MU-Net: Deep Learning-based Thermal IR Image Estimation from RGB Image

Jet Propulsion Laboratory
California Institute of Technology

Yumi Iwashita[1], Kazuto Nakashima[2], Sir Rafol[1], Adrian Stoica[1], Ryo Kurazume[2]

[1]Jet Propulsion Laboratory, California Institute of Technology (USA), [2]Kyushu University (Japan)

Contact Info: Yumi.Iwashita@jpl.nasa.gov

Motivation

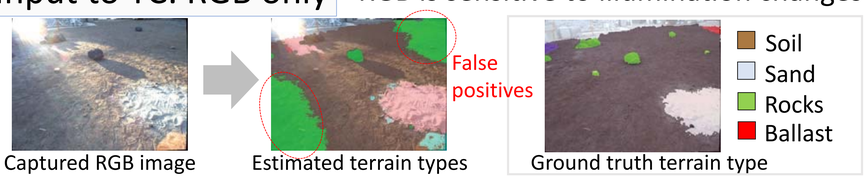
Terrain classification (TC) is an essential component of a broader understanding of the terrain to be traversed by rovers

Spirit got stuck in a sand trap, 2010

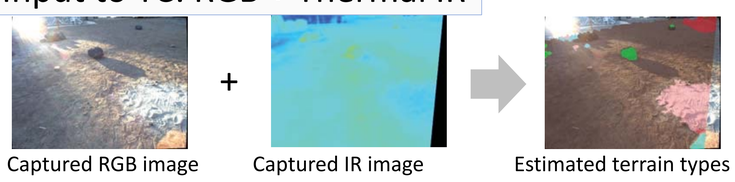
Wheels of Curiosity rover got damaged

Input to TC: RGB only

RGB is sensitive to illumination changes



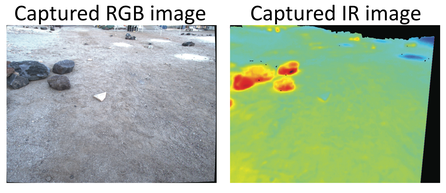
Input to TC: RGB + Thermal IR



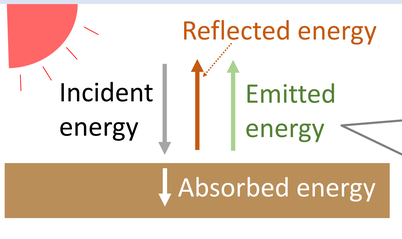
Fusing visible and thermal images can make the terrain classification robust to illumination changes

However, neither the Mars Science Laboratory (MSL) nor Mars 2020 have IR cameras

Instead of real IR, use estimates of IR. There are pretrained examples of images seen both in RGB and IR

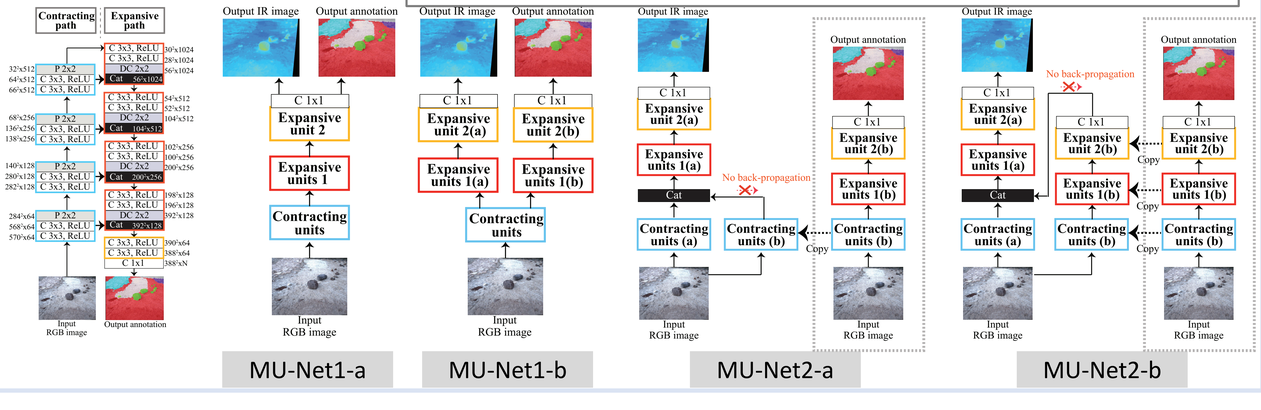


Proposed MU-Nets (Multiple U-Nets)



In given conditions, estimation of IR from RGB could be related to the balance of energy exchange at the imaged object.

