Robotic Remote Surgery: Application of ICTs for Craniotomy

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Outline

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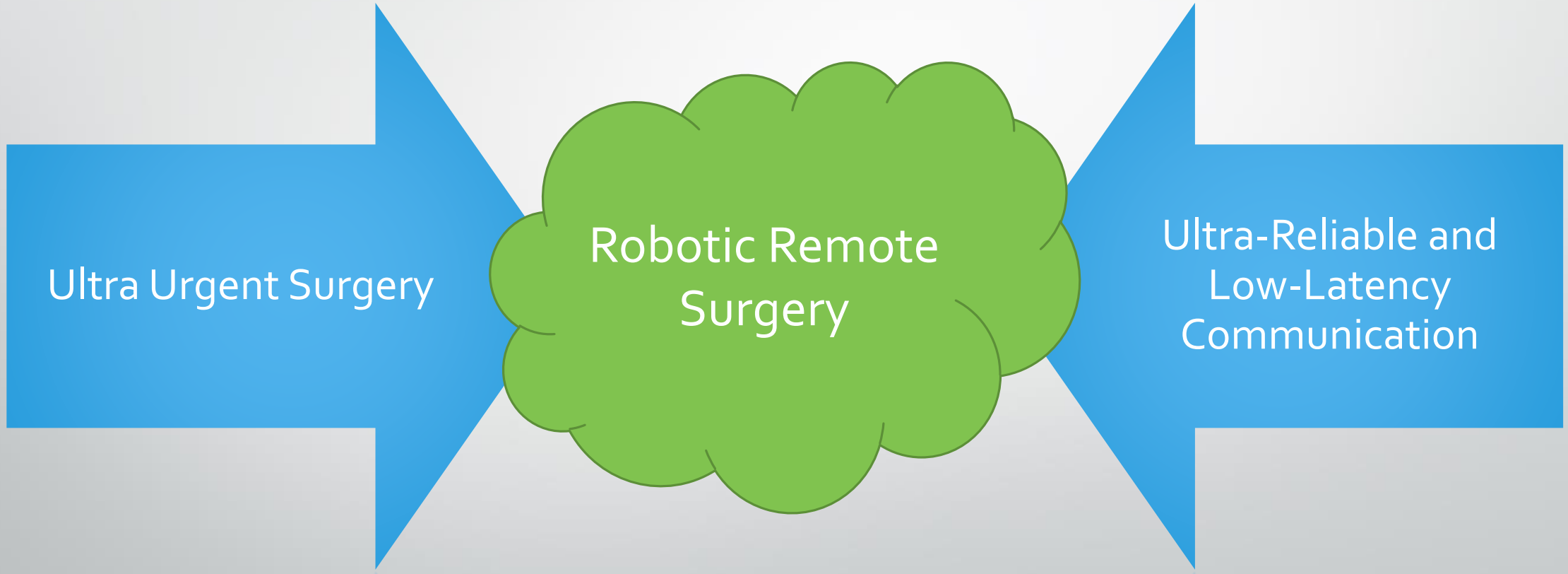
- Epidural Hematoma
- Architecture at a Glance
- Requirements
- Apparatus for Robotic Remote Surgery
- Human Head Phantom
- Wireless Communication Platform
- Conclusion

Motivation

Ultra Urgent Surgery

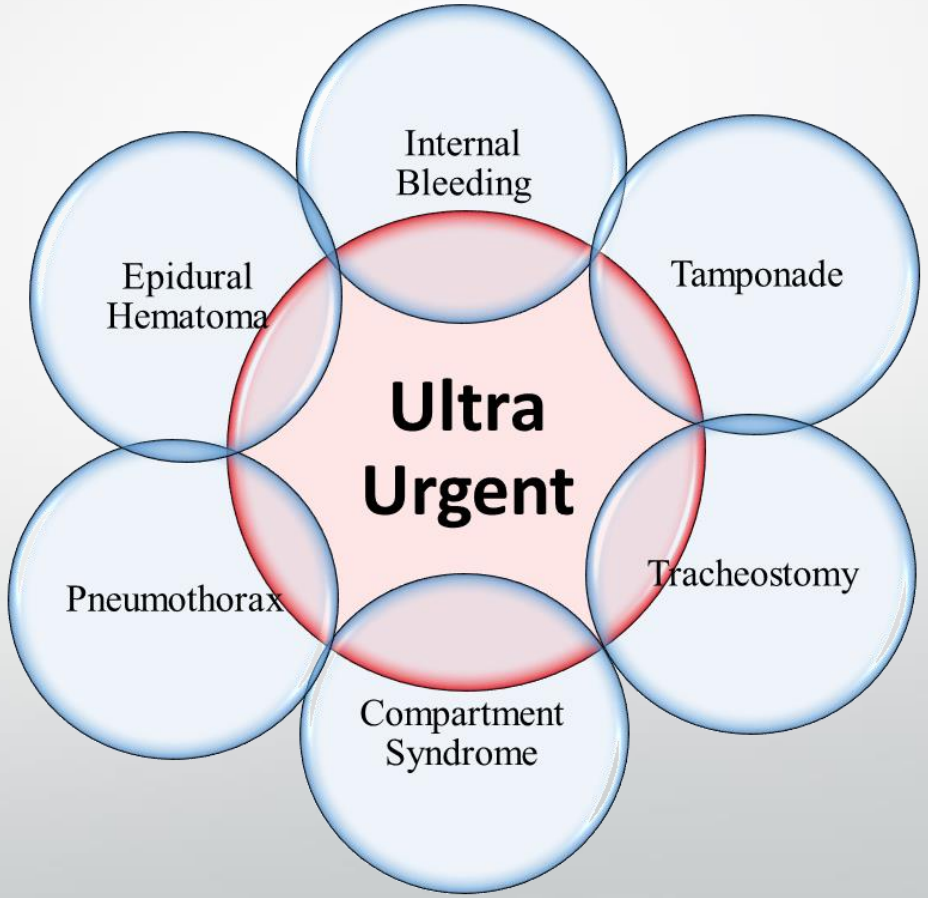
Ultra-Reliable and Low-Latency Communication

