Abstract
We analyse the feasibility of imaging the footprints left on the surface of the moon by Neil Armstrong in the 1969 moon landing. We find that a telescope roughly 1.5 km across would be needed to resolve the bootprints from earth, and a telescope of 13.7 km diameter would be needed to resolve the details of the bootprints. We then evaluate the distance at which a probe would need to orbit the moon to image the bootprints. We find a probe would need to orbit at 117 km to resolve the bootprints and 12.7 km to resolve the bootprints in detail.

Introduction
The Apollo 11 mission in 1969, which successfully landed astronauts on the moon, was one of the most historic events of the 20th century. Footage of Neil Armstrong’s “One small step for man” speech has been viewed by millions since, and the footprints he left behind on the lunar surface to mark man’s scientific and engineering prowess are still there today. Because the moon has no atmosphere, and thus no wind or weather, nothing has disturbed them. Assuming image distortion due to the atmosphere is minimal, we estimate the diameter of the telescope necessary to image those footprints and take detailed photographs of them from Earth. We then estimate the distance at which a telescope 0.5 m across would need to be to do the same from a lunar orbiter.

Observing From Earth
We set the distance between the observer and the the moon to be the minimum possible, to make the observation easier. At perigee (the point at which the Moon is closest to Earth), the Moon and the Earth are 356000 km apart [1]. Subtracting the radii of the Earth and Moon, the observer and the bootprints would be 348000 km apart. Given that Neil Armstrong was a shoe size 9\(\frac{1}{2}\) [3], with about an inch of insulation, we defined the length and width of the bootprints to be 33 cm (13 inches) and 15.2 cm (6 inches) respectively. As shown in Figure 1 the bootprints have 10 ridges, so we defined the ridges as being 1.65 cm across. Assuming the width of the boot-
them, and the width of the ridges would be the
limiting factor in resolving detailed images, we
calculated the angular resolution needed to im-
age the bootprints using the small angle equation
Eq.(1).
\[
\theta = \frac{D \times 206265}{d}
\]  (1)

In Eq.(1)[4] \( \theta \) is angular width in arcseconds, \( D \) is
the width of the object in meters, and \( d \) is
the distance between the observer and the object
in meters. 206265 is a dimensionless conversion
factor. We calculated the angular width of the
bootprints to be \( 9.0 \times 10^{-5} \) arcseconds and the
angular width of the details of the bootprints to
be \( 9.8 \times 10^{-6} \) arcseconds.

\[
R = \frac{134}{T}
\]  (2)

In Eq(2)[5] \( R \) is the resolution limit of a tele-
scope in arcseconds, and \( T \) is the diameter of the
telescope in millimetres. Letting \( R = \theta \) to find
the minimum diameter required to resolve the
bootprints and their details, we calculated that a
telescope of diameter 1.5 km would be needed to
resolve the bootprints from Earth, while a tele-
scope of 13.7 km would be needed resolve de-
tails. These sizes are far greater greater than
what is feasible, making imaging the bootprints
from Earth impossible.

**Observing From Orbiter**

To find the distance at which a lunar or-
biter could image the bootprints, we assumed
the probe would carry a telescope with a diameter of
0.5 m; quite large for an orbiter. Using Eq.(2),
we calculated that the telescope would have a
resolution limit \( R \) of 0.268 arcseconds. Again we
set \( \theta = R \) to find the maximum distance at which
the telescope could resolve the bootprints and
their details. We used Eq.(1) to find the max-
imum distance at which the lunar orbiter could
resolve the bootprints would be 117 km above
the lunar surface, while to capture detailed im-
ages of the bootprints the orbiter would need to
drop to 12.7 km. While 117 km is a perfectly rea-
sonable distance for a probe to orbit the moon,
below about 100 km altitude above the moon
the probe would be in Low Lunar Orbit (LLO).
To image the bootprints in detail would subject
the probe to intense perturbations in its orbit
around the moon, making this a risky prospect
if recovering the probe is to be assured [6].

**Conclusion**

Due to the small nature of Neil Armstrong’s
bootprints in comparison to the distance be-
tween the Earth and the Moon, or even the
Moon and a probe orbiting it, resolving them
is a challenging prospect. Building a telescope
large enough to do so on Earth would be impossi-
ble, and while sending a probe capable of resolv-
ing the bootprints is possible, acquiring detailed
images risks the orbiter. While we assumed a
reasonable value for the dimensions of the boot-
prints, there is a degree of error associated with
our results, but not great enough to render them
invalid. Even a 10% change in any of the cal-
culated distances would not make resolving the
bootprints feasible from Earth.

**References**

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