Incident = Reflection + **Absorbed** (assuming opaque material)
(Absorbed ≈ Emitted)
Over a short duration of time, the emitted energy is approximately equivalent to the absorbed energy

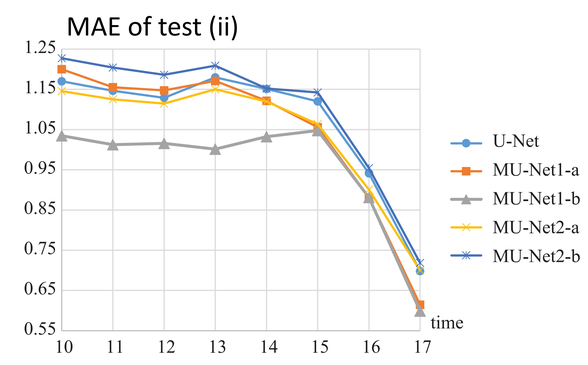


Experiments

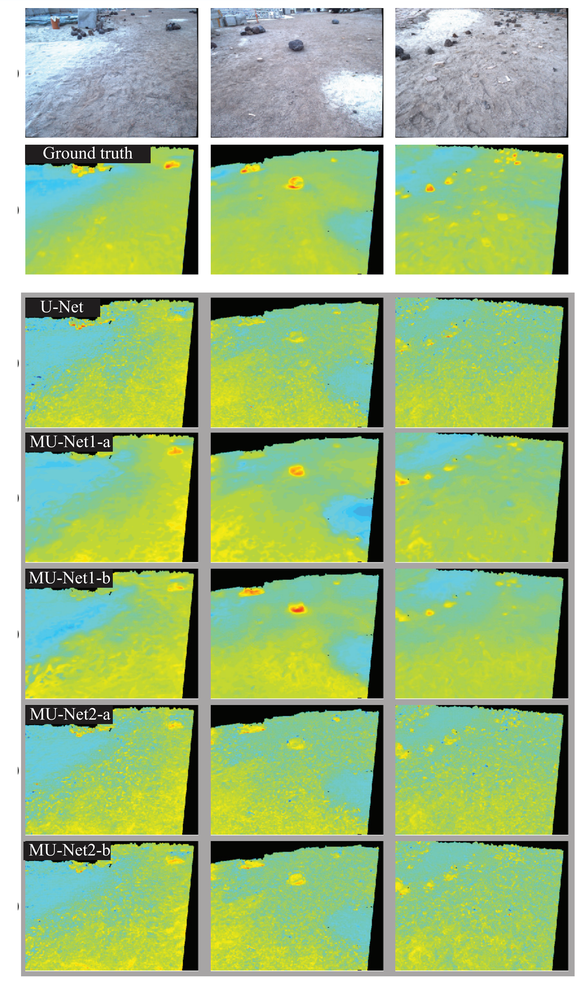
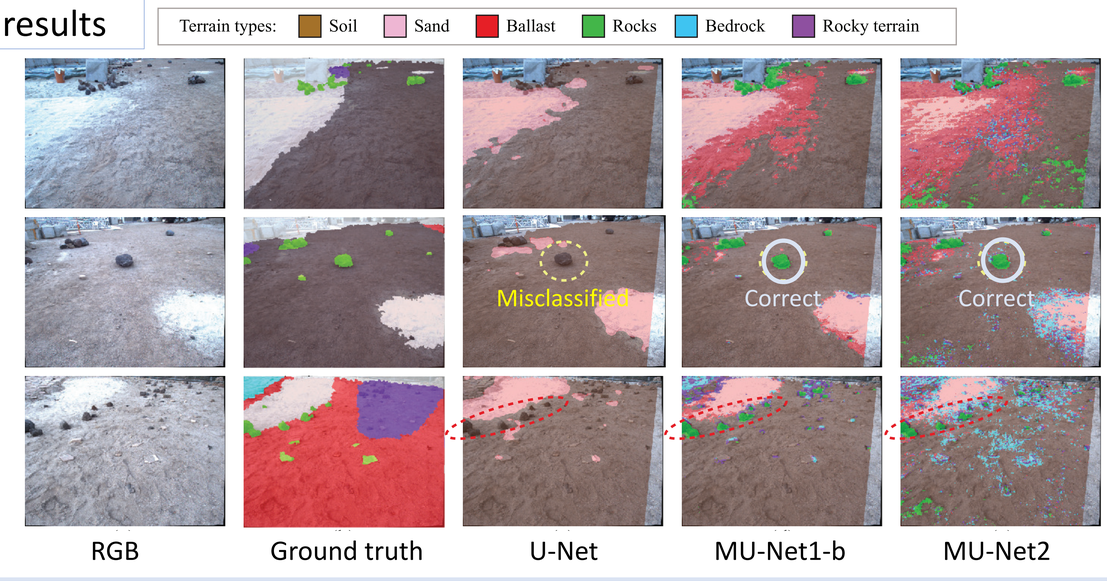
Data collection: Nov/2017, 10am to 5pm, every 1 hour
# of images: 52 images / hour x 8
Experimental settings:
- Training: 50% of RGB and IR at 5 pm
- Validation: 25% at 5pm
- Test: (i) the rest 25% at 5 pm and (ii) images from 10 am till 4 pm

MAE (mean absolute error) of test (i)

	U-Net	MU-Net1-a	MU-Net1-b	MU-Net2-a	MU-Net2-b
MAE	0.69	0.61	**0.59**	0.70	0.71



IR results



TC results