Motivation


Ultra Urgent Surgery
Robotic Remote Surgery
Ultra-Reliable and Low-Latency Communication

Motivation

Ultra Urgent Surgery



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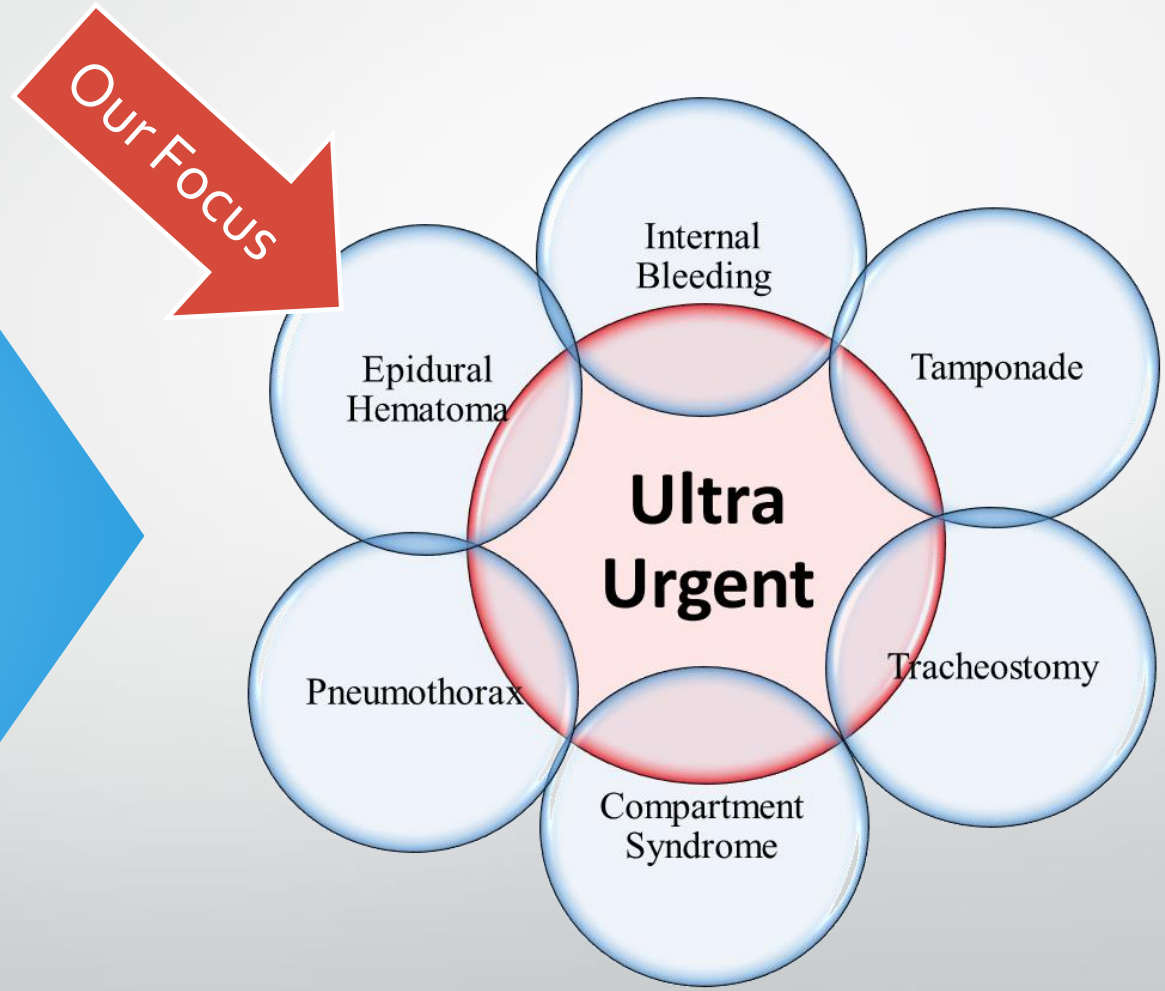


