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Faculty Summit
10
YEAR ANNIVERSARY

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Transformational Improvement in Healthcare

Using Smartphones for Medical Imaging

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Motivation

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- According to the World Health Organization, over 75% of the world population has no access to medical imaging:
  - Equipment that's available is too hard to use or in disrepair,
  - Equipment is too expensive to obtain,
  - Lack of trained people to use the equipment and interpret the results, and
  - For remote locations, equipment needs to be highly portable.
- Modern medical science is enabled by medical imaging:
  - Used for diagnostics
  - Used for treatment

Solutions

Make it easy to use

- Typical medical ultrasound machines require special hardware to support them
  - Use standard equipment that people know how to use
- Typical ultrasound interfaces require technical expertise
  - Simplify the UI to minimize training and expertise
- Typical medical ultrasound machines are hard to move about
  - Make the equipment small, lightweight and able to run entirely on battery power for extended periods

Solutions

Make it inexpensive

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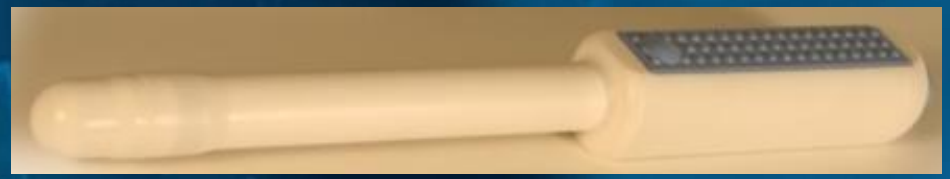
- Typical medical ultrasound machines cost $15,000 and up
  - Use commercially available USB-based ultrasound probes
  - Adapt them for use with smartphones



Solutions

Allow use of system by minimally trained people

- In poor and rural areas, there is a lack of trained people to use and interpret medical images
  - Allow the system to be used by untrained people
    - Portable
    - Easy to use
    - CONNECTED

Solutions

Make system extremely portable

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- Imaging system needs to be small and lightweight so it may be carried in a small bag or pocket
- Imaging system needs to run on battery power for several hours a day
- Imaging system needs to connect, wirelessly, to communication networks
  - All of these requirements are met by using a smartphone as the platform that supports the imaging system!

Application Areas

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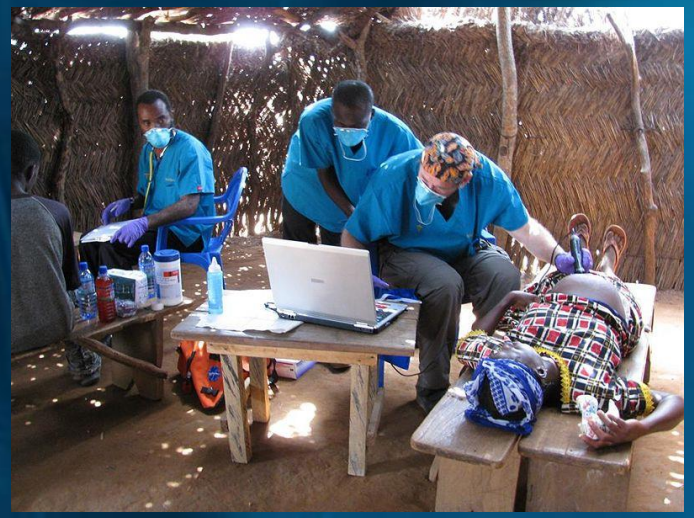
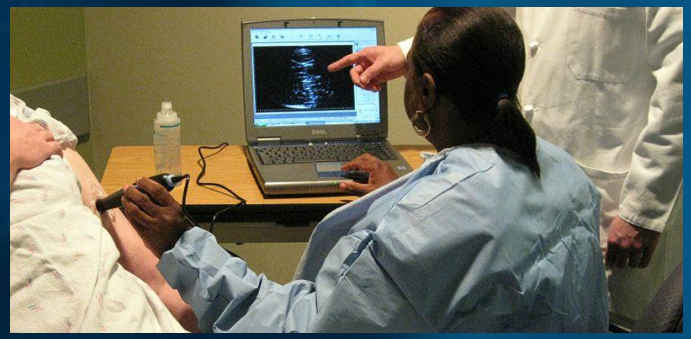
- Remote diagnostics and treatment in poor and developing countries
- First-responders (civilian and military)
- Bedside for starting IVs, PICC lines, bladder volume, etc.
- *Electronic stethoscope*
- Home monitoring
- Others





Smartphone as a Platform for Healthcare

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- Smartphone sales are increasing, whereas general mobile phone sales are declining – more than 13% of all new phones are smartphones and growing every year [Gartner, May 2009]
- UN reports that 60% of the world population use cell phones [March, 2009] – in 2002, less than 15% did
- By using a Smartphone as a healthcare platform, millions of people with little or no access to modern, primary heath care are now within reach of such care:

  “Health technologies are the backbone of all health systems. They are essential tools in solving health problems. Even the most simple health system cannot function without at least some of them.” [WHO Report 2003]

GSM Coverage

Data from Wireless Intelligence

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Smartphone as an Ultrasound Machine

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> "[G]lobally, diagnostic imaging services are still insufficiently available. There is a depressing lack of equipment.... It is estimated that some three-quarters of the world's population have no access to such services."
> [WHO Report 2003]

- Use a Windows Mobile smartphone with an available USB-host port and adapt FDA approved, CE Marking approved USB-based ultrasound probes to run on less power and a lower data rate
- Process all raw data on the smartphone to keep costs down and to allow for transmission of the data for remote viewing
- Use an open architecture to allow for customization of the application features, language, back-end integration, etc.

Ultrasound Machine Architecture

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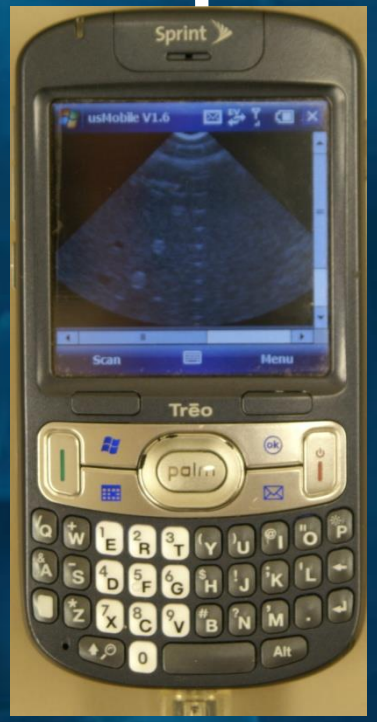
User GUI

Imaging API

USB High-Level API

USB Low-Level Driver



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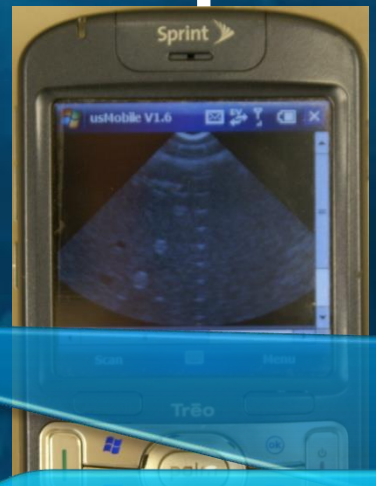


```
bmDrawImage
bmInitializeDisplay
bmSetDisplayZoom
bmSetTGC
bmTurnOffTGC
bmTurnOnTGC
ZeroLUT
CreateLUT
CreateSinTGC
SaveBSxml
LoadBSxml
```

```
usbFindProbes
usbInitializeProbes
usbHardwareDetected
usbNumberAttachedProbes
usbProbeButtonPressed
usbProbeSampleFrequency
usbSetCineBuffer
usbSetCineBuffers
usbWaitFrame
```

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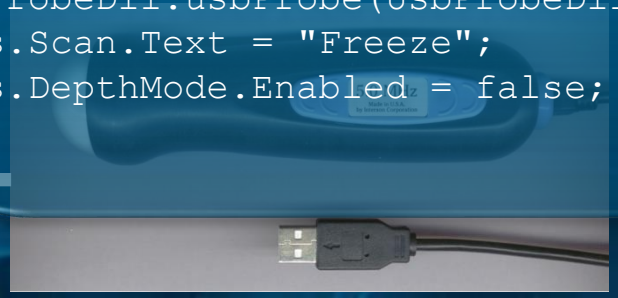
```
UsbProbeDll.usbProbeHandle(0, ref hProbe);
int curProbeID =
    UsbProbeDll.usbProbeID(UsbProbeDll.usbActiveProbe());
if (curProbeID != UsbProbeDll.usbProbeID(hProbe))
{
    // if not the same, we need to recalculate before imagin
    UsbProbeDll.usbSelectProbe(hProbe, 0);
    UsbProbeDll.usbSetCineBuffers(32);
    LiveImaging.CalculateDisplay(UsbProbeDll.usbActiveProbe());
    imaging.ClearBitmap();
}
frozen = false;
scanning = true;
imagingThread = new Thread(starter);
// when scanning, do not allow power down
imaging.PowerSave = false;
imagingThread.Start();
UsbProbeDll.usbSetCineBuffer(0);
UsbProbeDll.usbProbe(UsbProbeDll.RUN);
this.Scan.Text = "Freeze";
this.DepthMode.Enabled = false;
```



