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NPS-19-F044 Low $WaP trained Neural Net for nLoS LPI LPD applications

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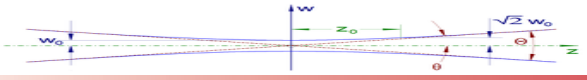
Abstract:
Leveraging Machine Learning for Optical MIMO laser QR signaling – Movidius Fathom / Intel Neural Compute Stick NPS: Peter R. Ateshian; Capt Adrian. W. Felder, Gibson John H., Gurminder Singh PhD, Don Brutzman, PhD, SPAWAR: David T. Wayne PhD, Burton Neuner III PhD

NPS/SPAWAR Laser/LED QR code ML application

Goal: Laser QR MIMO 5 Domain and boundary Optical Communications

Problem Statements: Beam Divergence

The **beam divergence** of an electromagnetic beam is an angular measure of the increase in beam diameter $2W_0$ or radius W_0 with Z_0 far field distance from the optical aperture or antenna aperture from which the electromagnetic beam emerges. This beam divergence will cause beam overlap in an undesired manner where white space is required. The **speckle pattern** of the beam at target is another correction that will be needed. Lastly, the **ellipsoidal nature** of a well-controlled mode for Gaussian/Bessel laser will cause asymmetric overlaps due to initial laser diode array placement and orientation.



Analysis of Alternatives (AoA)

•Machine Learning compensation by pairing in :
(a) TensorFlow/TFlite or
(b) PyTorch
•Deployment
(a) Fathom Movidius (aka Intel Neural Compute Stick) or
(b) RaspberryPi3B
•ML Algorithmic Alternative (50% Bandwidth reduction cost) Transmit QR then
(a) Blank then transmit !QR (complement
(b) or simultaneously on different wavelength DWDM with receiver filter) then use
(c) correct QR = QR - ! QR (subtract operation in OpenCV) on Fathom Movidius or
(Note) test on PC MATLAB imdiff(image1, image2) in MATLAB for change detection then conversion of M to C++ on Raspberry Pi3B
(d) Parallel Laser Morse code – siso below

Laser beams have a well know characteristic solid angle beam divergence characteristic.
The effects of the beam divergence are an elliptical spread of about one meter per kilometer (~1/1000). Raleigh effects are also a natural phenomenon that makes two observed point sources appear to be one at a certain distance. We are investigating pattern machine learning to perform computational compensation for these effects. The initial point observation can be used as the correct classification of a distance observed multiple overlap set of divergent beams. A minimum test set or array design would be desirable as the QR code MIMO approach has a 21x21 or 441 element minimum configuration. A more manageable array size to have edges, corners and center would be a 3x3 array (fig 4a). This would yield 512 possible on/off combinations and would be a reasonable starting point for a training set. The 3x3 pattern could be scanned through the 21x21 array to make a 7x7 (fig 4b) or 49 way position combinations for a total of 25088 patterns vs 2^(441). 3x3 array –Laser diodes 512 pattern combinations QR minimum 21x21=> 7x7 for each 3x3 to for 25088 or ~25K combinations. Project potential DARPA offspring.

NPS Development Environment

TensorFlow Lite tflite
Caffe Caffe2