Epidural Hematoma

- Intracranial bleeding is an example of ultra-emergency surgery
  - Bleeding Inside the Brain

    Epidural Hematoma:

    bleeding between the tough outer membrane covering the brain (dura mater) and skull

    When head is hit in an accident, about 10% of patients suffer moderate to severe head injury

Example of Epidural Hematoma

Ref: Noor Private Radiology Clinic, Tehran, Iran

Immediate Action for Epidural Hematoma

To prevent death, the accumulated blood should be drained as soon as possible

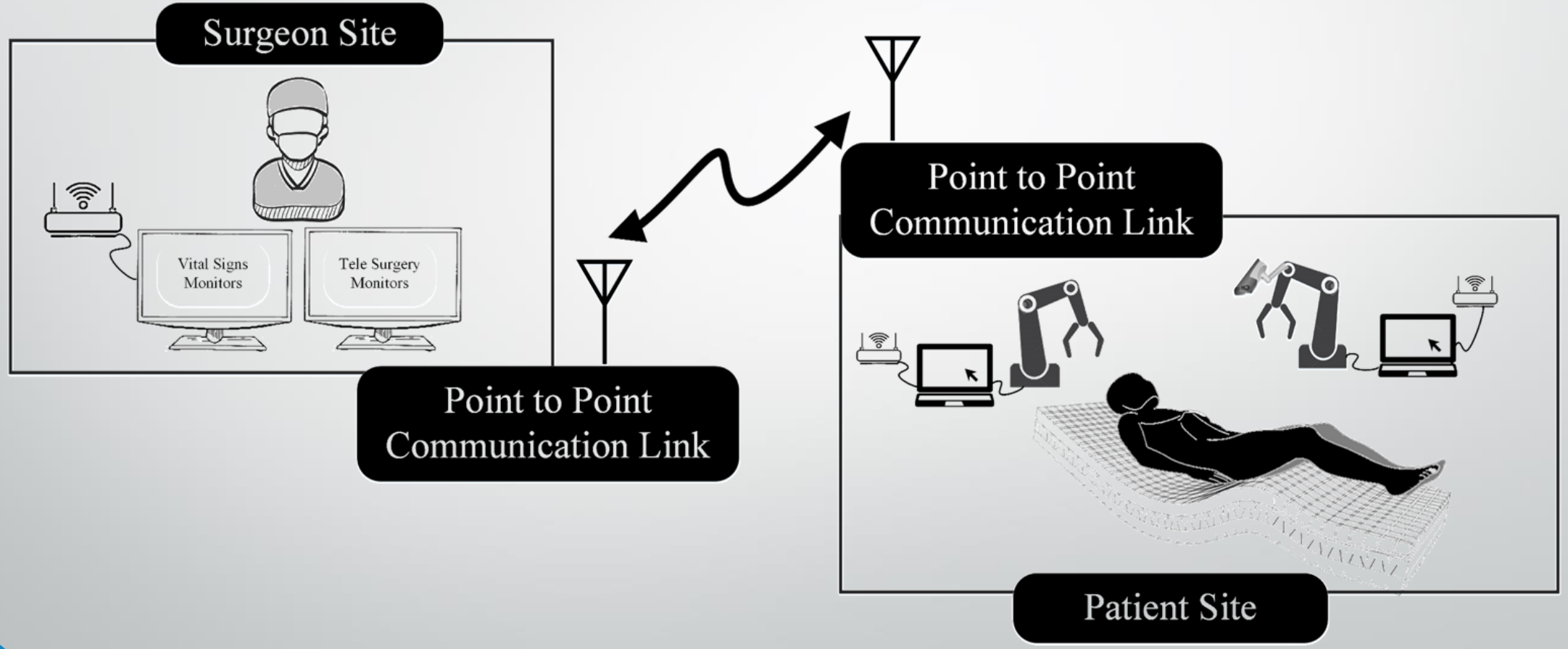
Craniotomy Surgery

- cutting and removing a bone flap from the skull

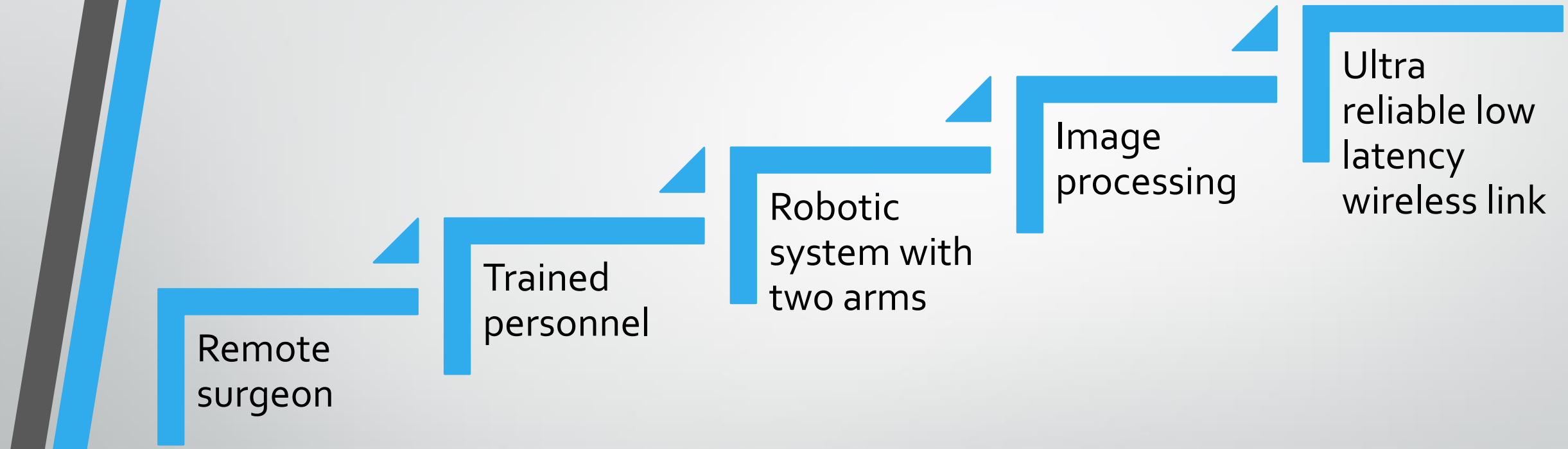
Steps:

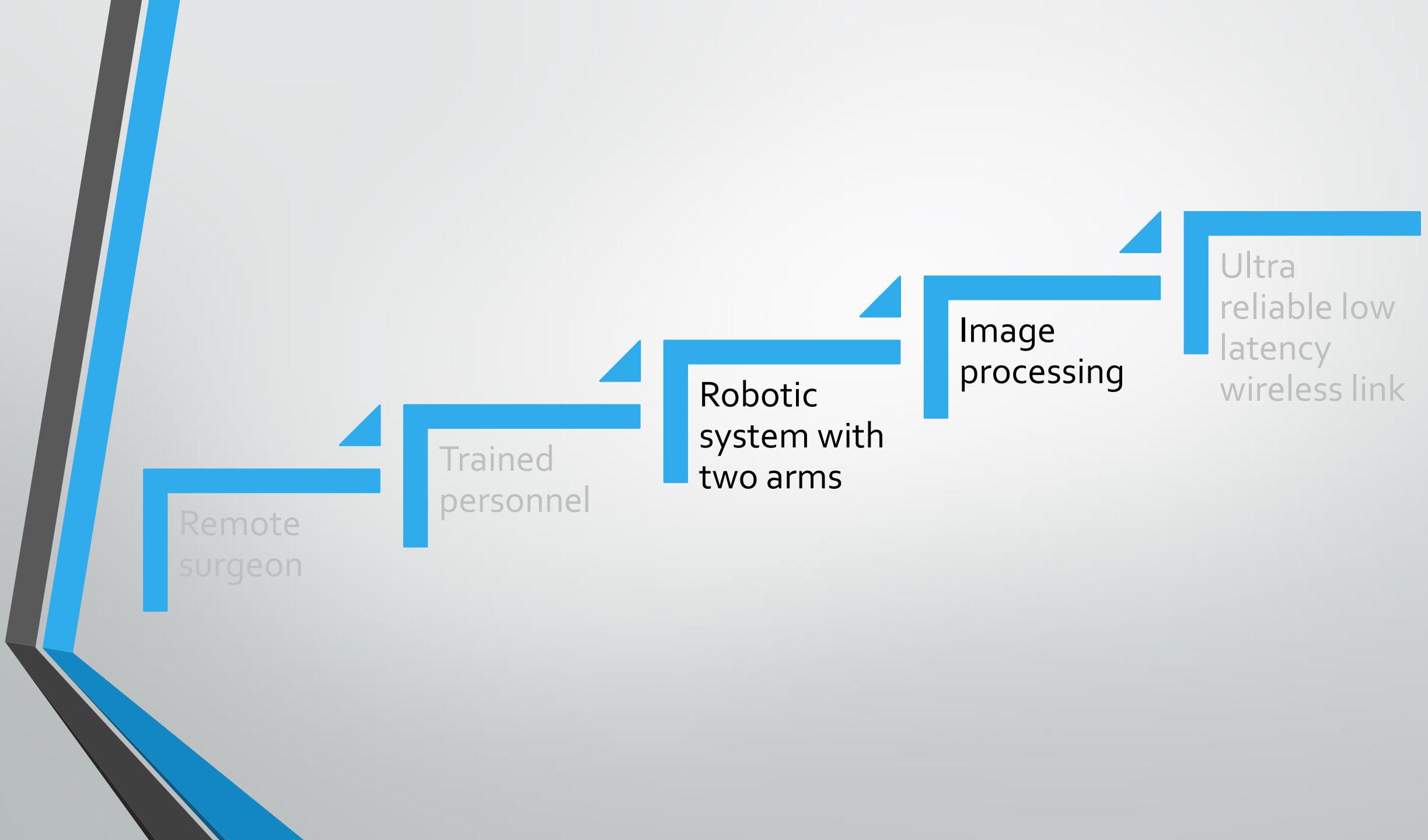
- Identify the affected region of the brain
- Cut the skin of that region
- Create 2 to 4 holes on the skull using surgery drill
- Remove the bone between the holes

