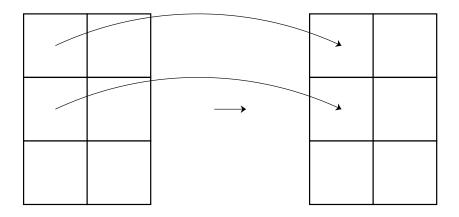
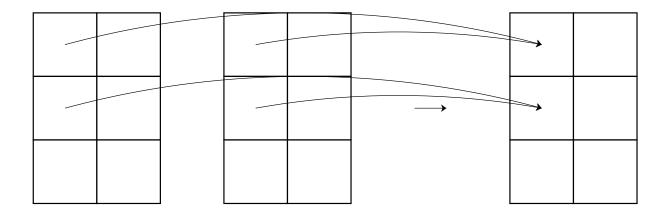
### Module 2.3 - Advanced Tensors

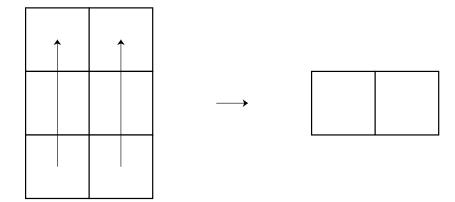
# Мар



# Zip



### Reduce



## Quiz

### Outline

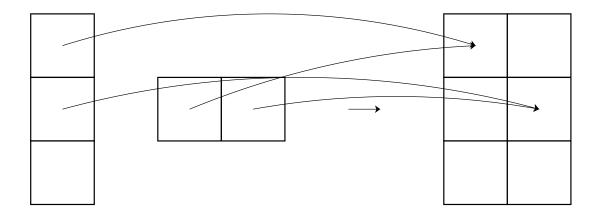
- Broadcasting
- Gradients
- Tensor Puzzles

# Broadcasting

#### Motivation: Scalar Addition

vector1 + 10

## Zip Broadcasting



#### Rules

- Rule 1: Dimension of size 1 broadcasts with anything
- Rule 2: Extra dimensions of 1 can be added with view
- Rule 3: Zip automatically adds starting dims of size 1

### Applying the Rules

- (3, 4, 5) | (3, 1, 5) => (3, 4, 5)
- (3, 4, 1) | (3, 1, 5) => (3, 4, 5)
- (3, 4, 1) | (1, 5) => (3, 4, 5)
- (3, 4, 1) | (3, 5) => X

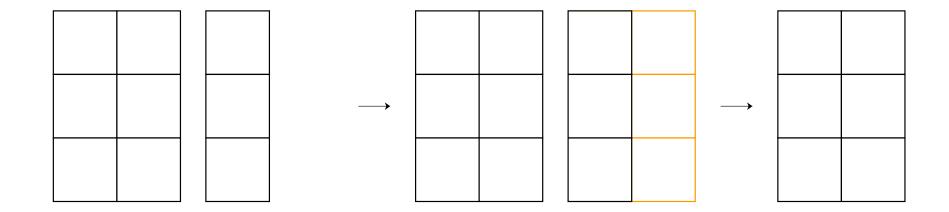
## Broadcasting Example

```
3 4 1
1 5
-----
3 4 5
```

### Matrix-Vector

```
x = minitorch.tensor([[1, 2], [3, 4], [5, 6]])
y = minitorch.tensor([[1], [3], [5]])
z = x + y
z.shape
(3, 2)
```

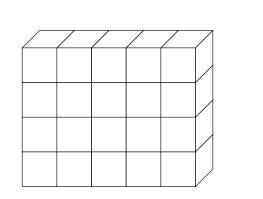
## Matrix-Vector

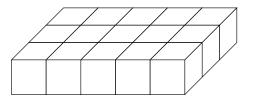


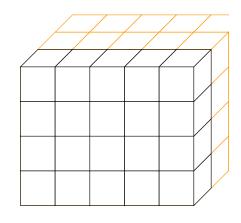
### Matrix-Matrix

```
x = minitorch.zeros((4, 5))
y = minitorch.zeros((3, 1, 5))
z = x + y
z.shape
(3, 4, 5)
```

### Matrix-Matrix







# "Matrix multiplication"

```
x = minitorch.zeros((3, 2))
y = minitorch.zeros((2, 1, 2))
z = (x * y).sum(2)
z.shape
(2, 3, 1)
```

# "Matrix multiplication"



### Implementation

- Never create an intermediate value.
- Implicit map between output space / input space

#### **Functions**

- shape broadcast create the broadcast dims
- broadcast\_index map from broadcasted to original value

# Tensor Puzzles

## Special PyTorch Syntax

(Not avaiable in minitorch)

```
import torch

x = torch.tensor([1, 2, 3])
print(x.shape)
print(x[None].shape)
print(x[:, None].shape)

torch.Size([3])
torch.Size([1, 3])
torch.Size([3, 1])
```

### Tensor Function

```
x = torch.arange(10)
print(x)

y = torch.arange(4)
print(y)

tensor([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
tensor([0, 1, 2, 3])
```

#### Tensor Function

```
x = torch.where(
    torch.tensor([True, False]),
    torch.tensor([1, 1]),
    torch.tensor([0, 0]),
)
print(x)

tensor([1, 0])
```

### Tensor Puzzles

**Tensor Puzzles** 

Q&A