • MathLibrary.MathLib.CountPow(Double, Int32)
      ◢ 8,33 %  CountPow • 1 ms • 1 001 calls • MathLibrary.MathLib.CountPow(Double, Int32)
        • 3,02 %  CountPow • 0 ms • 1 001 calls • MathLibrary.MathLib.CountPow(Double, Int32)
  ◢ 5,91 %  MoveNext • 1 ms • 1 001 calls • System.Collections.Generic.List+Enumerator`1.MoveNext
      0,01 %  MoveNextRare • 0 ms • 1 call • System.Collections.Generic.List+Enumerator`1.MoveNextRare
    4,37 %  Add • 0 ms • 2 000 calls • MathLibrary.MathLib.Add(Double, Double)
  ◢ 2,61 %  Root • 0 ms • 1 call • MathLibrary.MathLib.Root(Double, Double)
    ◢ 1,85 %  Pow • 0 ms • 62 calls • MathLibrary.MathLib.Pow(Double, Double)
      ◢ 1,36 %  CountPow • 0 ms • 62 calls • MathLibrary.MathLib.CountPow(Double, Int32)
        ◢ 0,85 %  CountPow • 0 ms • 62 calls • MathLibrary.MathLib.CountPow(Double, Int32)
          • 0,32 %  CountPow • 0 ms • 62 calls • MathLibrary.MathLib.CountPow(Double, Int32)
    0,03 %  Div • 0 ms • 2 calls • MathLibrary.MathLib.Div(Double, Double)
    0,02 %  Count • 0 ms • 1 call • System.Linq.Enumerable.Count(IEnumerable)
    0,01 %  Sub • 0 ms • 2 calls • MathLibrary.MathLib.Sub(Double, Double)
    0,01 %  get_Count • 0 ms • 1 call • System.Collections.Generic.List`1.get_Count
    0,01 %  Mul • 0 ms • 1 call • MathLibrary.MathLib.Mul(Double, Double)
```

Results of profiling with 1000 values, detail of `CountStandartDevCountStandartDev` function.

From these results can by inferred, that most timeconsuming function is `MathLibrary.MathLib.Rnd`, but it was only used for testing, so its not important for optimalization. From actualy used functions `Pow` is called most times and `Root` takes most of time per call, so these function should by considered for optimalization as the first one.