Architecture at a Glance

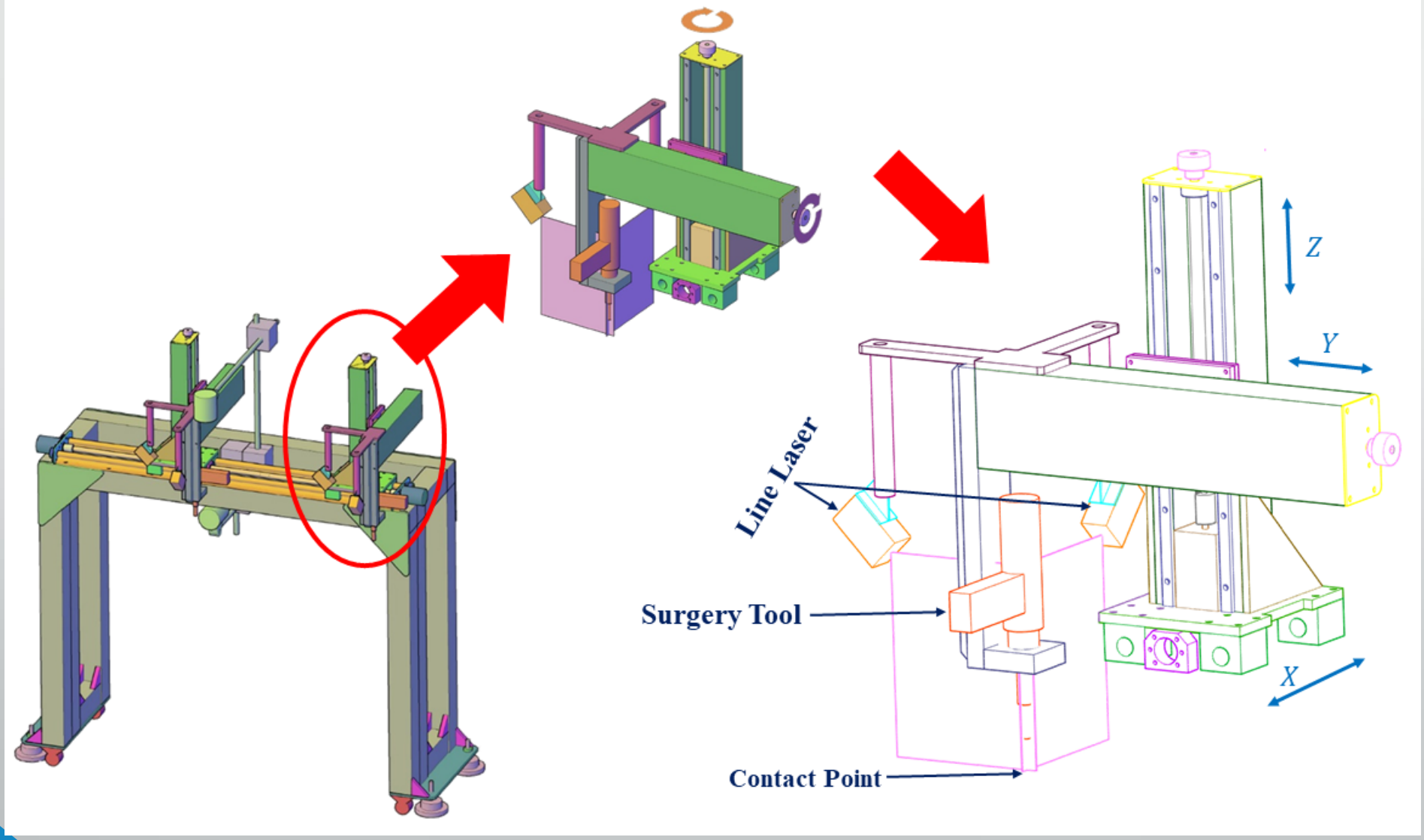


Requirements




Remote surgeon
Trained personnel
Robotic system with two arms
Image processing
Ultra reliable low latency wireless link