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```
private void ImageThread()
{
  while (true)
  {
    if (UsbProbeDll.usbWaitFrame() == 1)
    {
      FramesReceived++;
      try
      {
        hBitmap = imaging.DrawBmodeImage(false);
        theBitmap = Bitmap.FromHbitmap(hBitmap);
        if (theBitmap != null)
        {
          this.Invoke(this.delegateUpdateImageBitmap,
                      theBitmap);
        }
      }
    }
  }
}
```

Results of MSR Funded Research

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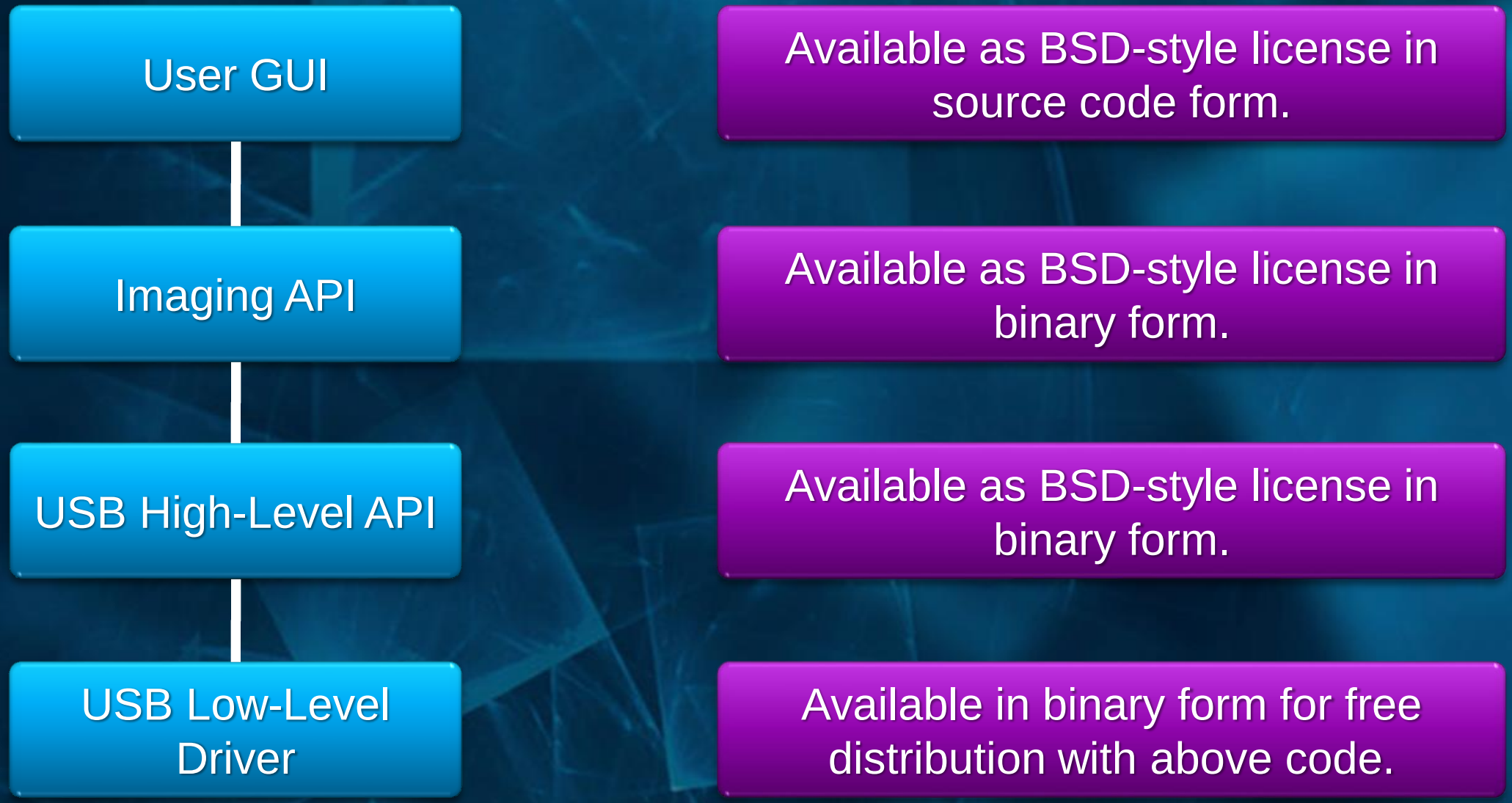

More Information and Code

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- Ultrasound SDK Web Page
  http://ultrasound.engineering.wustl.edu/index.php/Cell_Phone_SDK
- Source code project on SourceForge.net
  http://mobileus.sourceforge.net/
- Initial project supported by Microsoft Research grant from January 2008 – August 2009
- Additional funding obtained from Microsoft Research for deployment of some systems to patients with DMD for in-home use and testing: July 2009 – June 2010

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Live Ultrasound on a Smartphone

Palm Treo 800W Phone

Trimble Nomad

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