Robotic Remote Surgery Apparatus



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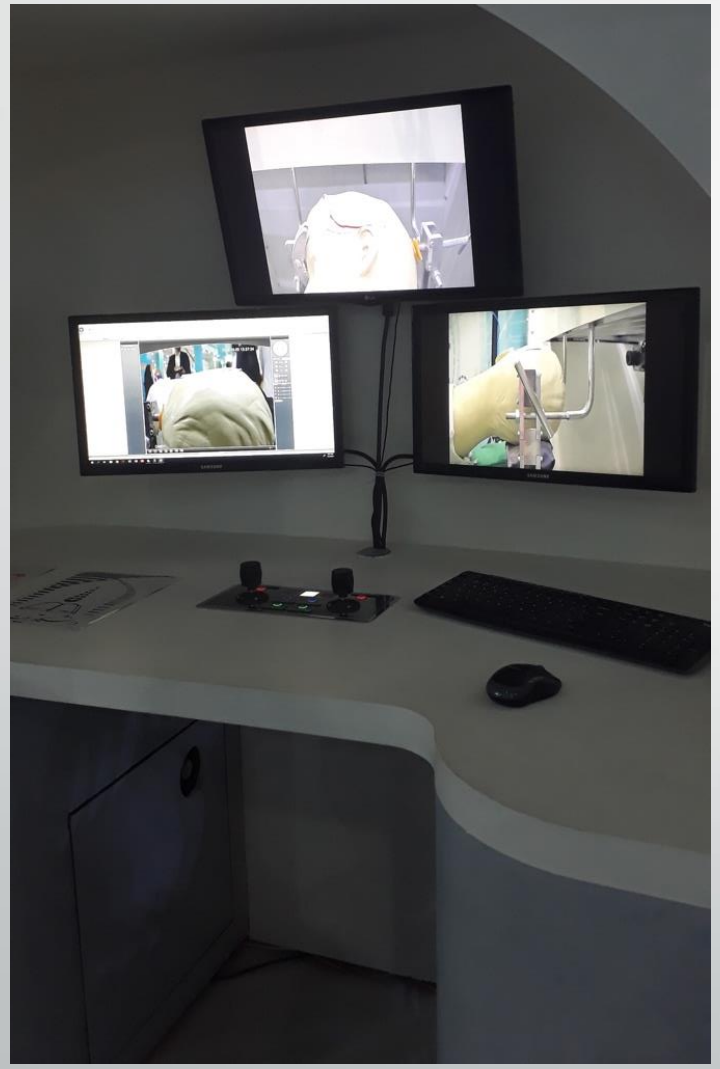
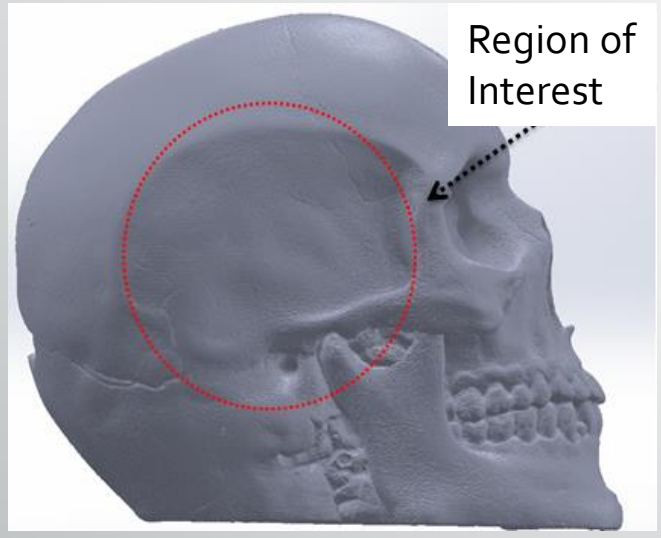
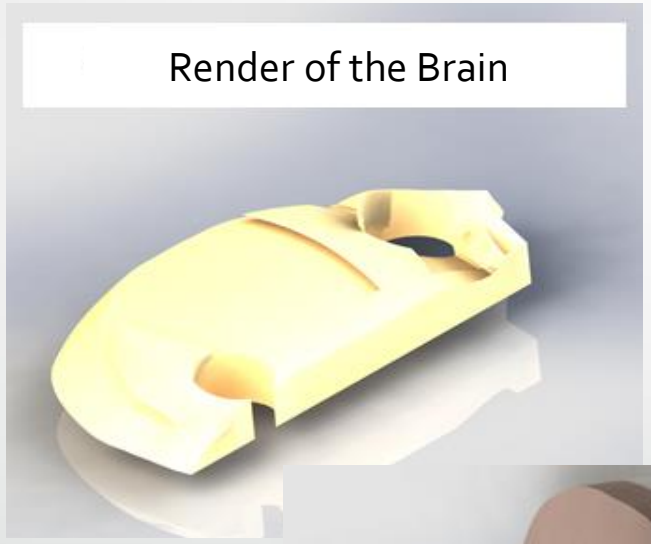


Human Head Phantom

To evaluate the performance and functionality of our apparatus for robotic remote surgery, we designed and implemented a 3D-printed phantom of the human head

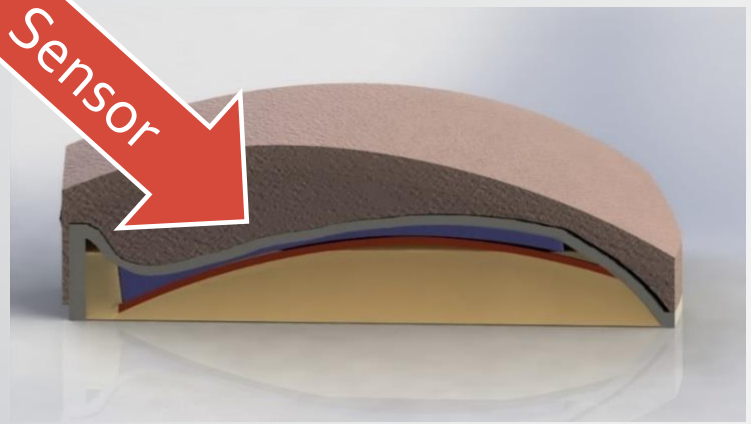


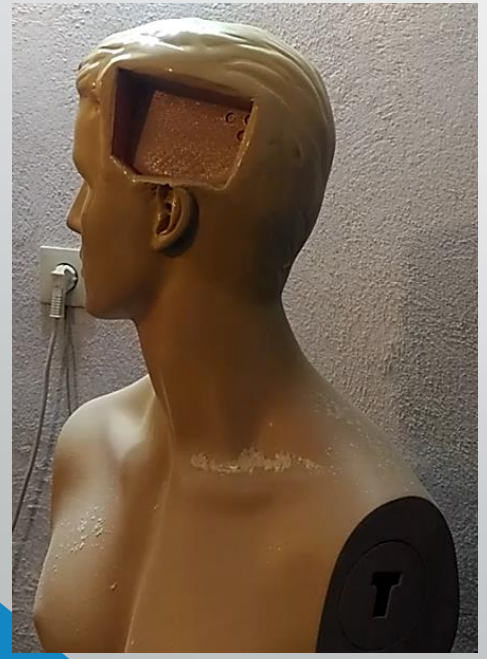
3D Render of the actual human skull



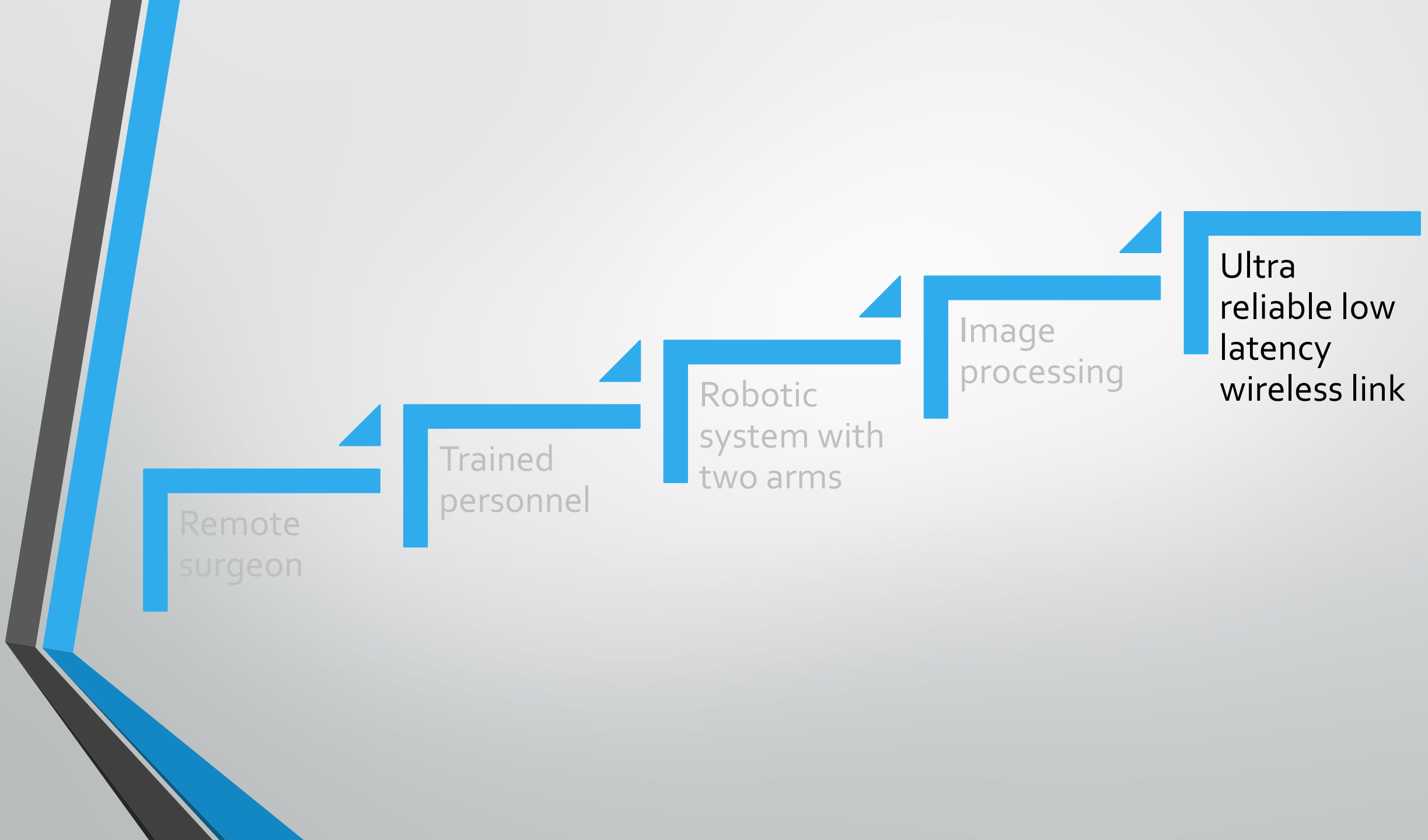
Human Head Phantom

Sensor





Failure Detection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Wireless Communication Platform

- Maximum end-to-end delay: 300 ms
- Video frame rate: 25 fps
- Encoding H.265, 720p
- VHF UART link for the command link
- Dedicated point-to-point 5 GHz link for the video link

Radio	
Frequency Range	400-470MHZ
Frequency Accuracy	±2.5ppm, -30 to +60 ‘C Ambient
Transmitter	
TX Power	0.01 to 5W (+10dBm to +37dBm)
Modulation	Filtered Narrow-Band RCFSK, GMSK
TX Spurs	Less than 45dB
Receiver	
Sensitivity	-116dBm for 12dB SINAD
Selectivity	Better than 60dB
Node/ Network Address	Can be Filtered
Connections	
Serial Data Port	RS232 , 9600b/s
Interface port	Serial RS232 9600b/s
Antenna	1 N-Type female
LED Display	Pwr, Lock-Detect, TX, RX- Sync,
Modem	
Bit Error Rate	< 1x10-6 @ -107dBm (9600b/s)
General	
Power Supply	12VDC nominal (9 – 14VDC)
Transmitter Current	1500mA nominal @5W
Receiver Current	< 150mA @ 12VDC
Dimensions	153x104x64mm
Weight	< 500gr

VHF Command Link

Antenna	Patched , Gain > 20dBi
Modulation	QPSK
Coding	RS(255,223)
Digital pulse shaping Filter	Square-root-Raised-Cosine, Roll-Off=0.1
Bit rate	20Mb/s
Symbol Rate	10MS/s
RF Bandwidth	11MHz
TX - RF Output Power	+18dBm
RF Frequency	5 ~ 6 GHz
Interface	Ethernet(10/100 Mb/s)
GUI interface port	RS232 Serial Port
Antenna Gain	23 dBi
3dB Beamwidth	9º (typ)

Conclusion

- In ultra urgent cases, immediate action is crucial to prevent death.
- Epidural Hematoma is an example of ultra urgent cases.
- An apparatus for robotic remote surgery was designed and implemented to drain the accumulated blood.
- To evaluate the performance of the designed system, a human head phantom was designed and used.
- The performance was satisfactory.

Acknowledgment

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